2018 Activity Report

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Content

Shifting our focus forward

by the Director General

Have you ever wished you could have been in the room the day NASA switched on the first screen at Mission Control? Or when Louis Pasteur began his experiments with fermentation that eventually led to the discovery of bacteria? At ESS, we're convinced we witnessed a historic first moment in 2018 – a moment that will, in a few years, enable scientists to create their own world-changing firsts.

In 2018, we turned on the first section of the ion source for what will become the world's most powerful particle accelerator. Measuring 500 metres when fully operational, we now have the first two metres of the particle accelerator delivering a low-power beam of protons. Built in Italy as an in-kind delivery and officially inaugurated with a visit from Sweden's King and Italy's President, this is an important milestone for our broad European collaboration.

A whole new view

We've been witnessing "firsts" at ESS for years, but 2018 marks a significant shift. Powering up the ion source is a technical milestone, of course. Yet equally important is the psychological milestone that ESS now has operational equipment in place, and is not just a building site. This psychological shift is reinforced by our move into temporary offices next to the facility, which was also completed during 2018.

Relocating nearly 500 people didn't change anybody's job description or the day-to-day work, but it did change the focus and mindset of our organisation because it's clearer why we're here. You only need to look out of the window, especially now as we've passed the halfway mark in construction with 55% complete at the end of 2018.

Planning to adapt

Of course, creating something that's never been done before is full of challenges. Design of the target building – the heart of ESS, where neutrons will be made – had to be upgraded to comply with updated safety and security requirements, newly set in place internationally after studies of the impact of the earthquake and tsunami on Fukushima in Japan.

To minimise the impact of delays from this and future changes, we completely revisited our project planning – a major endeavour involving over 25,000 separate tasks. The new schedule was officially approved in June and keeps us on track to deliver first science to outside users in 2023.

Defining collaboration

With unforeseen change, of course, comes extra costs. As we discuss the financial impact with our member countries, we're optimistic for an agreement during 2019 as to how extra contributions will be made by the European partners, and how sustainable funding for the period 2019–2025 will be secured. In the meantime, all partners provided the full funding requested for 2019, enabling us to continue full steam ahead.

The measure of support we have from the member countries is defining a whole new era of scientific collaboration as, together, we deliver the biggest greenfield investment Europe is making in science right now.

Glance back, focus forward

It's tempting to just look up and see the mountain we have yet to climb. Yet, this report is our moment to pause, look back, and realise that we've already scaled multiple Everests – through terrain no one has ever travelled before. There's no map to follow. No guidebook. We are creating it.

The commitment of everybody at ESS is truly something to celebrate. People work beyond their comfort zones, because we're on a mission here.

We drive ourselves hard – "relentless progress" some external experts have called it. I call it passion and purpose. We are pulled, not pushed, toward our goal. We each know this is our opportunity to be part of something to benefit humanity – a scientific facility 20–50 times more powerful than anything that exists in the world today. Here, scientists won't just be able to do things better. They'll be able to do radically new things, focused on solving practical, everyday needs.

That's our focus forward – delivering first science in 2023. From planning and preparing individual dishes, we have begun to put the whole meal together. What a smorgasbord it will be.

JOHN WOMERSLEY
DIRECTOR GENERAL, ESS

"You always need that vision of what's better"

HELMUT SCHOBER
DIRECTOR GENERAL, ILL

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The science of neutron scattering has a long, distinguished history across Europe. For decades, scientists have been uncovering the secrets of matter in the hope of advancing our understanding of the world around us. ESS will be a big part of this future, as the world-leading scientific hub in Lund, Sweden, comes online in a few years. The Institut Laue-Langevin (ILL) in Grenoble, France, paved the way more than 50 years ago, helping to transform the city into an international research destination.

ESS will be important for the future of neutron research, but that won't be the only benefit once it's online. It will also be the latest addition to a new scientific hub in Lund, and this is something that can have a huge positive impact on the region. Grenoble was a pioneer in this respect as the city became home to the ILL, as well as the European Molecular Biology Laboratory (EMBL) and the European Synchotron Radiation Facility (ESRF), and the ambition is that ESS joins MAX IV and the Science Village to bring this same level of success to southern Sweden.

"Our most important contribution to Grenoble is the enormous increase in international visibility," explains Helmut Schober, director of the ILL. "In the 60s Grenoble was extremely ambitious, creating research centres, a university, a national research lab, and many other important things, but they really wanted recognition on a global scale. That's where the addition of the ILL really changed things."

This all led to the transformation of Grenoble into a global powerhouse of important research, where the the ILL is just one of many important facilities.

"Here in Grenoble we've created a science hub," Mr. Schober continues. "If you're a researcher in any of the natural sciences, you will be able to find a complete set of tools here which allow you to carry out your work at the highest level."

Broad spectrum of benefits

Between the ILL, EMBL and ESRF facilities in Grenoble, there are well over 1000 employees from all over the world, creating an international hub of expertise. The ILL also works with universities, with many PhD students able to work on site whether from the local schools or other universities from the member countries. These numbers alone are enough to make a positive impact in Grenoble, but then there are the scientists that visit every year to conduct experiments.

"There are around 800 experiments carried out every year," says Mr. Schober. "This translates to roughly 1,500 people visiting the ILL, where some stay for a couple of days, and others stay for weeks. This benefits everyone involved – we get top scientists coming to Grenoble, which boosts both knowledge and enthusiasm, and local businesses feel the benefit of more people being in the city. The member countries then get the benefits of the work that's done here by being able to access the results, findings and methodologies."

The ILL benefits the area and the member countries in such a variety of ways that it would be unwise to try to attach a figure to it, in terms of return on investment. More than purely financial returns, the ILL has an impact on expanding knowledge and understanding all over the world. ESS is already experiencing these benefits, with many employees having trained at some point with the ILL.

The importance of the experience

The ILL, like ESS will be when operational, is there to offer a service first and foremost. The decades of success enjoyed by the ILL are not only due to meeting the expectations of the users, or customers, but often exceeding them.

As so many visit every year, there is a guest house in the area where the scientists can stay. There's also a tramline which runs into the centre of the

city, and all the way to the university on the other side, so everything is well connected. Again, this is mutually beneficial, as the accessibility works well for the city and for the science hub.

The most important part of the service the ILL offers though, is the reliability. "We put a lot of emphasis on this," says Mr. Schober. "As the work and the beam time is planned so far in advance, we can't just call to say it's been moved two weeks due to maintenance. We work to have 100% reliability and predictability, and this is why we're still number one. The services we offer can be seen as a chain, and a chain is only as strong as its weakest link. I'm proud to say we have no weak links."

The ILL is constantly evaluating what needs to be done to meet the needs of a changing scientific landscape too, which is a vital part of staying both relevant and in demand.

Competition is key

Scientific breakthroughs often occur because of the combination of two very important factors – collaboration and competition. The same is true with the ILL as a facility, and the same will be true of ESS.

"Competition is good," adds Mr. Schober. "Everyone strives to do their best, and then we share, because we know that together we can drive the whole field forward. We always need to push ourselves, and keep that motivation, but collaboration is also absolutely necessary as we need to optimise how we use our resources. We need to avoid doing things that have already been done, and instead focus on the exciting opportunities in front of us. That way we ensure the best returns on investments, and consistently push performance."

ESS will only add to this competition and collaboration, and the hope is that it will drive the field even further, and faster than ever before, as Mr. Schober concludes:

"It's exciting for the whole neutron scattering field. You always need that vision of what's better, and what's performing at a higher level. It will give a completely different weight to the field in Scandinavia too, just as the ILL did here, and it will spark even more interest around Europe. It will be exciting to see how this community develops, and what we will see in the future!"

Welcome to our world

The fundamental goal of ESS is to enable science to advance and to enhance our understanding of the world around us. Neutron research has given so many incredible insights over the decades, and the hope is that with this new source which is significantly more powerful, we will make even more exciting and important discoveries.

ESS will be home to the most powerful neutron source in the world, which will be 20 times more sensitive, on average, than anything else in operation today. This, along with the planned 22 stations for experiments, should lead to a lot of exciting, new scientific work after we open for users in 2023. Neutron research can be a great benefit across a wide range of applications, including:

Enzyme structures and chemical processes

As the process and analysis is non-destructive, testing can reveal protein and emulsion structures, which in turn can help reduce energy consumption in food production.

Atomic structures of materials

We can learn more about materials on an atomic level, as well as their behaviour. Deeper understanding can help with the development of lighter, stronger, cheaper and more sustainable materials.

Understanding the human body

Neutron research can tell us more about DNA, proteins and biological material on a molecular and atomic level. This can give us a better understanding of the ageing process, or how diseases function, and that could result in the opportunity to develop more effective medicines.

Improving sustainability

Through a better understanding of environmentally friendly products and processes, like hydrogen fuel cells and solar power, we can potentially develop more effective and efficient technology which will further limit our impact on the world around us.

Neutron scattering in existing facilities has already advanced these fields, but the fact that ESS will be so much more powerful means that there could be new leaps forward in understanding. It could even mean that the science will be like nothing we've seen or considered before.

How we operate

We are a global institution, built with the help of more than 450 employees of more than 50 nationalities, and more than 100 institutions around the world with which we collaborate. As well as cash investments, we receive many in-kind contributions from all over Europe.

These in-kind contributions allow us to benefit from the vast amounts of experience and expertise found across the continent, and it promotes healthy cooperation and knowledge sharing.

In practical terms, in-kind contributions can take many forms. Some countries have supplied technical components, or products and services needed for the completion of ESS, where others have given us access to personnel needed for various activities, from helping with R&D to testing equipment. Italy, for example, provided the Ion Source which will be so central to our facility.

As ESS is a greenfield project which will offer the 13 member countries, and to an extent the rest of the world, so many important insights, this breadth of expertise and contribution is an essential part of ensuring success.

Revealing facts on an atomic level

At ESS, scientists will be able to study the structure of materials down to a molecular and atomic level, and they will be able to do this over a huge range of distances and times. The equipment will allow researchers and analysts to study down to one hundred-thousandth of a micrometre, and down to ten-million-millionths of a microsecond.

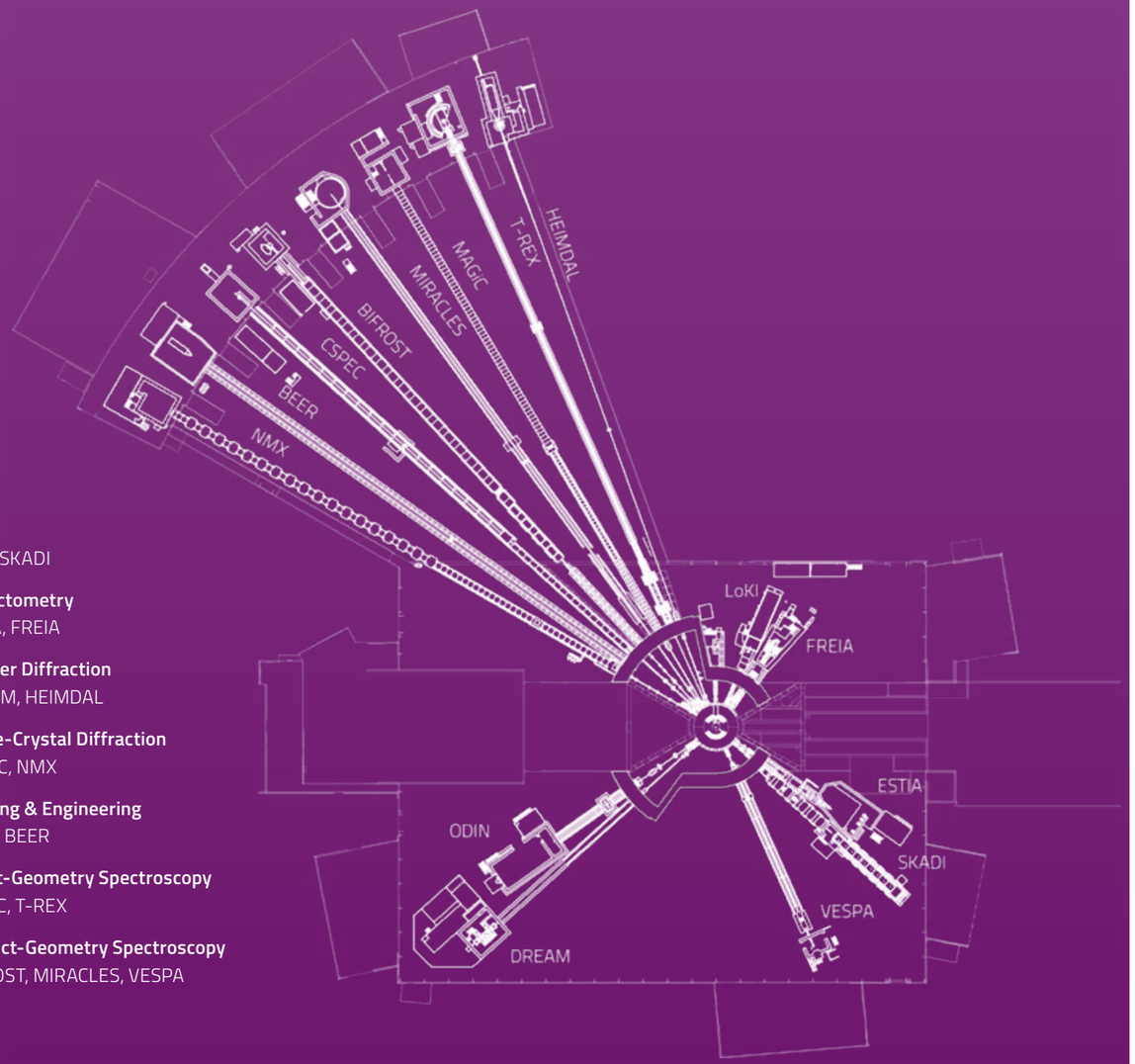
This can only be done because of the equipment, and the facility that houses it. The ion source produces a proton beam which is fired at the target more than 600 metres away down the ESS Accelerator Tunnel. These protons hit the tungsten target at close to the speed of light, this produces neutrons which are then directed towards the sample, which in turn scatters the neutrons.

This information from the scattering is then collected by the instruments that are in use, which will be dependent on the scientists and their proposal. Then the work begins!

Our instruments
Each instrument selected for construction at ESS is versatile, and the overall goal is to be able to serve a wide range of scientific communities. There will be 15 in total, although not all will be operational in 2023. It's anticipated that this number will rise to 22 instruments eventually, but the 15 that are already confirmed will fall into four separate categories:

- Diffraction
- Engineering and Industrial
- Large-Scale Structures
- Spectroscopy

Each of the instruments is unique, and designed to be world-leading from day one. They all serve specific purposes, and together will give the scientific community real flexibility in the research that's possible at ESS.



SANS
LOKI, SKADI

Reflectometry
ESTIA, FREIA

Powder Diffraction
DREAM, HEIMDAL

Single-Crystal Diffraction
MAGIC, NMX

Imaging & Engineering
ODIN, BEER

Direct-Geometry Spectroscopy
CSPEC, T-REX

Indirect-Geometry Spectroscopy
BIFROST, MIRACLES, VESPA

The experiment phase in Lund
When fully operational, ESS will be able to accommodate around 800 experiments a year. This number may sound high, but we expect there will be many more requests than we can handle. This means we need to have a clear and fair process in place for the scientists from our member countries.

The first step is for the scientists to send an application to us, covering what they want to use, why it's important, and how long they will need to be able to extract the results. From there, ESS will review all applications and award the successful ones with the beam and equipment time they need.

As experiments will take a few days on average, we will have a guest house where scientists can stay for the duration of the experiments. They will be allocated time to prepare their experiment and perform it, so the logistical side of our operation is extremely important, as is the reliability of our equipment.

To be able to perform at the highest level, we put great efforts into making the guest house and facilities as friendly and relaxing as possible. Our location in Lund, with its thriving academic and cultural scene, as well as being in the Öresund region just a quick commute from Copenhagen, also means that visitors to ESS will easily be able to enjoy their stay outside of their experiments too.

Analysis to get the result
The data and results are then sent to the Data Management and Software Centre in Copenhagen, Denmark, which has been a division of ESS Science Directorate since 2013. The goal of this centre is to facilitate and advance the research carried out on the ESS neutron beam instruments. It can also help with data visualisation, modelling and simulation, which gives a full, detailed picture of the research carried out.

After the experiment and analysis is complete, they can then share the hypothesis and results with the rest of the community.

Critical steps towards first science

As a kid, did you ever take things apart just to see how they worked? Or "dissect" your dinner to see what a bean looked like inside? That's the kind of curiosity we're looking to satisfy with science here at ESS.

Here, the world's most curious minds will get the chance to see with neutrons better than ever before – to look into materials down to the tiniest atomic distances, to uncover where hydrogen atoms actually sit, or to better understand how the hundreds of thousands of atoms in our bodies move and interact.

There are vast amounts of insights and information that can only be obtained with neutrons. Many neutron sources are in use worldwide today, yet these are neutron flux limited. With ESS, the world gains a source that gives 1–2 orders of magnitude more for a given technique.

That means we can offer completely new experiments never possible before, with a variety of instruments for different needs.

"Excitement is high both here at ESS and among the scientific user community," says Prof. Andreas Schreyer, Director for Science at ESS. "People want it to be ready as fast as possible, of course, and we're excited to share that 2018 was a year of tremendous progress that's now brought us closer to delivering first science in 2023."

"At ESS, scientists will be able to look at smaller samples, smaller distances and get bigger answers – some of the biggest answers of our lifetimes. In 10–15 years, I'm sure there will be life-saving medicines and resource-saving technologies that couldn't have existed without the information gathered here."

ANDREAS SCHREYER
DIRECTOR FOR SCIENCE, ESS

2018: Engaging our user community
As Schreyer emphasises: "We will be a user facility. Our scientists are here to help other scientists use our facility to their best advantage – to understand the new possibilities available to them, and to help them design new kinds of experiments. Together we will change the way neutron science is done, so it's very important for us to have early and continued communication with the user community all over Europe."

In October, ESS held its first user meeting together with ILL in Grenoble, the world's most successful neutron source which has been in operation since the 1970s. With sign-up exceeding capacity, the event was extremely well received, revealing the high levels of curiosity and excitement about the expanding future of neutron science in Europe. The next event is planned for 2020 at ESS in Sweden.

"Collaboration across facilities is vital to giving scientific users the best possible opportunity to make discoveries that will benefit all of us – all of humanity," explains Schreyer. "We need to join forces, make sure we don't waste time reinventing the wheel, and create a joint lobbying power for funding. So we also kicked off LENS in 2018, the League of Advanced European Neutron Sources. It's a new joint organisation that basically gives the European commission one phone number to call if they want neutrons."

Forward thinking
The first three instruments will begin operating in 2023, starting the exciting journey of science at ESS. The facility will ramp up from there, with increasingly complex instruments coming online over the next years, as well as a continual powering up of the source to initially two, and later five, megawatts over time.

Our instrument scientists stay constantly active across scientific disciplines, doing measurements at existing facilities to be up-to-date and provide the best possible advice and help for our users. Their main job is, of course, all the detailed planning and project management left to do before then. The focus is on the future and enabling our users to achieve great things.

"When I came here, I was really excited to see the high motivation in the team," says Schreyer. "To be a part of building the leading neutron source on the planet right here in Europe, and do things that nobody else can do, is a dream come true. No year is the same at ESS, and no one can fully know what will be possible here. For us, it's the ultimate adventure."

Top 3 highlights of 2018

1 You've probably heard the saying "measure twice, cut once." Without a doubt, meticulous planning is essential for projects of this magnitude. In 2018, we wrapped up our work on scope and preliminary design of our neutron instruments, moving into the detailed design and procurement phase during 2019.

2 The bunker is the central shielding component near the target, and a critical element to finish before continuing with other steps. It's a big challenge to design correctly, requiring recalculations along the way. We're happy to have finished this critical-path item during 2018 without any delays to the project.

3 ESS has 15 different scientific instruments in construction, being built by in-kind partners under their homelands across Europe. All 15 are making good progress and the first instrument components are scheduled to arrive on site at ESS at the end of 2019.

Changing the world, together

More than 450 people from over 50 different countries work at ESS, and those numbers are only set to increase in the future. Of course, every single person is different, but one of the unique things about the people at the European Spallation Source is that they're all working to one common vision – to contribute to a better world.

We wanted to celebrate this, so during 2018 we interviewed different members of our various teams to find out how they ended up working at ESS, what it means to them, and how they see the future. The answers were as wide ranging as they were exciting.

One area where we were in unanimous agreement though, was the desire to help change the world for the better. Whether that's through helping to coordinate the building of a world-class facility, or helping with the research and working principles, every one of the team is a key player and works at ESS because they want to be a part of something so special, so positive, and so game-changing.

To hear more about ESS from our colleagues, visit europeanspallationsource.se

Rising to the international challenges

Our state-of-the-art research facility will be home to groundbreaking science that may change the world for the better, and help us prepare for the challenges of the future. As ESS is so visible on the international stage, ambassadors representing the member countries of the United Nations (UN) Security Council visited Lund, alongside the Swedish Minister for Foreign Affairs, Margot Wallström, to find out more about the project.

The ESS project stands as a great example of cross-border collaboration, with 13 member nations. Each country is dedicated to meeting the goals of this project, and cooperation is crucial to the success of this endeavour as ESS is being built from the efforts of hundreds of scientists and engineers from around the world. It was important for the UN Security Council to see this cooperation in action, but also for them to learn about the potential of the facility.

"We're honoured and pleased to host the UN Security Council today. ESS is a great example of international collaboration, with European nations pooling their resources to build the facility and staff members from no less than 50 countries," said ESS Director General John

Womersley upon welcoming the group. "But ESS is more than just a symbol of cooperation – this visit emphasised the key role that scientific and technical innovation must play in helping to addressing the world's pressing challenges, from energy sustainability to healthcare to better use of materials."

During the visit, the UN Security Council had the chance to tour the construction site, and learn about the possible benefits for society that could come as a result of the research carried out by the thousands of scientists that will use ESS.

"We are proud to be able to show ESS to the Security Council," said Wallström. "We talked about technological development and global challenges, and how research and innovation can be used to meet today's problems and crises."

Technical teamwork

The technical collaboration between ESS and J-PARC (Japan Proton Accelerator Research Complex) has been going from strength to strength since since it began in 2012. During 2017, the relationship was consolidated through a signed Memorandum of Collaboration (MoC), and in 2018 a two-day workshop was held with representatives from both facilities.

The focus of the workshop was to facilitate knowledge sharing on the various technologies which will be key to ESS.

Another important topic of discussion was on the best ways to safely operate the respective facilities. This came as a result of the signed MoC, which laid out a roadmap and framework allowing for this type of meeting.

"The workshop created an opportunity for the staffs of ESS and J-PARC to engage proactively to provide essential insight into the operation and maintenance of the two facilities," said ESS Technical Coordinator Masatoshi Arai, previously Director of the Materials and Life Science Division at J-PARC. "Such activities provide a basis for future collaboration."

Cooperation is set to continue well into the future, with the experience being a real mutual benefit. J-PARC began operations in 2008, so their experience in operations and accelerator development is extremely valuable to ESS, where First Science is to begin in 2023, and the instruments and equipment at ESS is world-leading, and can be an inspiration to J-PARC in their own facility.

Why ESS?

I started at CERN, working in France, and I'd always wanted to travel. Working at a place like CERN, working in particle physics, and working for an organization where the goals are greater than profit really meant something. A colleague came to ESS, and then got in touch with me and said, 'do you fancy a challenge?'. I thought, I could stay at CERN, or I could step out of my comfort zone to work on another exciting mega-project, so me and my family moved here!

What is ESS to you?

There are a lot of challenges, as it's such a big project, but it's all part of the project, and it's fun. Every day is different. Also, it's exciting. We don't know what we're looking for with the research itself, but we will find something that will aid mankind in some way.

ALASDAIR DAY SENIOR ENGINEER FOR RADIATION MONITORING

Watch the full video

Instrumental to ESS success

During IKON14, a three-day meeting held by ESS and Laboratoire Léon Brillouin (LLB), two-hundred contributors for our Neutron Scattering Systems sub-project met in France to discuss the progress of instrument construction. This was the 14th event of this nature, where the main focus is on in-kind contributions, and the good news was that as of February 2018, construction of the first 15 instruments stood at nearly 20%.

This means that all instruments have passed what is known as Tollgate 2 – a substantial preliminary design review – and have only two more Tollgates before completion. At IKON14, a lot of the discussion was around integrating these plans and time schedules with the re-baselining of the overall ESS project, and how to smoothly pass through Tollgates 3 and 4.

"We need to adjust our circumstances to deal with issues as they arise," said ESS Director General, John Womersley. "But all of our activities in the coming year are directed toward maintaining the momentum toward that famous serving of SOUP – the 'Start of the User Programme'. There's a lot of serious work to be done underpinning this goal."

Every one of the 15 instruments had moved into detailed engineering design, with some in more advanced stages, already at the beginning of 2018. The next steps are to facilitate face-to-face collaboration between the instrument engineers and ESS technical teams, and then it's on to Tollgate 4 – assembly.

"Every little detail has to be accounted for – it has to be ready, IKEA-style," said Antonio Bianchi, who is coordinating detailed planning for on-site installation. "It is very exciting for the project to enter this stage of instrument construction."

Why ESS?

I came for the challenge. We're standing in front of something special at ESS, like new technologies which can be used for good in the future. We can move fields forward with this technology.

When I saw the announcement that the ESS detector group was looking for a leader, I decided to test myself! I've worked with leadership before, but never in a pure leadership role, so I took the challenge!

What is ESS to you?

It's a melting pot of young people, incredibly advanced brains, and motivated people that would like to make a change.

ZIVILE KRAUJALYTE ACTING SECTION LEADER OF THE DETECTOR SYSTEMS SERVICES SECTION

Watch the full video

Orchestrating the first proton beam as tempo increases

Imagine a target monolith of 6,000 tonnes and kilometres of pipes and parts; yet precision on the tiniest scale. Now imagine that most pieces are being built in different countries and must arrive in perfectly synchronised time and space.

"Building this machine is like conducting a symphony with musicians in different rooms, inventing new instruments as they play, while constantly adjusting key and tempo," says Roland Garoby, Technical Director for ESS. "We have the responsibility of creating perfect harmony – to keep an ear out for flat notes and keep everything in sync. It's a permanent challenge and relies on the competence and dedication of a huge number of people."

The machine, where protons will be accelerated to produce neutrons, will be more powerful than any existing machine. Even its construction is unique for accelerators. Over 50% is being built off-site by in-kind partners around Europe, requiring unique logistical and technological processes.

As Garoby explains, "We face challenges unheard of in existing labs. Even if things have been tested elsewhere, when it gets on site it can be different. We have to continually invent, test, reorganise, and adjust. For accelerators," he continues, "ESS is setting a precedent and a new way of mobilising resources from multiple countries – allowing us to do something on a scale not possible for a single country, while still allowing each country to make use of and benefit from their local resources and suppliers. And our progress in 2018 was remarkable."

"Turning on the ion source is a striking achievement, shifting us from paperwork and prototypes to actual protons on site. Although it's only the first few metres delivering a low-power beam, we all feel a change of spirit. Now we begin to hear real music and the tempo is high."

ROLAND GAROBY
TECHNICAL DIRECTOR, ESS

2018: Shifting to initial operations
The start of 2018 was bogged down with replanning and contract negotiations as ESS revisited its schedule due to stricter international safety regulations. Yet with a more robust schedule in place and huge progress from in-kind partners in Italy, France, Germany, Spain and beyond, the end of 2018 shifted to full focus on delivering first science in 2023.

ESS began serious work in September analysing the needs for initial machine operation, setting up an operations coordination team, and bringing onboard an operations manager for the neutron source and technical infrastructure. Night shifts are also in place as we begin preparations for a machine that will crank out neutrons 24/7 during most of the year.

Evolution built right in
As the world's most powerful proton accelerator begins to ramp up, our attention is, of course, on first science and reliable neutron production starting in 2023. Still, the spirit of ESS is to break new ground. So already in its design and construction, the machine has the potential and flexibility for more capabilities to address needs we cannot fully imagine today.

"The magic of a superconducting linac," explains Garoby, "is that it's not very difficult to increase in power by increasing the number of pulses per second. We've also foreseen and made room in the accelerator tunnel for an additional 100 metres of beam line, which could be used to install more accelerating structure and increase the beam energy. This could be for neutrino production, higher performance with neutrons, or other advances for new science. We can also investigate what interesting physics could be done with our muons by-product."

Garoby concludes with a prophetic outlook: "If I can look past today, past 2023, past my lifetime, I hope this place will be lively – burgeoning with ideas and continuous requests for the machine to do more, to nurture the curious, open-minded, ambitious scientific spirit. Beyond simply a neutron factory, we have the potential to continually evolve and break new ground. That is what ESS is doing today, and that is what it should actively pursue."

Top 3 highlights of 2018

1 2018 marked the first proton beam at ESS as we turned on the first section of the particle accelerator. Though the power is trivial at this stage, this is truly the start of our machine. Our cryogenics operations also began producing liquid helium, and even supplying the local university, as they need it.

2 In spite of challenges with resources and suppliers, ESS Bilbao made excellent progress and confirmed the plan to deliver large components, such as the monolith vessel, before the end of 2019. On site, we received sophisticated HVAC equipment from our Czech partner, and we began first installations on site with six storage pits and multiple liners in active cells.

3 The ESS temporary control room came online in 2018, from which we can run the ion source and cryoplants. The Oxygen Deficiency Hazard System was installed and operational, and we also held a full-scale demonstration of our Personal Safety System for authorities.

Staying on target

At the beginning of 2018, the ESS target division announced the completion of the three Butterfly V2 cold moderators. Manufacturing of these unique parts was finished in December by in-kind partner Forschungszentrum Jülich (FZJ).

The moderators are based on a design which came as a result of optimisations carried out at ESS, which were then verified through further testing at J-PARC (Japan Proton Accelerator Research Complex). The idea behind this new design is to increase neutron flux at ESS by a factor of up to 2.5 when compared to the original design from 2012. This is a major step up, and will result in a dramatic improvement in the scientific capability of ESS.

All three moderators were leak tested, and declared ready for assembly in the Moderator & Reflector Plug.

A stately inauguration

Italy and Sweden worked very closely in the planning, construction and delivery of the accelerator's Ion Source and Low-Energy Beam Transport Line (LEBT). After these technical components were successfully delivered and assembled, it was important to properly mark the occasion. In November, high level delegations from Sweden and Italy came to ESS to inaugurate the new equipment, and to celebrate the successful collaboration between the two nations.

King Carl XVI Gustaf of Sweden and President Sergio Mattarella of Italy inaugurated the equipment together, and they were joined on the visit by Queen Silvia of Sweden, Mrs. Laura Mattarella, the president's daughter and First Lady of Italy, Swedish Minister of Higher Education and Research, Helene Hellmark Knutsson, and Ricardo Antonio Merlo, Secretary of State of the Italian Ministry of Foreign Affairs and International Cooperation.

Italy is one of the 13 founding members of ESS, and they are playing a major role in developing the state-of-the-art equipment central to the future of ESS. This inauguration marked a major milestone in the in-kind contributions to come.

"The relations between Italy and Sweden are of great collaboration," said President Mattarella. "I am pleased that this visit is oriented to retrace many aspects of the advanced technological frontier that Sweden represents. I believe that the collaboration between our countries will develop further in the field of technological advancement and in the application to the business sector of new scientific advancements."

The equipment itself was developed and engineered by the Italian National Institute of Nuclear Physics (INFN), and makes up EUR 4.5 million of Italy's EUR 70 million total of in-kind contributions to ESS.

Validation for innovation

The ESS Multi-Blade detector was the first of its kind, and has been developed according to our world-leading reflectometers ESTIA and FREIA. During 2018, a review article was published in *The proceedings of the Royal Society A* which validated this Boron-10-based device, meaning it was officially ready for use.

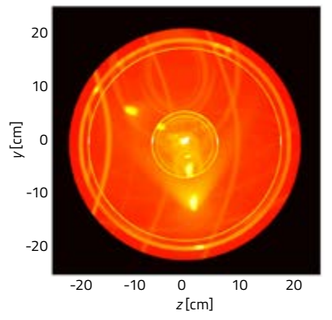
The Multi-Blade prototype was installed on the CRISP reflectometer at ISIS, and the collaboration between ESS and ISIS was essential to the success of this prototype. Several other institutions have been involved over a number of years as well, and all shared the same ultimate goal – world-leading detectors for ESS. This Multi-Blade detector will serve ESTIA and FREIA, two of the initial 15 instruments at ESS.

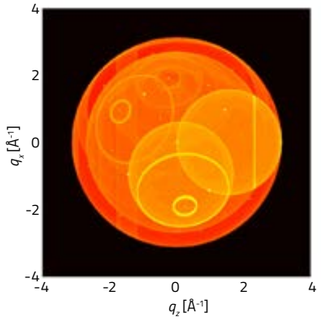
Advances in detection equipment can only be a benefit to the wider scientific community, as better detectors can offer higher quality neutron reflectometry. This means that fields operating in this discipline, like research into next-generation energy or structural biology, could improve their research and results.

This now-validated detector concept can originally be traced back to Francesco Piscitelli, a detector scientist at ESS. His work at ILL and the University of Perugia paved the way, after which ESS and Linköping University also made critical contributions to engineer the proof-of-concept prototype. The project was funded through the European Union's BrightnESS grant, and marks the beginning of a new age of neutron detection.

Simulations drive reality

When ESS opens fully, neutron research will effectively be leaping into the unknown. As the world's brightest, most powerful neutron source comes into operation, there's no way to be certain what discoveries lay beyond the horizon. However, as with any scientific endeavour, accurate hypotheses and prediction models are vital, which is why Mads Bertelsen has been working in coordination with MAX4ESSFUN Interreg to develop the neutron instrument simulation programme.





The programme is called McStas, and is a critical tool both at the ESS facility in Lund, where it can help with instrument development, and at the ESS Data Management and Software Centre in Copenhagen, where it can assist with data modelling work. This will all be a great benefit, as it will help researchers understand the capabilities of ESS, harness the unprecedented power of the beam, and ultimately make better use of the instruments available.

"The project I will carry out via MAX4ESSFUN is a validation of a simulation," said Bertelsen. "The Interreg money will be used so I can go and test a simulation against reality – measure all the small details – to make sure that the correlation between my software and how it is in reality is as good as possible."

The goal of the simulation software is to provide better background correction during simulation runs of neutron scattering experiments. This improved accuracy will mean that researchers can develop more ambitious experiments, and ultimately gain better results from their beam time. The fact that the beam is orders of magnitude more powerful than any before meant that there was a real need to develop and advance modelling tools, and McStas is designed to meet that need.

“Good science is always rewarded”

SANTO GAMMINO
DIRECTOR OF RESEARCH AT INFN-LNS

The ongoing project at ESS is pioneering in so many ways. It’s not only breaking new ground in the equipment and capability of the facility, but also how the project itself works. Most of the equipment is as a result of In-Kind Contribution (IKC) Agreements, which represent a total of EUR 550 million of the total budget. These collaborations are with over 100 institutions all around the world, in what has become a landmark in cross-border cooperation within the scientific community.

One of the most important in-kind contributions is the Ion Source, which came all the way from the Italian National Institute for Nuclear Physics’ National Laboratory of the South (INFN-LNS). This week-long journey from Sicily to Lund was completed towards the end of 2017, and was a true landmark in the construction and progress of ESS.

“All the way back in 2009, we had a meeting to discuss what we could do for the team in Lund,” says Santo Gammino, Director of Research at INFN-LNS. “The main point of the discussion was to see if we could offer something to do with accelerators, and it was decided that because of our experience and expertise, we would provide the Ion Source.”

The Ion Source is the origin point of the ESS Accelerator’s proton beam, so is a central part of the entire facility. This is the equipment that results in the beam being accelerated over 500 metres at a target, which produces the necessary neutrons for the research.

Cross-border collaboration
The success of ESS will continue to rely on in-kind contributions, and although the agreements and processes are planned to cover every detail, it’s still a big undertaking for both ESS and the collaborating institutions.

“I’ve had many experiences with European collaboration,” says Mr. Gammino. “But none like this one. This is the first project where there are so many different contributors offering different machines, and for our part it was a challenge to work on this totally new type of operation. I learnt a lot though, and I feel really proud to be a part of it.”

The contribution from INFN included not only building the Ion Source, but also planning how to transport it, and how to make sure it was assembled correctly at the other end. In addition to this, ESS is a greenfield project, meaning there was no existing template to work within, it was all new.

“As a team, we have had experience with greenfield projects before,” Mr. Gammino continues, “so we knew it was a different kind of effort. Every single aspect of the project can impact the design of the equipment. So things like positioning impact the design. It’s different from making new machines for existing laboratories. Thankfully, by 2014 we were able to confirm which batches of work would be done by whom, to ensure we’d all have the most efficient process. It was all about making sure this was a shared responsibility.

“We also saw that upon delivery, the team in Lund were prepared to do exactly as required to get the Ion Source installed correctly. It was great to see that, and a real positive for the team here as it shows that we weren’t just providing equipment, but efficiently transferring valuable knowledge.”

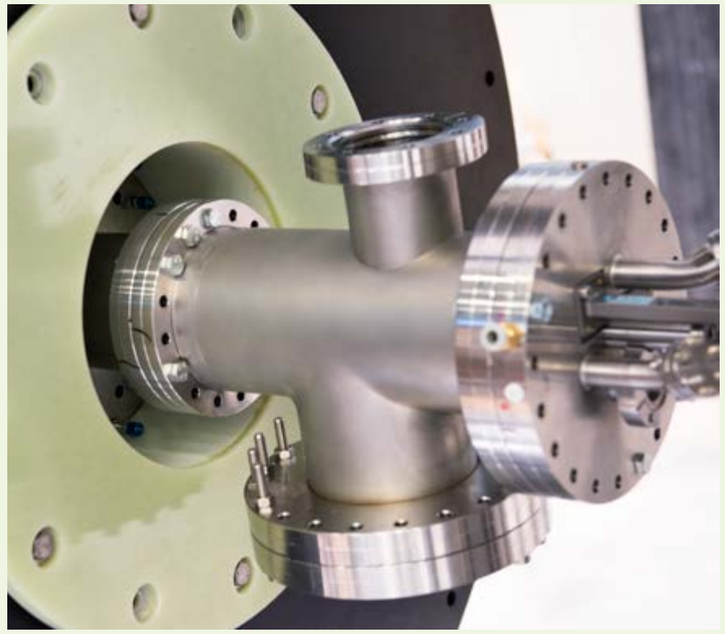
INFN is now preparing some other in-kind contributions to help with the construction of the accelerator, including the Drift Tube Linac and the Medium Beta Superconducting Cavities which are both under construction, at Laboratori Nazionali di Legnaro and at the Milano unit respectively. Additionally, INFN is serving the Italian Ministry of Education, Universities and Research as Representing Entity for the activities involved with ESS, cooperating with Elettra Sincrotrone Trieste in delivering in-kind contributions to the accelerator, and with CNR (Consiglio Nazionale delle Ricerche), in delivering in-kind contributions to the Neutron Instrumentation.

Looking forward
The Ion Source is an essential part of the world’s brightest spallation source, and the exciting thing is just how difficult it is to predict what the research and results will look like in the future. However, this technology could be also be applied in completely different industries in the future.

“I think this technology will eventually be used in other fields, but many still rely on old-fashioned beams as they can’t yet see the benefits of changing versus the costs,” says Mr. Gammino. “But the story won’t end with ESS, and I think we will continue to find new ways to innovate. There are so many possible applications. What our team has done will be rewarded in the future by other fields though. Good science is always rewarded.”

Aside from the scientific achievement, and the potential for future success, another big positive out of this part of the project has been the collaboration, and that can serve as a model for the future.

“I’m not a member of ESS management,” concludes Mr. Gammino. “But people look at me as a real member. I haven’t been seen as a partner providing some knowledge, but as a full member of the team. I’m really happy that my experience could help with this project.”



"Our user facility will be permanently adapting to the science community. There will be no routine operations. One thing is sure: we will never be bored here."

AGNETA NESTENBORG
DIRECTOR FOR PROJECT SUPPORT AND ADMINISTRATION, ESS

Empowering science through service

In scientific experiments, we know that environmental factors affect samples and results. We also know that the scientists conducting the experiments perform better in positive, stimulating environments. In fact, Harvard-based researcher Shawn Achor has found that our brains in a positive state are 31% more productive than when negative, neutral or stressed. The right environment matters, and we aim to give scientists every advantage.

"We want ESS to be more than a great place to be. It should be THE place to be," says Agneta Nestenborg, Director for Project Support and Administration for ESS. "We want people to come not only for the science, but because they're also taken care of – before, during, after and in between scheduled instrument time. We believe all things matter, from the ease of accessing information to fresh coffee and a stroll in a park. These things set people up for the best possible work and outcome."

Ralf Trant, Associate Director for Environment, Safety, Health & Quality at ESS, agrees: "When scientists come here, we don't want them to feel hindered; we want them to feel empowered. For us, safe means no one at risk for preventable injuries and missed beam time. It means an environment free from stress, enabling people to be their most creative and productive selves. It means thinking beyond today for long-term sustainability. There may be times we'll need to step in if a method is too risky, but then we won't say no, we'll say 'let's find a way.'"

People are our greatest asset
As a greenfield project, ESS is being built from the ground up not only physically, but organisationally and philosophically as well.

"ESS is different," Nestenborg points out. "We don't have a legacy with existing processes or a culture of 'we've always done it this way.' We are able to look at serving science from a fresh perspective, for a new generation."

"Our diversity is also key," adds Trant. "It's important that ESS staff is diverse because our users will be diverse. Otherwise we'd lack understanding."

In both Administration and Safety, our mission is to create a "highway to science" as Nestenborg calls it. These two areas have a pioneering role within the ESS organisation in that they're already in full operation. Now as ESS gears up for science operations, these areas pave the way to make sure all the other parts of the organisation can do their jobs.

2018: Merging construction, installation and operations
2018 was unique in the timeline for ESS because it was the moment construction, installation and initial operations all merged to take place in parallel – each with very different needs from an administrative and safety standpoint.

"You don't typically have all three going on at once," explains Trant. "Usually, you try to keep a construction site just construction, but we have radiation areas and cryogenic systems running, along with new installations and commissioning. It's a challenging time, and our team is handling it well."

Huge efforts were also made in administration to coordinate everything from the logistics of in-kind deliveries from all over Europe to setting up new budgeting, ERP and e-tendering tools. "Compared to other years," shares Nestenborg, "we developed more support services to prepare for operations while simultaneously providing support for ongoing project needs."

Change is the new normal
In this fast, challenging environment where change is the norm, we believe working actively with, instead of hesitating about, shifts in internal culture is a key to long-term success at ESS.

A Career and Job-level Management project, key safety and health trainings, manager's meetings, and more, took place in 2018 as we work to support holistic success in both career development and personal health and safety.

As Nestenborg points out, "Our user facility will be permanently adapting to the science community. There will be no routine operations. One thing is sure: we will never be bored here."

"When scientists come here, we don't want them to feel hindered; we want them to feel empowered. We want to provide an environment free from stress, enabling people to be their most creative and productive selves."

RALF TRANT
ASSOCIATE DIRECTOR FOR ENVIRONMENT, SAFETY, HEALTH & QUALITY, ESS

Top highlights of 2018

Project Support and Administration

1 In 2018, not only did we break ground for our Campus, but we also managed the move of nearly 500 employees to temporary offices on site. Although temporary space has its challenges, it's exciting to be here "where the music is playing."

2 To prepare for transition into initial operations for ESS, we set up a new administrative infrastructure (e.g. budget codes and related processes). In particular, we prepared to have two parallel funding streams ready as of January 2019: Construction phase funding + Operations funding.

3 Our team focused purposefully on improving communication during 2018, in particular internally with a follow-up employee survey and our ESS Inside channel. Externally, our website surpassed over 800,000 views, and we released an employer branding film to positive response.

Environment, Safety, Health and Quality

1 Major progress in licensing happened in 2018. Most importantly, we received the permit to run the ion source and started initial operations. This follows major safety requirements, and we established a safety readiness programme for this first step.

2 We began coordinating local support for operations already in 2018. For example, we conducted joint training with the local fire brigade for major accident scenarios. Lund University also performed a radiological Point Zero measurement inside and "outside the fence" as an impartial, external, accredited source.

3 Our global Environment, Safety, Health and Quality team expanded during 2018 with major recruitments, including the group leaders for Radiation Protection and Occupational Health & Safety, as well a Chief Information Security Officer who began establishing the first plan for information security. In this context, GDPR was one of the major things we had to adapt to quickly.

Sustainable science

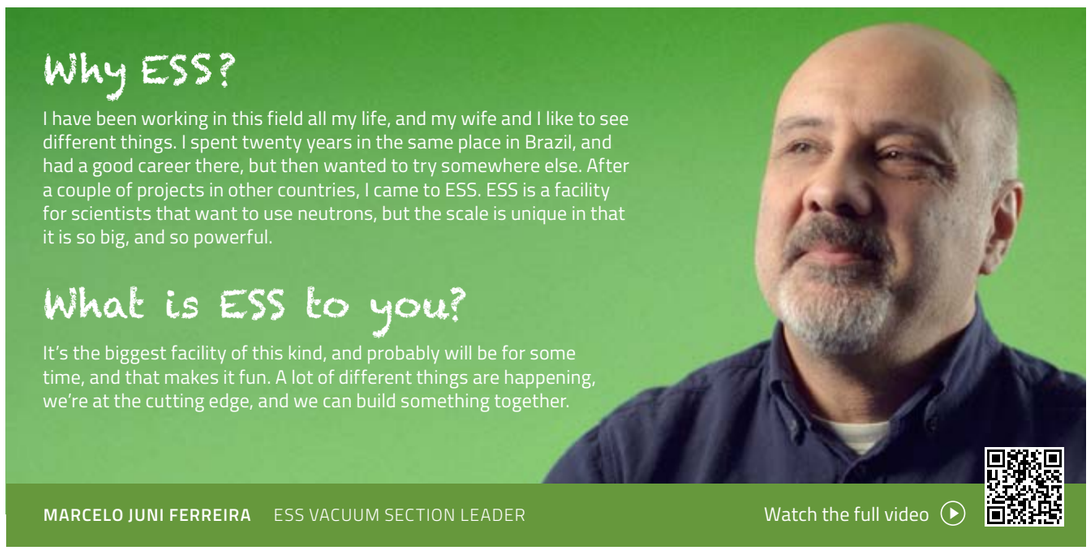
Efficient heating and cooling are essential to the ESS research facility, as is being ambitious when it comes to operating in a more sustainable way. During 2018, ESS concluded an agreement with the international utilities company E.ON, which will see them supply the facility with cooling, whilst also being able to offer an innovative, environmentally friendly solution to reusing any surplus heat.

E.ON will supply the cooling, purified water and the compressed air, all of which is essential in the daily operation of ESS. When it comes to heating, the operation of the facility will naturally generate a lot of heat due to the equipment used. Instead of this heat going to waste, E.ON will recycle it and make it available to heat homes and other workplaces in the area.

"One of the reasons ESS was placed in Lund was our ambitious sustainability goals," said John Womersley, ESS Director General. "We aim, to set a new standard for big science facilities, and recycling our waste heat is key to that. E.ON will be an excellent partner for ESS as we seek to become one of the most environmentally sustainable research centres in the world."

Reliability and consistency in suppliers is key, especially when it comes to energy sources, as any issues with cooling can cause disruptions in both operations and experiments. With this in mind, ESS needed to secure long-term stability, so the initial agreement with E.ON is signed for a period of 40 years.

The solution itself is innovative, with any surplus heat being recovered by a system of heat exchangers. From there, the heat will be used to make hot water, which will in turn be fed back into the district heating network. It's a win-win solution, as it is not only environmentally responsible, but also reduces operational costs.



Support from Spain

Spain were the first partner country to sign a letter of intent to be a part of the construction of ESS all the way back in 2014, and during 2018 they became a full member of the European Spallation Source ERIC (ESS). The first collaboration agreement between Spain and Sweden was signed already in 2009, and for Spain to become a full founding member in 2018 shows the importance and stability of this partnership.

Becoming a full founding member means Spain can now participate in the governance of the project, as well as contributing directly on the financial side. As a result, they will contribute around 3% of the total cost of construction, which will help a great deal in the building of this facility.

"This is an important milestone for ESS, and we are pleased that Spain, always manifesting strong support and commitment to this European research infrastructure project, has become a full member" said Lars Börjesson, Chair of the ESS Council. "Spain was already from the start a fundamental contributor to the ESS construction and is since long an important country in European science using the neutron scattering techniques."

In addition to the financial contributions to the overall construction, Spain has also provided ESS with a number of key components in the form of in-kind contributions, including the Medium Energy Beam Transport, Target systems, and the instrument named MIRACLES. These contributions are managed by the Spanish Government and Basque Regional Government-owned ESS Bilbao, as well as being designed and manufactured by them.

"It is an honour for me that Spain has become a Founding Member of the European Spallation Source ERIC," said Mario Pérez, Executive Director of ESS Bilbao. "Since the very beginning, Spain has always granted a strong support to the European project. And I am convinced that from now on, and through ESS Bilbao, Spain will execute successfully, and under the highest standards of quality, all the In-Kind contributions committed to ESS."

Bright on time

When embarking on a project as significant as ESS, it's essential to regularly review the processes in place, and check that everything is going as anticipated. The plan for this project has been built up from tens of thousands of different, but interlinked, work packages, and this year it was time to take stock and review the project, as well as the deadlines.

One reason for the review was to address the fact that there were delays in the construction and completion of the target building, which had the knock-on effect of delaying the start of neutron production.

As all work packages affect each other, this delay meant a new schedule was necessary. The ESS Council met to discuss the results of a full reassessment which was undertaken by ESS staff, where the goal was to make the necessary changes whilst keeping the same overall deadline. After the thorough review of the thousands of work packages, the ESS Council approved a new schedule which would still meet the key milestone of the first science being underway in 2023. The new plan has also been endorsed by the ESS member countries and an external panel, and while updates have been made, everything remains on track. The external group, chaired by Mark Reichanadter of the SLAC National Accelerator Laboratory in the US, was pleased with what they saw in the new plan.

"The review committee was duly impressed by ESS's excellent progress toward delivering the most powerful neutron source facility in the world," said Reichanadter. "The revised schedule is well thought out and based on sound methodology, the results of which the committee endorses."

Campus construction begins

The ESS Campus buildings are set to be an important part of the facility, and the groundbreaking ceremony was held in December 2018, with construction now fully underway.

Campus is where there will be work spaces, laboratories, and workshops for staff and visiting scientists. The ambition is that the campus will be where scientists from all over the world gather, together with ESS staff, and plan and prepare for research and experiments that will advance their respective feels, and enhance our understanding of the world.

The start of campus construction is important, and a further sign that the building phase of this project is well over halfway complete now. At the groundbreaking ceremony, the milestone was marked with gold-coloured spades and celebratory speeches.

Skanska will be building the campus, and have worked alongside ESS to come up with a detailed design for the building work with sustainability as a major focus. The Campus complex will cover 19,000 m² of total floor space, and the largest of the buildings will be the main meeting point for ESS. Within, there will be office space, a canteen and an auditorium, with the smaller buildings housing the laboratories and workshops. All of the architectural design was done by Henning Larsen Architects, COBE and SLA, who all worked closely with ESS to come up with something modern, innovative and importantly, fit for purpose.

"The start of the construction of the ESS Campus is an important milestone on the road to completion of this unique research infrastructure, that will help to address some of the big societal challenges of our time," said Agneta Nestenborg, Acting Director General ESS. "The ESS Campus will be the most public part of the site, and we have focused on optimising the full experience for staff and visitors."

The Campus is set to be complete by the end of 2020, with occupancy expected in the beginning of 2021. That's when the ESS staff will be moving from the current, temporary offices and into these modern, purpose-built facilities.

Why ESS?

As a kid I loved numbers, physics problems, number puzzles, especially related to space rockets. So when I finished high school, I decided to become a physicist. Then I went to the US to pursue my Masters and PhD, and there I was a user of a small accelerator lab, so that's when I got interested in accelerator physics and got involved in the community. Through that community, I met my husband who lived in Sweden at that time, and that's how I ended up here, and I've been at ESS for eight years!

What is ESS to you?

ESS for me is a unique opportunity to be a part of something large and something meaningful. It's probably a once in a lifetime chance for me to be part of such a complex facility, that's also going to make an impact in the world. We're going to learn so many things about different materials, and we're going to use that knowledge to be able to develop technologically and scientifically, and change the world. Every day is different and I'm really happy to be here.

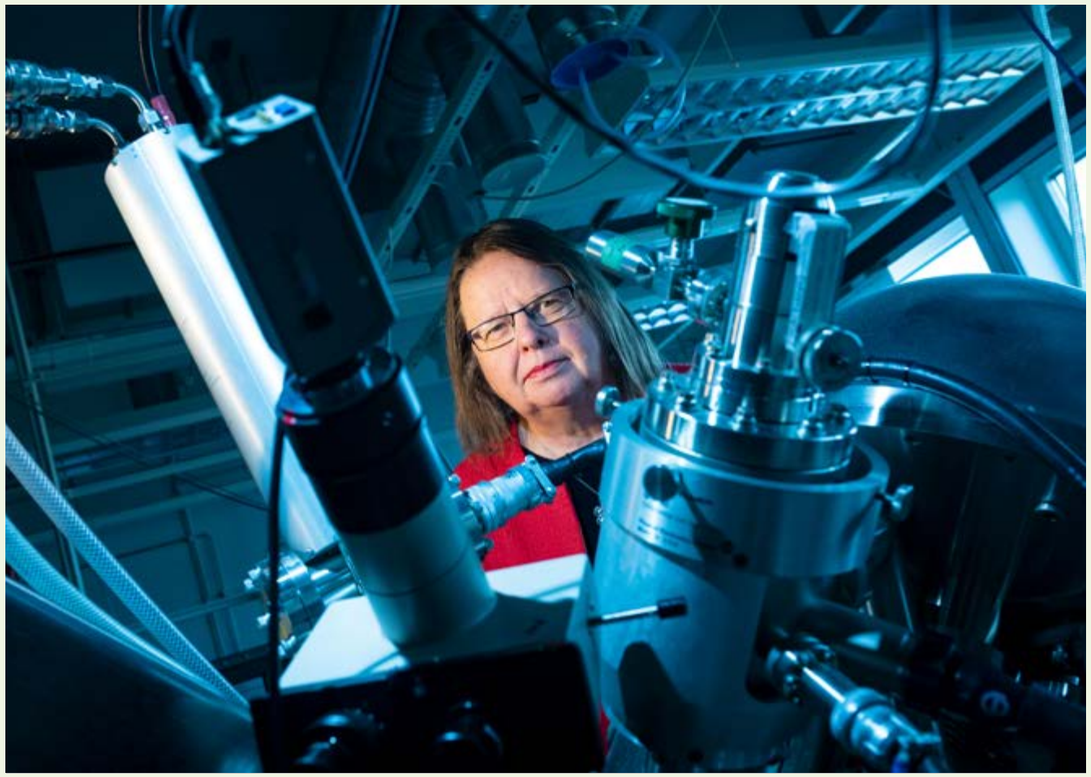
LALI TCHELIDZE

OPERATIONS SECTION LEADER
– ORGANISING THE WORKING CONTROL ROOM

Watch the full video

“Neutron research is helping us develop better batteries, which is so important.”

KRISTINA EDSTRÖM
PROFESSOR OF INORGANIC CHEMISTRY AT UPPSALA UNIVERSITY
AND LEADER AT ÅNGSTRÖMS ADVANCED BATTERY CENTRE



Almost every industry can benefit from better neutron research, whether directly or indirectly. As it can help us to understand more about how things work, and how atoms and molecules interact with each other, a perfect application for neutron scattering is research into battery materials. Batteries are already an important part of our everyday lives, and they’re set to become even more vital in the years to come.

As a society, we’re using batteries more and more, and the demands are always increasing. We want our phones to last longer, our laptops to charge quicker, and our electric cars to go further. The only way to meet these demands is to develop new, more efficient, and more powerful batteries, and this can only be achieved through carrying out the right research.

“My group is trying to achieve better batteries,” said Kristina Edström, professor of inorganic chemistry at Uppsala University and leader of the Nordics’ largest battery group at Ångströms Advanced Battery Centre. “We want to understand the processes within battery cells to really gain deeper knowledge about the complex relationships between the negative and positive electrodes, and how the electrolytes affect the performance of the battery. Neutron research can help us with this.”

Although it’s easy to take batteries for granted, the science involved is extremely complex. Researchers need to look into how to synthesise new cathodes and anodes, and then see if they’re compatible with each other. They also need to look into complex metal oxides which are almost identical in atomic structure. Then there’s the need to work on extremely small atoms.

“My group is studying lithium, which is in great demand in batteries today,” continued Kristina. “It’s a very small atom, which makes it difficult to study with other techniques. Neutrons, however, are a brilliant way to study it. You can locate it in an atomic structure in a way that you cannot with other methods. Then you also have some batteries that become magnetic, where you also need neutrons to investigate effectively.”

To develop batteries which perform better, it’s not possible to rely on just one kind of research. That’s why Batteries 2030+, a large-scale and long-term European initiative coordinated by Kristina with the goal of carrying out experiments to discover new materials for batteries, and then to research them, has applied to a number of different research facilities in Europe.

“We’ve had a meeting with MAXIV in Lund, ILL in France and the reactor in Munich,” added Kristina. “We wanted to meet with ESS too, but at the time it was too early. ESS is really interesting for battery research though, as to do it well you need to use a portfolio of techniques. ESS can provide an entire portfolio at one location, with the various instruments that will be available. If you study one problem, you apply for time at one instrument, then you study new phenomena at a new beam line, and then together your results can paint a coherent picture.”

The neutron research into batteries can be carried out at other facilities, but ESS offers unique opportunities due to the fact that it’s home to the brightest beam in the world.

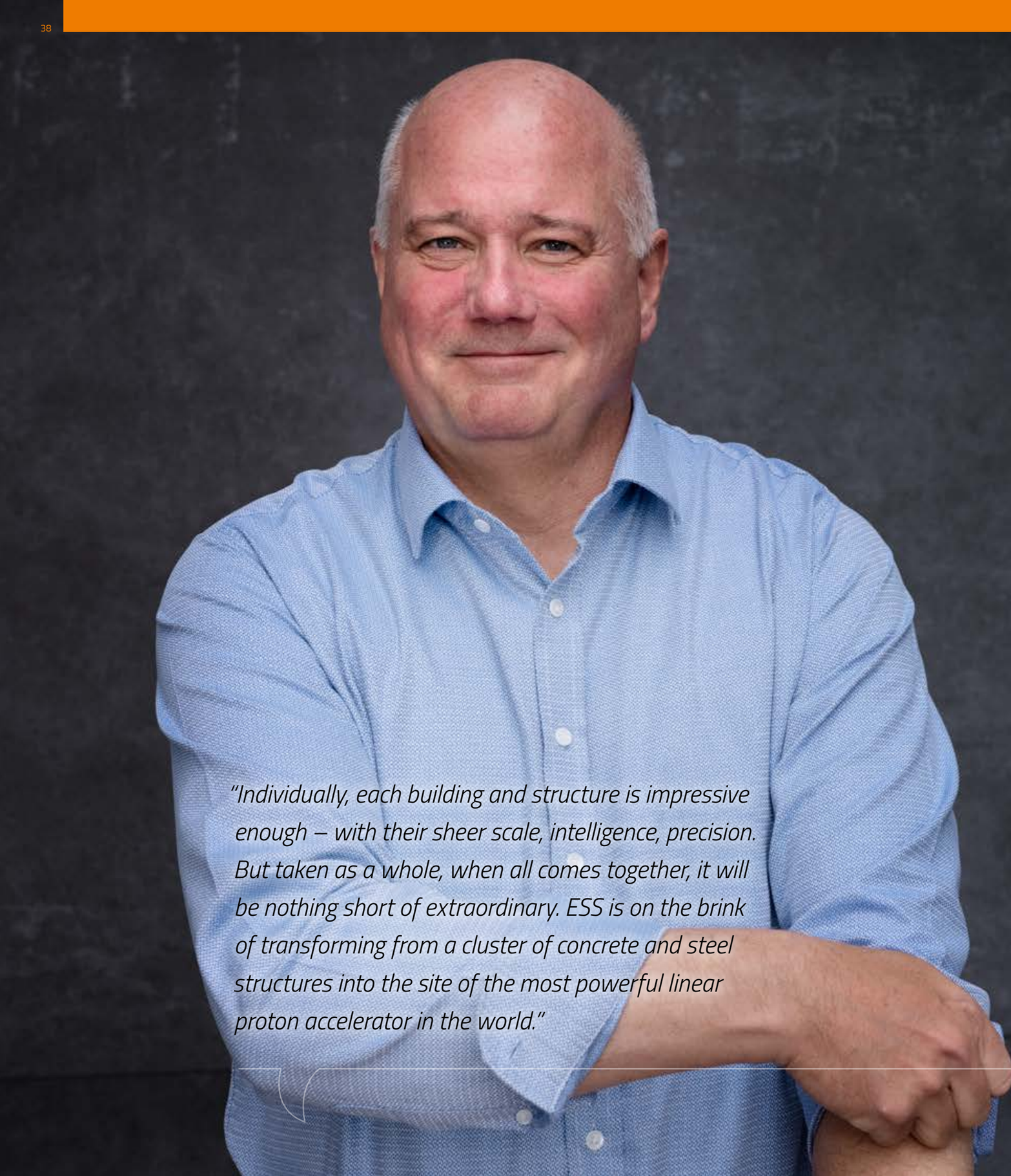
“At ESS, you will be able to get results from more realistic sample sizes,” Kristina confirmed. “In other facilities you need large samples to effectively study them. Here, you will be able to get valuable, tangible data from a smaller sample. You’ll also be able to more accurately follow what’s happening mechanically when things are moving within the material, as the charge moves back and forth. The possibilities are exciting!”

Lithium ion batteries are the most important at the moment, so there will be studies into how to make them perform better. However, there are newer types of battery which use chemicals more abundantly available, like sodium. The scientific community will also need to find out more about these, and how to strike the right balance between what we’re using and where.

“Sodium is not as powerful as lithium,” added Kristina. “But it’s much easier to obtain. Sodium is everywhere, and it’s become cheaper. The idea would be that these batteries can take certain segments of the market, and we save the more powerful lithium ion batteries for things like electric cars, which will be crucial to limiting our environmental impact in the future.”

ESS is arriving at the right time too, as neutron research is becoming more widespread in the battery community. There are only a limited amount of neutron scattering facilities around the world, so it’s likely that ESS will be in great demand from those looking to develop exciting new ways to power our lives.

“My dream battery is one that you could cycle for up to thirty years, that’s sustainable, powerful, safe and doesn’t cost much,” said Kristina. “But that’s impossible! Research is helping us develop better batteries though, which is so important. If we can, for example, bridge the gap between batteries and gasoline in terms of powering cars, that will be a huge benefit to society. I just hope that I’m still working when ESS is open, I have so many ideas for proposals!”



Conventional facilities beyond all convention

How do you build something today that will serve a future no one's seen yet? Something that must merge multiple needs – from present to future, from science to services, from working to living? That is the unconventional task our Conventional Facilities team has pieced together from day one – envisioning how all the individual elements will connect to create ESS.

The full power of ESS comes from more than the accelerator. It comes from building an entire experience – everything scientists will need to work at their best. With a greenfield site like ESS, we have the opportunity to take the lessons from existing facilities and apply them to a new generation of scientists who live and work in a more interconnected and informed world.

"I've travelled the world to see other science facilities", shares Kent Hedin, Head of Conventional Facilities for ESS, "and if you ask people, you'll often get the rational answer, 'don't put money on the buildings; invest as much as possible in the machines.' But scientists are human, too, and younger people want form and function. They know that rest, food, exercise, even entertainment and beauty are important – especially since you can't be at the instruments 24/7."

With a cross-functional approach to design, the Conventional Facilities division sees how all buildings connect. The designs take into account how everyone needs to work, both internally for our staff at ESS and for our users. Now with 68% of conventional facilities complete at the end of 2018, we can truly see it all coming together.

"Individually, each building and structure is impressive enough – with their sheer scale, intelligence, precision. But taken as a whole, when all comes together, it will be nothing short of extraordinary. ESS is on the brink of transforming from a cluster of concrete and steel structures into the site of the most powerful linear proton accelerator in the world."

KENT HEDIN
HEAD OF CONVENTIONAL FACILITIES, ESS

2018: Design peak
During the past year, Conventional Facilities came to a peak in design, during which the team began ramping down that work and moving more and more over to production. In fact, Conventional Facilities should be off the critical path already in 2019, and should be 100% complete by the end of 2021.

"After we re-baselined the whole project in the first half of 2018," shares Hedin, "we gained a clear and confident view of what we have left to do. We know exactly what we need to build and how, and we're confident we can make the schedule."

The last quarter of 2018 brought a slight slip in the production schedule, but that was made up in the second half with excellent progress. The continued progress in design delivery has made it possible to increase the workforce on site. A new design phase is being planned for spring, where a reduced and combined design team will focus on construction support going forward.

Designed today to give back tomorrow
Values, transparency, and community integration are also vital for transitioning our facilities to operations. Our infrastructure is bigger than ESS. Besides collaboration with other high-tech facilities – from Max IV next door to the ILL in France – part of our success comes from interaction with the local community. From universities to convenient bridge, tunnel, ferry and airport access, we have tremendous support around us.

With those benefits come big responsibility to support our communities and partners. For example, proactive design allows us to convert hot water and feed it into the district energy grid. More than 50% of the energy we use will go back to the community.

Making room for the future
Now as we near completion of Conventional Facilities, we look ahead to science even beyond 2023. Our Conventional Facilities division has worked closely with scientists, engineers and others to ensure possibilities increase naturally here. Space is already reserved within buildings to make room for new instruments that aren't even invented yet.

"Success for me would be that 10-15 years from now, all the buildings we have made are still fulfilling their purpose – even though we don't fully know what that purpose may be since people will be doing science here that isn't being done today," envisions Hedin.

Top 3 highlights of 2018

1 In early 2018, we handed over the Accelerator buildings, in time and on budget.

2 Later in the year, we handed over part of the landscape surrounding the building. Decorative and environmental elements such as these, along with outdoor infrastructure such as roads, walkways, meadows and ponds, are just as important as our buildings to create a highly positive, stimulating, functioning environment at ESS. Handing off these elements, in particular, begins to give a sense of visual completeness to Conventional Facilities.

3 On 3 December, we officially broke ground for our Campus, with representatives from ESS, ESS Council, Skanska and Skandrenting. ESS staff around the world could watch live too, as we streamed the ceremony.

Statutory Report

European Spallation Source ERIC
Org. no. 768200-0018

ESS Expenditures Reach Across Europe

The following shows the expenditures (cash basis) by ESS during 2018 for ESS founding member and observer countries and other countries. The data is based on invoices paid for the period January – December 2018. 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 2018 BY COUNTRY

	Thousand SEK	Thousand EUR
Australia	51	6
Austria	56	6
Belgium	702	78
Bosnia	104	12
Canada	594	66
China	487	54
Denmark	48,719	5,413
Estonia	46	5
Finland	2,332	259
France	9,033	1,004
Germany	115,158	12,795
Greece	723	80
Hong Kong	31	3
Hungary	798	89
India	13	1
Ireland	1,185	132
Israel	68	8
Italy	5,313	590
Japan	11,646	1,294
Netherlands	2,208	245
Norway	205	23
Poland	299	33
Romania	34	4
Russia	933	104
Slovenia	506	56
South Africa	31	3
South Korea	6	1
Spain	21,993	2,444
Sweden	1,315,500	146,167
Switzerland	10,102	1,122
United Kingdom	23,050	2,561
USA	6,645	738
TOTAL	**1,578,571**	**175,397**

Highlights 2018

Q1

The Ion Source and first part of the accelerator installed in the Accelerator tunnel.

Start of delivery of RF distribution system components to ESS, copper plating of DTL tanks and quality control at DESY of the first batch of Niobium for the high beta cavities.

Successful testing of the first tungsten cassette in the target wheel prototype, showing that the required narrow tolerances can be achieved.

14th IKON meeting held in LLB, France, gathering in-kind partners from NSS subprojects.

ESS initiated collaboration with PSI and ISIS to improve certain neutron scattering data analysis software.

The final parts of the accelerator buildings were handed over to ESS, on time and on budget.

28 new employees were recrutied during Q1.

Seven contract awards, each worth more than 200,000 EUR, completed.

Q2

Project 48% complete.

Project re-baselining, confirming first science in 2023.

The Ion Source installed.

The Ampegon modulator, which powers one of the klystrons, turned on in Test Stand 2.

The 12th instrument, SKADI, enters Phase 2 Detailed Engineering Design.

A mock-up of the sample area for instrument SKADI built in Jülich, for evaluation of the ergonomics of performing experiments.

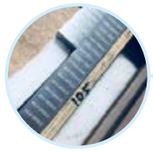
Pump station handed over to ESS.

ESS was granted a permit for trial operation of the Ion Source.

Q3

Project 50% complete.

Beam permit for The Ion Source and LEBT successfully signed by SSM after passing through the first Safety Readiness Review (SRR-1).



Target tungsten bricks manufactured and delivered to ESS Bilbao.

Sprinkler building and Pump station handed over to ESS.

Electrical infrastructure on-site handed over to ESS.

The 13th instrument received approval to enter Phase 2, Detailed Engineering design.

EU funding awarded to a collaboration project between ESS, ILL, EU-Xfel, Ceric ERIC and ELI for cloud access to data and analysis services.

First half of 2018 concluded with 68 recruitments.

ESS Safety Readiness Review implemented, with experts from ESS and other research facilities worldwide, verified the hardware, personnel and procedures associated with commissioning and operation of a system. Representatives of the Swedish Radiation Safety Authority (SSM) took part as observers.

Q4

The project reached 55% completion.

The Ion Source and Low Energy Beam Transport, the first major technical components commissioned at ESS, were officially commissioned.

The Target Moderator Cryoplant cold box delivered and installed.

First joint users meeting ILL-ESS in Grenoble gathered 500 participants with a wide variety of scientific interests.

Annual review of the project concluded with the statement : *"impressive progress is being made towards delivering the world's most capable neutron science facility".*

Delivery on site of ten 704 MHz klystrons which will power ten of the medium beta superconducting cavities in the linac.

First three series of double spoke superconducting RF cavities tested at IPN Orsay exceeding requirements.

Parts of Landscape, including roads, meadows & planting, ponds, water & sewage, handed over to ESS.

Official groundbreaking event for ESS Campus.

In 2018, ESS finalised 116 recruitments.

The Ion Source inaugurated by the King of Sweden and Italian President.

83 recruitments finalised during first three quarters.

At the end of the year ESS had 467 employees.

This timeline reflects key events according to the current baseline.

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.

Lars Börjesson (Chair)
Chalmers University of Technology
SWEDEN

Beatrix Vierkorn-Rudolph (Vice Chair)
German Federal Ministry of Education & Research (ret.)
GERMANY

Lukas Levak
Ministry of Education, Youth and Sport – MEYS
CZECH REPUBLIC

Petr Lukáš
Nuclear Physics Institute
CZECH REPUBLIC

Bo Smith
Danish Ministry of Higher Education & Science
DENMARK

Niels Christian Nielsen
Aarhus University
DENMARK

Toivo Räim
Ministry of Education & Research
ESTONIA

Priit Tamm
Estonian Research Council
ESTONIA

Emmanuelle Lacaze
French National Centre for Scientific Research – CNRS
FRANCE

Pascal Debu
French Alternative Energies and Atomic Energy Commission – CEA
FRANCE

Oda Keppler
Federal Ministry of Education & Research
GERMANY

Sebastian Schmidt
Research Centre Jülich GmbH
GERMANY

László Rosta
MTA Wigner Research Centre for Physics
HUNGARY

Balázs Kápli
National Research, Development and Innovation Office
HUNGARY

Eugenio Nappi
National Institute of Nuclear Physics – INFN
ITALY

Salvatore La Rosa
Ministry of Education, Universities and Research
ITALY

Erik van Aert
Netherlands Organisation for Scientific Research
THE NETHERLANDS

H.T. (Bert) Wolterbeek
Delft University of Technology
THE NETHERLANDS

Odd Ivar Eriksen
Research Council of Norway
NORWAY

Marek Jeżabek
The Henryk Niewodniczanski Institute of Nuclear Physics
POLAND

Mateusz Gaczyński
Ministry of Science & Higher Education
POLAND

Inmaculada Figueroa Rojas
Ministry of Science, Innovation and Universities
SPAIN

Adolfo Morais
Basque Ministry of Universities & Research
SPAIN

David Edvardsson
Ministry of Education & Research
SWEDEN

Sven Stafström
The Swedish Research Council
SWEDEN

Martin Kern
State Secretariat for Education, Research and Innovation – SERI
SWITZERLAND

Christian Rüegg
Paul Scherrer Institute
SWITZERLAND

Mark Thomson
UK Research and Innovation
UNITED KINGDOM

Claire Durkin
UK Government Department for Business, Energy & Industrial Strategy
UNITED KINGDOM

EXECUTIVE MANAGEMENT TEAM (EMT)

Director General	**John Womersley**
Director for Project Support & Administration	**Agneta Nestenborg**
Director for Science	**Andreas Schreyer**
Technical Director	**Roland Garoby**
Associate Director for Environment, Safety & Health, and Quality	**Ralf Trant**
Associate Director for Strategy	**Sharon Cosgrove**
Head of Relations with Host States	**Pia Kinhult**
Head of Conventional Facilities Division	**Kent Hedin**
Project Manager	**John Haines**
Head of Communications	**Martin Sjöstrand**
Senior Executive Assistant	**Karin Hélène**

SCIENTIFIC ADVISORY COMMITTEE (SAC)

Michael Preuss (Chair)	*Manchester University*
Sine Larsen (Vice Chair)	*University of Copenhagen*
Monika Budayova-Spano	*Université Grenoble Alpes*
Juan Colmenero De León	*Universidad del País Vasco*
Sabrina Disch	*University of Köln*
Richard Dronskowski	*RWTH Aachen University*
Bela Farago	*University of Grenoble*
Giovanna Fragneto	*Institut Laue-Langevin*
Thomas Hellweg	*Bielefeld University*
Steve Hull	*ISIS Neutron and Muon Source*
Bella Lake	*Helmholtz Zentrum Berlin*
Kell Mortensen	*Niels Bohr Institute*
Martin Månsson	*KTH Royal Institute of Technology*
Marie Plazanet	*Université Grenoble-Alpes / CNRS*
Bill Stirling	*Former Director of ILL and ESRF*
Fred E. Wietfeldt	*Tulane University*
Regine Willumeit-Römer	*Helmholtz-Zentrum Geesthacht / University of Kiel*

ADMINISTRATIVE & FINANCE COMMITTEE (AFC)

United Kingdom	**Neil Pratt (Chair)**
France	**Stephanie Dupuis (Vice Chair)**
Czech Republic	**Petr Ventluka**
Czech Republic	**Naděžda Witzanyová**
Denmark	**Morten Scharff**
Denmark	**Victoria Fuglsang-Damgaard**
Estonia	**Priit Tamm**
France	**Claire Lechevalier**
Germany	**Andreas Volz**
Germany	**Ingo Pfeil**
Hungary	**Balázs Kápli**
Italy	**Antonella Tajani**
Italy	**Ileana Gimmillaro**
Norway	**Odd Ivar Eriksen**
Poland	**Michal Rybinski**
Poland	**Michal Wojtowicz**
Spain	**Guadalupe Córdoba Lasuncion**
Spain	**Javier Losada**
Sweden	**Johan Holmberg**
Switzerland	**Patrice Soom**
Switzerland	**Xavier Reymond**
United Kingdom	**Philippa Kingston**
United Kingdom	**Laure Sewell**

TECHNICAL ADVISORY COMMITTEE (TAC)

Alberto Facco *(Chair)*	*INFN Legnaro*
Frank Gerigk *(Co-Chair, Accelerator)*	*CERN*
Mark Heron *(Co-Chair, Controls)*	*Diamond Light Source*
Phillip Ferguson *(Co-Chair, Target)*	*Spallation Neutron Source*
Shane Koscielniak	*TRIUMF*
Maud Baylac	*CNRS*
Cyrille Berthe	*GANIL*
Tim Broome	*ISIS Neutron and Muon Source (ret.)*
Michael Butzek	*Forschungszentrum Jülich*
Francisco Martin Fuertes	*CIEMAT*
Masatoshi Futakawa	*Japan Atomic Energy Agency*
Roland Mueller	*Helmholtz-Zentrum Berlin*
Jurgen Neuhaus	*Technical University of Munich*
Bernd Petersen	*DESY*
Michael A. Plum	*Spallation Neutron Source*
Igor Syratchev	*CERN*
Szabina Török	*Hungarian Academy of Sciences Centre for Energy Research*
Hans Weise	*DESY*
Jörg Welte	*Paul Scherrer Institute*
Karen White	*Spallation Neutron Source*

IN-KIND REVIEW COMMITTEE (IKRC)

Norway	**Bjørn Christian Hauback (Chair)**
Hungary	**Daniel Csanády (Vice Chair)**
Belgium	**Hamid Aït Abderrahim**
Czech Republic	**Petr Šittner**
Denmark	**Søren Schmidt**
Estonia	**Rasmus Palm**
France	**Jean-Luc Biarrotte**
Germany	**Ulrich Breuer**
Italy	**Paolo Michelato**
The Netherlands	**Guy Luijckx**
Norway	**Erik Wahlström**
Poland	**Adam Maj**
Spain	**Pedro González**
Sweden	**Björgvin Hjörvarsson**
Switzerland	**Peter Allenspach**
United Kingdom	**Robert McGreevy**

COMMITTEE ON EMPLOYMENT CONDITIONS (CEC)

Chair	**Lars Börjesson**
Member	**Naděžda Witzanyová**
Member	**Sebastian Schmidt**
Host State Denmark	**Bo Smith**
Host State Sweden	**Katarina Bjelke**

ENVIRONMENT, SAFETY & HEALTH ADVISORY COMMITTEE (ESHAC)

Paul Berkvens (Chair)	*European Synchrotron Radiation Facility*
John Anderson	*FermiLab*
Enrico Cennini	*CERN*
Doris Forkel-Wirth	*CERN*
Sam Jackson	*United Kingdom Atomic Energy Authority*
Frank Kornegay	*Spallation Neutron Source (ret.)*
Katarina Norén	*MAX IV Laboratory*
Stefan Roesler	*CERN*
Steven Wakefield	*ISIS Neutron and Muon Source*

CHAIR'S COMMITTEE (CC)

Chair	**Lars Börjesson**
Member	**Beatrix Vierkorn-Rudolph**
Member	**Marek Jezabek**
Member	**Andrew Taylor**
Member	**Bo Smith**
Member	**David Edvardsson**
Ex-officio	**John Womersley**
Ex-officio	**Florian Weissbach**

Statutory Administration Report

The Director General of European Spallation Source ERIC (Organisation Number 768200-0018), with its registered office in Lund, hereby submits the Annual Report for the financial year 1 January to 31 December 2018.

General information on the company

The European Spallation Source (hereinafter referred to as "ESS") is an ERIC, a legal form of organisation which the EU has developed to facilitate the construction and operation of major European research facilities. Through the establishment of European Spallation Source ERIC, ESS has a legal status in all member and observer countries, enabling them to participate in decision-making and directly contribute to the funding.
See also Note 2.

ESS will be the world's next-generation neutron source, and will be the most powerful spallation neutron source in the world when it is completed. The facility will be used, among other things, for research on different materials, in energy, health and environment, and will be of great importance in the long-term with regard to competitiveness for European research and industry. Construction is ongoing in Lund and is scheduled to be completed in 2025; the user programme for researchers is scheduled to begin in 2023, with the facility in full operation by 2026. The project is one of the largest and most high-profile research infrastructure projects in Europe, and is prioritised by the European Strategy Forum for Research Infrastructures (ESFRI).

ESS comprises activities at the facility under construction in Lund, Sweden, and the Data Management and Software Centre (DMSC), which is based in Copenhagen, Denmark. Personnel include employees representing 50 different nationalities.

Collaboration is ongoing 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 operations, an estimated two to three thousand researchers from around the world will conduct experiments at the facility each year.

The construction project

During 2018, work has continued on maintaining the schedule in order to be able to complete the project within the established cost framework. By 31 December 2018, 55% of the facility was finished.

ESS adheres to the permitted noise levels regulated in the environmental ruling and has special contact routes with the local residents to inform about ongoing and future work, and to receive any complaints.
No complaints have been received during the year.

During the Construction Phase, rain water and drainage water from excavation pits are diverted to two of the three surrounding drainage companies via a delay reservoir located on the property. One of these three drainage companies leads on to Kungsmarken, a Natura 2000 area approximately one kilometre south of the property. No emissions of significant impact have taken place at the associated drainage companies during the period.

In-kind contributions

The ESS project is based on extensive collaboration with research institutions in partner countries, and ESS has a large network of laboratories in order 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 B€, 2013 price level), 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.

ESS is currently involved in 10 projects with EU support, one with regional support, and seven with national support: a total of 18 projects with a total volume of approximately 5.9 M€.

Environment, Safety & Health and Quality Divisions

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

All suppliers who have components or tools to be installed or used at ESS must ensure that their component fulfils the EU regulations regarding CE marking. This applies to both external suppliers and deliveries from in-kind partners.

ESH ensures ESS's safety and environmental objectives for personnel and users, as well as the surrounding area. This is done by setting requirements regarding the design, installation, and operation of the facility, among other measures. ESH has an important duty in coordinating and leading the work in order to obtain the required permits from Swedish authorities. The largest and most important task is the permit for ionising radiation, which is being handled by the Swedish Radiation Safety Authority (SSM). In 2018, ESS was granted a permit for trial operation of the first part of the accelerator.

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. The transfer of buildings from the contractor to ESS has begun, which creates new conditions that must be handled. As such, ESS takes greater responsibility and will continuously increase the proportion of the facility controlled by ESS and its personnel. This transition is managed in a controlled manner to ensure the highest possible level of safety.

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 has refined existing processes for configuration work during the year, and developed a new set of 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.

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

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

d) is 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:
   - 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,
   - significant previous shortcomings in the performance of previous contracts awarded by ESS
   - serious distortion of information submitted as part of a tendering procedure, or
   - 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.

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. Plans and cost estimates for ESS's Operations Phase have were developed during the year and were presented to the ESS Council in June 2018.

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 percent commitment, and bridge financing to secure the project's liquidity needs.

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 states 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:

- Making it easier for employees to be better aware of their health and to increase their own welfare.
- Facilitating access to physical and social activities, and encouraging ESS personnel to participate in these.
- Being an attractive workplace where people feel good and are satisfied with their work situation.
- 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.

The diversity of our employees is our strength. We want to create an inclusive work environment where each employee is valued and individual achievement is recognised.

We do 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.

The diversity of the workforce and an open and appreciative culture are important success factors in a globalised world, and with almost 500 employees from a total of 50 countries, cultural diversity is a well-established part of everyday life at ESS.

The recruitment rate has remained high. In 2018, 120 recruitments were finalised, and at the beginning of 2019 ESS had 14 open vacancies.

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

The number of sick leave cases has continued to be low in 2018.

Significant events during the year

In April, one of the founding countries, Spain, became a full member of ESS, after having previously held observer status.

In August, the BrightnESS project concluded after three productive years. The purpose of the project was to support the construction and development of the ESS facility. The BrightnESS project, however, will not end; a grant for BrightnESS^2 has been approved by the European Commission and began in January 2019 and will run for a further three years. The focus is on ESS's long-term sustainability.

At the end of August, the last technical laboratory was moved from Medicon Village and thereby the relocation of offices and technical laboratories to the construction site was completed. The groundwork for the construction of the permanent office and laboratory project, Campus, has begun.

On 12 September, the League of Advanced European Neutron Sources (LENS) was signed, along with representatives of seven other European research infrastructures. The signing marks the formation of a new strategic consortium of European neutron sources with the aim of "facilitating any form of discussion and decision-making that has the potential to strengthen European neutron science through enhanced co-operation between facilities." LENS will be an excellent forum for collaboration and further co-operation of neutron research activities in Europe.

The construction work continues with the monolith and instrument halls, while the installation work is ongoing in the cryo-buildings and in the accelerator tunnel.

Expected future development and significant risks and uncertainties

Final negotiations are underway to obtain an agreement on the UK's exit from the EU. This affects ESS as an organisation and employer.

In the memorandum produced by the Ministry of Justice on 15 January 2019, proposals were submitted that aim to counter certain serious consequences of a no-deal Brexit for British citizens and their families who currently live and work in Sweden. The proposals are current only in case the UK were to leave the EU without any agreement on transitional rules being in place between the parties. During a transitional period following the exit, there would be the opportunity to adapt to the new situation. The ordinance is proposed to be valid for one year.

The development of the company's financial performance and position

Net profit for the year amounted to –1,387 MSEK (–999). The result includes personnel and consultant costs, as well as the administrative and technical infrastructure during the Design Phase.

Shareholders' equity amounted to 3,045 MSEK (2,977).

Investments

Investments in buildings and land were made during the year totalling 0 MSEK (68), and investments in ongoing facilities amounted to 780 MSEK (942).

Financing and liquidity

During its fiscal year 2018, ESS received contributions from member countries totalling 1,455 MSEK (1,176). Further information on the contributions received can be found in Note 17. Cash and cash equivalents amounted to 1,710 MSEK (489) at the end of the period.

INCOME STATEMENT		
KSEK	2018-01-01 – 2018-12-31	2017-01-01 – 2017-12-31
Net turnover	-	-
Gross profit	**-**	**-**
Other operating income (Note 5)	65,649	58,892
Administration expenses (Note 6, 7)	–460,636	–417,279
Research and development expenses (Note 7)	–977,651	–636,685
Operating profit	**–1,372,638**	**–995,072**
Financial income (Note 8)	0	3
Financial expenses (Note 9)	–14,376	–4,159
Profit before tax	**–1,387,014**	**–999,228**
Tax (Note 10)	-	-
NET RESULT	**–1,387,014**	**–999,228**

BALANCE SHEET		
KSEK	2018-12-31	2017-12-31
ASSETS		
Non-current assets		
Tangible fixed assets		
Land (Note 11)	64,250	68,000
Equipment, tools and installation (Note 12)	27,787	16,800
Construction in progress (Note 13)	3,360,501	2,598,428
Total non-current assets	3,452,538	2,683,228
Current assets		
Short term receivables (Note 14)	176,587	176,168
Prepaid expenses and accrued income (Note 15)	55,089	30,462
Cash and bank	1,709,626	488,668
Total current assets	1,941,302	695,298
TOTAL ASSETS	**5,393,840**	**3,378,526**

BALANCE SHEET (CONTINUED)		
KSEK	2018-12-31	2017-12-31
EQUITY AND LIABILITIES		
Equity		
Capital contribution (Note 17)	4,431,912	3,976,490
Net result	–1,387,014	–999,228
Total equity	3,044,898	2,977,262
Long-term liabilities		
Liabilities to credit institutions (Note 18)	2,007,530	0
Current liabilities		
Account payables	154,544	194,057
Other liabilities (Note 19)	23,509	16,589
Accrued expenses and prepaid income (Note 20)	163,359	190,618
Total liabilities	341,412	401,264
TOTAL EQUITY AND LIABILITIES	**5,393,840**	**3,378,526**

EQUITY				
KSEK	Cash contribution	Previous year result	Net result	Total equity
Opening balance 2017-01-01	3,936,629	–1,136,430	-	2,800,199
Contributions	1,176,291	-	-	1,176,291
Net result 2017	-	–999,228	-	–999,228
Opening balance 2018-01-01	5,112,920	–2,135,658	-	2,977,262
Contributions	1,454,650	-	-	1,454,650
Net result 2018	-	-	–1,387,014	–1,387,014
CLOSING BALANCE 2018-12-31	**6,567,570**	**–2,135,658**	**–1,387,014**	**3,044,898**

CASH FLOW		
KSEK	2018-01-01 – 2018-12-31	2017-01-01 – 2017-12-31
Operating activities		
Income after financial items	–1,387,014	–999,228
Adjustment for non-cash items	7,281	5,399
Cash flow from operating activities before changes in working capital	–1,379,733	–993,829
Cash flow from changes in working capital		
Increases (–) / Decreases (+) in operating receivables	–25,046	132,474
Increases (+) / Decreases (–) in operating liabilities	–59,852	105,105
Cash flow from operating activities	–1,464,631	–756,250
Investment activities		
Acquisition of tangible assets (Note 11,12)	–18,268	–72,455
Acquisition of construction in progress (Note 13)	–762,073	–937,286
Sales of land (Note 11)	3,750	-
Cash flow from investing activities	–776,591	–1,009,741
Financing activities		
Cash contribution	1,454,650	1,176,291
New/taken loans	2,007,530	-
Cash flow from financing activities	3,462,180	1,176,291
Cash flow for the year	**1,220,958**	**–589,700**
Liquid assets at the beginning of the financial year	488,668	1,078,368
Liquid assets at the end of the year	1,709,626	488,668

Notes

NOTE 1: NOTES WITH ACCOUNTING PRINCIPLES AND COMMENTS ON THE ACCOUNTS

The annual report has been prepared in accordance with the Annual Accounts Act (*Årsredovisningslagen*) and the Swedish Accounting Standards Board BFNAR 2012: 1 Annual report and group consolidation (K3) (*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 Odarslövsvägen 113 in Lund, with post box address P.O. 176, 221 00 Lund, Sweden. The company's corporate identity is 768200-0018.

Classification etc.

Fixed assets, long-term liabilities and provisions consist of amounts expected to be recovered or settled after more than twelve months from the balance date. Current assets and current liabilities consist of amounts expected to be recovered or paid within twelve months from the balance date.

Valuation principles etc.

Assets, provisions and liabilities are valued at cost unless otherwise stated below.

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. Property plant and equipment is stated at cost less accumulated amortisation and impairment losses. The cost includes purchase price and costs directly attributable to the asset to put in place and in a condition and condition to be utilised in accordance with the intended purpose. Other additional expenses are expensed in the period they occur. The assessment of whether a subsequent expenditure is added to cost is whether the replacement of identified components or parts is capitalised. Additional components will be added and capitalised. Values of replaced components, or parts of components will be discarded and expensed in connection with the replacement.

Depreciation according to plan

Depreciation is based on cost less estimated residual value. Depreciation is linear over the asset's estimated lifetime.

The following depreciation schedules are applied:
IT equipment 3–5 years
Machinery and equipment 5–7 years

Impairments

The recorded value of the assets at balance date is reconciled for any indication of impairment. If any such indication exists, the asset's recoverable amount is the higher of value in use and net realisable value. Impairment loss is recognised if the recoverable amount is less than the balance value. When calculating the value in use, future cash flows at a pre-tax rate are discounted to reflect 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 assets are instead attributed to the smallest cash-generating unit where the independent cash flows can be determined.

An impairment loss is reversed if there has been a change in the estimates used to determine the recoverable amount. A reversal is made only to the extent that the assets balanced amount does not exceed the amount that would have been determined, after depreciation, if no impairment loss had been recognised.

ESS operates without profit in accordance with the requirements of the EU regulation relating to ERIC. Financing the future operation of the facility is planned to be achieved through contributions that ensure full cost recovery. This means that the assessment of external and internal indicators related to impairment review according to K3 regulations for ESS, is 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 "*Utkast till redovisningsuttalande från FAR Nedskrivningar i kommunala företag som omfattas av kommunallagens självkostnadsprincip*", which thereby is applied similarly for ESS.

Receivables

Accounts receivable are recorded to the expected value to be received after deductions for bad debts, which are assessed individually.

Receivables and liabilities in foreign currencies

Receivables and payables in foreign currencies are converted using the closing balance rate. Exchange rate differences for operating receivables and liabilities are included in operating income, while differences in financial receivables and liabilities are reported among financial items.

Short-term investments

Short-term investments are valued in accordance with Annual Accounts Act (Årsredovisningslagen) to the lower value when comparing cost and fair value.

Financial instruments

A financial asset or financial liability is entered into the balance sheet when the organisation becomes a party to the instrument's contractual terms. Accounts receivable are recorded in the balance sheet when the invoice has been sent. Accounts payable are booked when the invoice is received. 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 when the contractual obligation is fulfilled or otherwise concluded.

Leasing

All leases are accounted for as operating leases. Leasing fees are expensed over the term of the usage, as well as with regard to benefits paid or received at the signing of the agreement.

Liquid assets

Cash and cash equivalents, immediately available bank balances and other money market instruments with original maturities of three months or less are converted to the closing balance rate.

Accounts payable

Accounts payable have a short expected duration and are valued at nominal value.

Employee benefits

Defined contribution pensions
Operational payments for defined contribution pension plans are recognised as an expense during the period the employee performed the services covered by the fee. Consequently, no actuarial assumptions for calculating the obligation or the cost are needed and there is no possibility of any actuarial gains or losses. The obligation is calculated without discount, 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 recorded directly against equity, whereby the associated tax effect is recognised in equity. Current tax is tax to be paid or received for the current year. This includes adjustment of current tax with taxes from prior years. Deferred tax is calculated using the liability method for temporary differences between the booked and the tax value of the assets and the 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 do not take into account the differences relating to investments in subsidiaries and associates, which are not expected to be taxable in the foreseeable future. Untaxed reserves are reported including deferred tax liabilities. Deferred tax assets for deductible temporary differences and loss carry forwards are only recognised to the extent that it is probable that these will entail lower tax payments in the future.

Contributions

ESS is partly financed 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. See capital contributions in Note 17.

In-kind contributions
The process for approving in-kind contributions during the construction period are performed by the 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. After approval, finally 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: ASSOCIATED PARTIES WITH A CONTROLLING INFLUENCE

The Council is the governing body of the organisation and is composed 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 equal to its contribution relative to the 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

As of 1 January 2019, ESS has begun preparations for the organisational changes associated with the transition from the Construction Phase to commencing the Operational Phase of the business.

NOTE 4: EMPLOYEES, STAFF COSTS AND FEES TO THE AUDITORS

AVERAGE NUMBER OF EMPLOYEES

SWEDEN	2018-01-01 – 2018-12-31	2017-01-01 – 2017-12-31
Men	303	264
Women	137	130
Total	440	394
DENMARK		
Men	19	17
Women	5	5
Total	24	22
TOTAL	**464**	**416**

GENDER DISTRIBUTION IN THE MANAGEMENT

	2018-12-31	2017-12-31
Management Directors and Director General	4	3
Whereof women	25%	33%

SALARIES, OTHER REMUNERATION AND SOCIAL COSTS

KSEK	2018-01-01 – 2018-12-31	2017-01-01 – 2017-12-31
Sweden	275,187	248,856
Denmark	22,035	18,543
TOTAL	297,222	267,399
Social costs	86,072	78,091
Pension costs	37,721	35,109
TOTAL SOCIAL COSTS	123,793	113,200
Salaries and other remunerations includes		
to Director General	2,329	3,142
to Management Directors	5,653	3,829

ALLOWANCES TO MANAGEMENT DIRECTORS 2018

KSEK	Basic salary	Other benefits	Pension costs	Total
Director General	2,279	50	594	2,923
Management Directors (4 pers.)	5,611	42	946	6,599
TOTAL	**7,890**	**92**	**1,540**	**9,522**

ALLOWANCES TO MANAGEMENT DIRECTORS 2017

KSEK	Basic salary	Other benefits	Pension costs	Total
Director General	3,012	130	752	3,894
Management Directors (3 pers.)	3,765	64	927	4,756
TOTAL	**6,777**	**194**	**1,679**	**8,650**

Incentive scheme

European Spallation Source ERIC has no incentive scheme.

Severance pay to senior executives

In Director General and senior executives employment agreements there are no severance payments.

FEES AND REMUNERATION TO AUDITORS		
KSEK	2018-01-01 – 2018-12-31	2017-01-01 – 2017-12-31
PWC		
Audit assignments	475	475
Other assignments	1,850	1,080
TOTAL	**2,325**	**1,555**

Audit assignments involve examination of the annual report and accounts, other duties that are the responsibility of the Company's auditors to perform, as well as advice or other assistance arising from observations during such examination or implementation of such duties.

NOTE 5: OTHER OPERATING INCOME		
KSEK	2018-01-01 – 2018-12-31	2017-01-01 – 2017-12-31
Exchange rate gain on receivables/liabilities of operations	20,688	13,717
Contributions for EU-Grants	44,961	41,066
ESS AB liquidation	0	3,472
Other income	0	637
TOTAL	**65,649**	**58,892**

NOTE 6: LEASING FEES IN RESPECT OF OPERATIONAL LEASES		
KSEK	2018-01-01 – 2018-12-31	2017-01-01 – 2017-12-31
Leasing agreements where the company is the lessee:		
Minimum leasing fees	21,071	19,424
Variable fees	48	340
TOTAL LEASING COSTS	**21,119**	**19,764**
Contractual future minimum leasing fees relating to non-retractable contracts which become due for payment:		
Within one year	19,275	10,832
Between two and five years	23,344	3,930
TOTAL	**42,619**	**14,762**

NOTE 7: DEPRECIATIONS		
KSEK	2018-01-01 – 2018-12-31	2017-01-01 – 2017-12-31
Depreciation according to plan by asset:		
Equipment, tools and installation	–7,281	–5,399
TOTAL	**–7,281**	**–5,399**
Depreciation according to plan by function:		
Administration expenses	–1,161	–605
Research and development expenses	–6,120	–4,794
TOTAL	**–7,281**	**–5,399**

NOTE 8: INTEREST INCOME		
KSEK	2018-01-01 – 2018-12-31	2017-01-01 – 2017-12-31
Interest income	0	3
TOTAL	**0**	**3**

NOTE 9: INTEREST EXPENSE		
KSEK	2018-01-01 – 2018-12-31	2017-01-01 – 2017-12-31
Interest expense	–14,376	–4,159
TOTAL	**–14,376**	**–4,159**

NOTE 10: TAX ON INCOME FOR THE YEAR		
KSEK	2018-01-01 – 2018-12-31	2017-01-01 – 2017-12-31
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 make use of these is the reason deferred taxes have not been accounted for.

NOTE 11: LAND

KSEK	2018-12-31	2017-12-31
Accumulated cost of acquisition:		
Beginning of the financial year	68,000	0
Sales	–3,750	0
Acquisitions	0	68,000
TOTAL	**64,250**	**68,000**

NOTE 12: EQUIPMENT, TOOLS AND INSTALLATION

KSEK	2018-12-31	2017-12-31
Accumulated cost of acquisition:		
Beginning of the financial year	26,320	21,866
Acquisitions	18,268	4,454
TOTAL	44,588	26,320
Accumulated depreciation according to plan:		
Beginning of the financial year	–9,520	–4,121
Depreciation according to plan	–7,281	–5,399
Closing balance accumulated depreciation	–16,801	–9,520
NET VALUE	**27,787**	**16,800**

NOTE 13: CONSTRUCTION IN PROGRESS

KSEK	2018-12-31	2017-12-31
Accumulated cost of acquisition:		
Beginning of the financial year	2,598,428	1,661,142
Acquisitions	762,073	937,286
TOTAL	**3,360,501**	**2,598,428**

NOTE 14: SHORT-TERM RECEIVABLES

KSEK	2018-12-31	2017-12-31
VAT receivables	146,371	127,487
Other tax receivables	16,012	16,012
Contribution from members	13,834	27,074
Other	370	5,595
TOTAL	**176,587**	**176,168**

NOTE 15: PREPAID EXPENSES AND ACCRUED INCOME

KSEK	2018-12-31	2017-12-31
Prepaid rental costs	2,305	5,624
Prepaid insurance	15,764	15,601
Accrued income EU-project	32,921	7,485
Accrued interest	485	0
Other	3,614	1,752
TOTAL	**55,089**	**30,462**

NOTE 16: FINANCIAL INSTRUMENTS AND FINANCIAL RISK MANAGEMENT

Finance policy
In view of the phase in which ESS currently operates, no financial instruments are at present being used to hedge flows or the Balance Sheet.

Liquidity risks and interest rate risks
Cash surplus are placed in bank accounts or other equivalent.

Credit risks
Credit risks are considered limited, as the company's receivables consist of minor amounts.

Exchange rate risks
Exposure to exchange rate changes has been low and the exchange rate earnings that occurred during the year relates to exchange rate differences on account payables and bank balances mainly in EUR.

NOTE 17: CAPITAL CONTRIBUTION

KSEK	2018-12-31	2017-12-31
Czech Republic	47,059	34,184
Denmark	996,867	721,218
Estonia	8,884	8,196
France	64,010	30,566
Germany	1,259,899	858,762
Hungary	29,927	14,186
Norway	282,287	218,396
Poland	48,692	23,787
Sweden	2,506,033	1,982,033
Switzerland	179,653	77,333
United Kingdom	298,646	298,646
TOTAL	**5,721,957**	**4,267,307**

NOTE 18: LONG-TERM LIABILITIES

KSEK	2018-12-31	2017-12-31
External loans	2,007,530	0
TOTAL	**2,007,530**	**0**

NOTE 19: OTHER LIABILITIES

KSEK	2018-12-31	2017-12-31
Other	23,509	16,589
TOTAL	**23,509**	**16,589**

NOTE 20: ACCRUED EXPENSES AND DEFERRED INCOME

KSEK	2018-12-31	2017-12-31
Accrued vacation salary	22,364	20,443
Employee taxes and social costs	5,866	5,348
Accrued salary tax	9,543	8,687
Accrued payments for EU-projects	29,741	31,769
Cash in-kind	76,544	102,238
Accrued interest	1,310	0
Other accrued expenses and deferred income	17,991	22,133
TOTAL	**163,359**	**190,618**

NOTE 21: CONTINGENT LIABILITIES AND PLEDGED ASSETS

KSEK	2018-12-31	2017-12-31
Contingent liabilities	None	None
Pledged assets	None	None

The Council of European Spallation Source ERIC will decide upon the adoption of the financial statement and Annual report.

The Director General certifies that, based on his best knowledge, belief and understanding, the Annual Report is prepared in accordance with applicable accounting rules, the information provided is in accordance with the facts, and nothing of significance that could affect the image of the company as a result of the Annual Report, is omitted.

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esss.se