ESS ACTIVITY REPORT 2011 – 2012

Ready for Construction

The European Spallation Source will be the world-leading centre for materials research and life science with neutrons. The ESS project is partnered by 17 European countries.

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ESS new headquarters, within the Medicon Village, Lund

Director-General's Foreword:

FAIR WEATHER AHEAD FOR ESS

It has truly been a remarkable year for the European Spallation Source. This is the second year that ESS has been an independent entity, and it has been both exhilarating – and at times taxing. Many people have remarked that the current economic climate must have impacted on the project, but it has not proved to be the case. In such times, confidence is an essential element and we, within the project, have done our best to exude that. It has paid off, as the findings of our recent external review indicate.

Second-year highlights

• The build-up of personnel over the past year, from 75 to around 140, has meant that we are becoming a large team. We pay particular attention, therefore, to both the team-building and integration aspects as well as to the essential support for relocated individuals and their families. There are inevitable growing pains, but the organisation is crystallising nicely, and is now ready for the Construction Phase.

• At the turn of the year, we moved into larger, open offices, significantly more suited to our operational needs and future growth plans. They already feel like home. We feel warmly-welcomed and well-appreciated in Medicon Village, which is both within striking distance of our site and only a short cycle ride into town. We have even acquired our own bikes – part of our initiative on health and well-being also launched this year.

• The detailed applications to Sweden's Environmental Court and Radiation Protection Agency have been submitted. They are impressive documents that will pave the way to starting the physical construction process. On the site itself, archaeological surveys, geological surveys and excavations are ongoing, and a brass post is now in place marking the precise centre of the ESS target station. Furthermore, the search for an architectural team for the overall design of the ESS buildings has attracted high-quality interest and will reach a conclusion in the autumn.

• The ESS Conceptual Design Report (CDR) has been delivered according to plan. It has laid down a tangible milestone on the road to entering into the Construction Phase in 2013; it represents the work of the whole ESS team, both in Lund and in our partner laboratories. No doubt the CDR has sent a strong signal that ESS is well on track. In particular, the ongoing design work has allowed many key decisions, including the detailed baseline design of the accelerator and the concept for the target station and its cooling, to be successfully negotiated through our various advisory and governance committees.

• Engagement with the future user community of ESS has been strongly emphasised during the past 12 months. In this respect, the European Conference on Neutron Scattering, held in Prague a year ago, marked a watershed. As the chairman of the European Neutron Scattering Association remarked in his after-dinner speech, this conference was the first in which ESS had taken centre stage. This large gathering was immediately followed by the inaugural "Science and Scientists at ESS" meeting, attended by about 170 delegates. The second such meeting was held in Berlin in April and was attended by around 340 people. It was a very lively event, and it gave us a great deal of input; the enthusiasm, particularly amongst the large contingent of young scientists, was infectious. The doors are open to the user community – and it is heartening to experience their involvement and to deal with their many diverse expectations. "Get Involved" is, indeed, our sincere invitation to them.

• In May, an external expert review was held – the first of many, no doubt, as ESS is built and becomes operational. We wholeheartedly prepared for this review with determination. External reviews are an integral part of the success of such a large project as ESS, and new organisations such as ours need to learn how to handle them. The whole exercise proved to be very worthwhile, and much valuable advice and guidance were given by the reviewers. In their report, they praised ESS and its organisation, and left no doubt as to their view that ESS is ready to proceed to construction without delay. It is my view also.

• This will be the last time that I write the introductory remarks to the annual ESS Activity Report. In March 2013, I will hand the leadership of ESS over to James H. Yeck, who will take charge of an organisation with the spirit and determination to drive ESS onward in producing the proton beams, and thence the neutron beams needed to generate the scientific output for which ESS is being built. It will be an exciting period, and there will be challenges ahead, but I am confident that the project is in safe hands. I wish James H. Yeck the best of times. I will, naturally, maintain a strong interest in the progress of ESS and in its people – ESS has been part of my life for 20 years, and it will remain so. I have, indeed, been privileged to lead the project to where it is today.

The wind is in the ESS sails!

Colin Carlile
ESS Director-General & CEO

A MAJOR NEW EUROPEAN RESEARCH FACILITY GEARS UP FOR CONSTRUCTION

The European Spallation Source will be the world's leading facility for research using neutrons. ESS is cohosted jointly by Sweden and Denmark, and so far, 17 European countries are partnering the project. The ESS Programme is coordinated from Lund, where the facility will be built on a green field site, close to the MAX IV synchrotron. The ESS project is now wrapping up the Pre-Construction work and is gearing up to go into the Construction Phase.

In 2003, the European Strategy Forum for Research Infrastructures (ESFRI), set up by 31 European countries, agreed that a new European facility generating intense, low-energy neutron beams – the ESS – was needed to advance a wide range of scientific research areas of strategic economic importance. A design for ESS was put forward that would generate neutron beams 30 times more intense than achieved with similar sources operational today.

In 2009, EU research ministers decided that the preferred site for ESS would be Lund in southern Scandinavia. Since then, rapid progress has been achieved towards realising ESS, in terms of setting up management structure, carrying out science and engineering R&D, and developing the international collaborations.

Why science with neutrons?

Neutrons are subatomic particles found in atomic nuclei. Like X-rays, they interact with materials to produce diffraction or reflection patterns that provide information about their internal structure at the scales of atoms, molecules and biomolecular assemblies. They can also exchange energy with these structures to reveal details about their motions.

Neutrons also have a number of useful properties such as a magnetic spin, which makes them ideal for studying novel electronic and magnetic materials with technological potential. They are sensitive to very light atoms such as hydrogen, making them unique probes of biological materials and soft matter. Like X-rays, neutrons can even be used for imaging. A wide variety of sophisticated instruments (diffractometers, spectrometers and reflectometers), and associated analytical methods, have been developed to exploit neutrons.

The resulting experiments complement analogous studies with X-rays. Indeed, experimental programmes often require both kinds of analysis. Neutron studies are now essential in research investigating new materials, elucidating biomolecular mechanisms in cells, developing electronic and magnetic devices, and exploring processes relevant to climate change and greener energy generation. The properties of neutrons themselves are also of interest as they throw light on the fundamental physics of the universe. The result is that in Europe alone, up to 10,000 researchers, mainly from academia, but also from industry, are likely to require access to a high-power neutron source during the 21st century.

How do you get neutrons for research?

Neutrons are emitted either through nuclear fission or in the process of spallation, whereby neutrons are knocked out when a beam of protons hits a target. The neutrons are then guided down beamlines to the experimental areas housing the instruments. Both methods are used to produce neutron beams for research; however, spallation sources have the potential for generating greater intensities of neutrons with superior efficiency, and so are the preferred option for the new generation of more powerful neutron sources. Spallation neutron sources require a proton accelerator, which delivers the protons – and thus the neutrons – in pulses.

Neutron science around the world

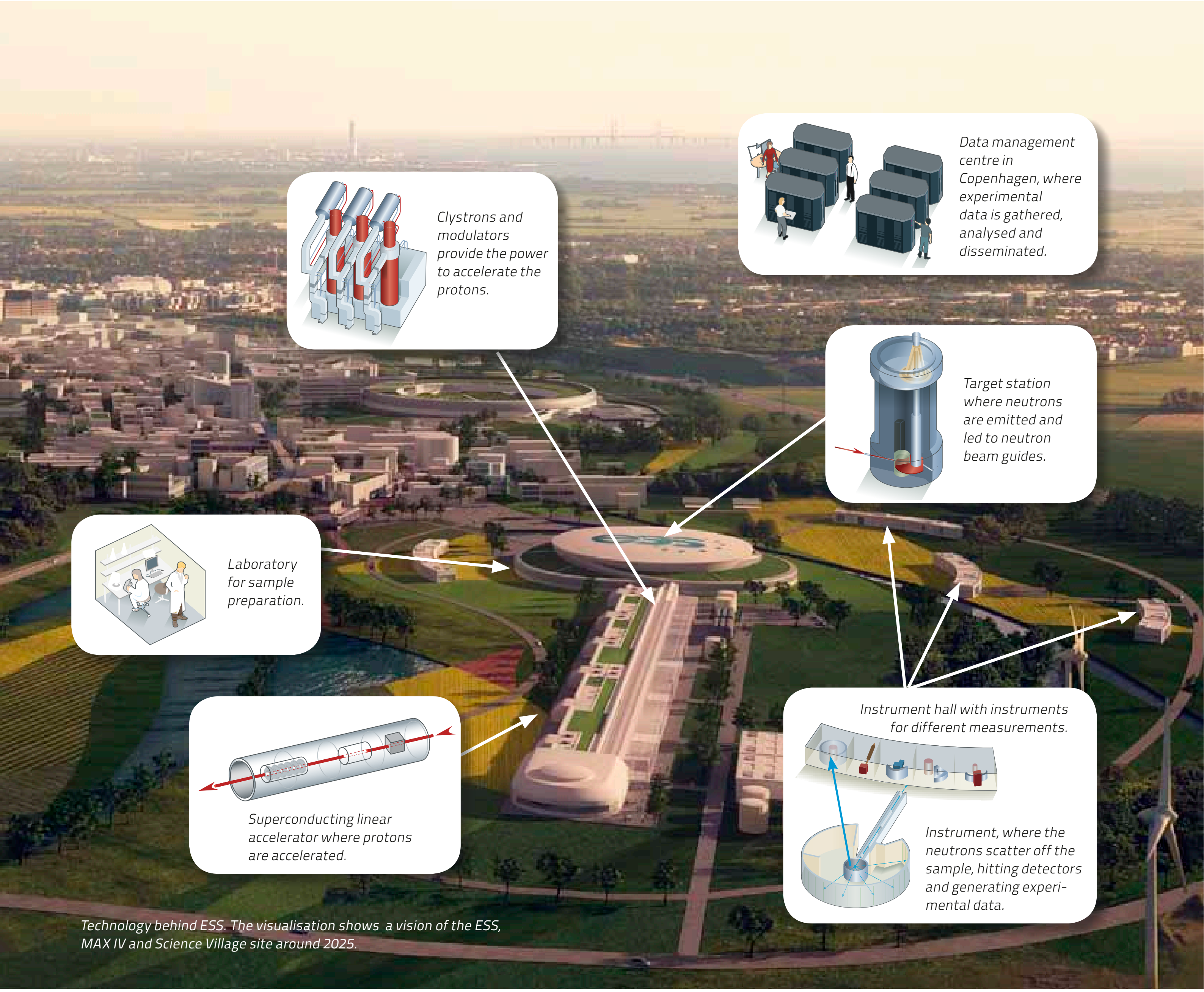
Today, there are two spallation sources in the world operating at the required megawatt power levels: the Spallation Neutron Source (SNS) at Oak Ridge National Laboratory in the USA, and the Materials and Life Science Experimental Facility (MLF) at J-PARC, in Tokai, Japan. ESS will be five times more powerful than SNS and will use long-pulse technology (as opposed to short-pulse technology employed at SNS and MLF) to generate much more intense beams. ESS users will also benefit from the siting of ESS close to a new X-ray synchrotron source, MAX IV. It is planned that essential experimental support infrastructures will be shared between the two facilities.

The ESS Programme

Following the development of a conceptual design for ESS with a 5 MW, long-pulse, single target station layout, serving 22 instruments, a life-cycle timeline has been set in place consisting of:

- Pre-Construction Phase;
- Construction Phase;
- Operations Phase;
- Dismantling and Decommissioning Phase.

The Pre-Construction Phase started in 2010 and will end in early 2013. It consists of three major projects:



Technology behind ESS. The visualisation shows a vision of the ESS, MAX IV and Science Village site around 2025.

- The Design Update, which involves developing and refining the engineering baseline of the whole facility, and also carrying out a cost update of the construction, operation and decommissioning.

- The Preparation-to-Build activity, which aims to minimise technical and financial risks in constructing the facility by prototyping essential components, and also undertaking the various licensing processes needed to obtain the permits necessary to transition to the Construction and Operations Phases.

- The Integration, Acceptance and Support programme, which aims to integrate ESS locally and support negotiations with international partners.

An international facility

ESS will be a jointly owned European research facility. Seventeen partner countries have so far agreed to participate in the Pre-Construction Phase and move towards the Construction Phase, aiming at a formal agreement in 2013. The financial structure, i.e, levels of support and in-kind contributions, and the legal framework are currently under discussion.

Today, ESS is managed as a Swedish publicly-owned limited liability company, European Spallation Source ESS AB, and operates according to Swedish law. The international partners are represented by the Steering Committee (STC). The Technical Advisory Committee (TAC) and the Science Advisory Committee (SAC) regularly review technical and scientific progress, and the Administration and Finance Committee (AFC) oversees all administrative and financial functions. Ongoing engineering and science projects within the Design Update and Preparation-to-Build programmes are carried out by partner institutes, and organised in Collaborations currently broken down into Work Packages (pages 34-35). As the ESS Programme infrastructure develops and grows (pages 15-16), these are being integrated into the overall ESS Programme Plan and coordinated by ESS management.

The first minister to pay a visit to the ESS site was the Swedish Minister of EU Affairs Birgitta Ohlsson. November 2011.

The ESS host country ministers, the Swedish Minister of Education Jan Björklund and the Danish Minister of Research and Innovation Morten Östergaard, chose to meet for the first time during a visit to ESS and the MAX IV construction site, in March 2012. Here with ESS Director-General Colin Carlile and Chairman of the ESS AB Board Sven Landelius.

17 PARTNER COUNTRIES

The period 2011-2012 saw substantial progress for ESS in creating a new international organisation and infrastructure, as well as planning the programme for construction. The number of staff has increased rapidly, and management, legal and financial systems are being established. ESS is currently preparing the Technical Design – the accelerator, instrumentation and support infrastructure – scheduled for completion in early 2013, after which the Construction Phase will begin.

An international organisation

ESS now has 17 partner countries. In February 2011, the majority of partner countries signed a Memorandum of Understanding that signals their intention to participate in the Design Update Phase, and expresses their intention to participate in the subsequent construction and operation of ESS. In the summer of 2011, the Swedish Government appointed Lars Anell (chairman of the Swedish Research Council and previously the Swedish ambassador in Brussels) as Chief Negotiator to formalise the bilateral agreements with the partners, along with Lars Kolte as the Danish negotiating representative. During the past year, the chief negotiators have visited all of the partner countries, and discussions have continued on mechanisms for participation in the construction of the ESS, moving the organisation towards a legally binding international agreement for funding and participation.

Lena Gustafsson, Member of ESS AB Board and Vice-Chancellor of Umeå University.

The partner country representatives

The international partners are represented by the Steering Committee (STC), which advises the Board on all aspects of the scientific, technical and financial planning, taking on board specific recommendations from the ESS Science and Technical Advisory Committees (SAC and TAC), as well as the Administration and Finance Committee (AFC). This advice then forms the basis of Board decisions. A Bureau has also been established within ESS AB, which now manages all Board, STC and AFC activities.

ESS AB Board and management

In order to become an independent organisation, ESS first became a Swedish publicly-owned limited liability company – European Spallation Source ESS AB – in 2010. Currently, the Swedish and Danish Governments are the shareholders. The ESS AB Board is responsible for the financial and strategic management of the project, and also takes an active role in negotiations with current and potential international partners.

The future legal framework

An important component of the future agreement for construction is the legal framework for the ESS organisation, which has yet to be decided. Currently, ESS AB and the 17 partner countries are analysing the different options. Much of this work is being conducted within the ESS Administration and Finance Committee, where the alternative legal frameworks are being mapped and discussed.

Administration and finance

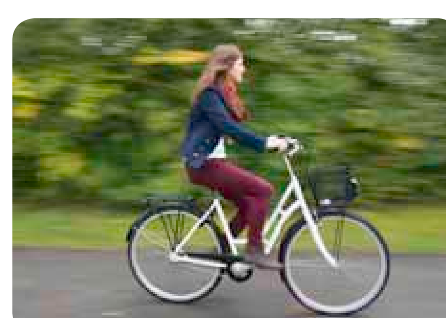
In-kind contributions from partner countries will be of the order of 50% of the total construction costs, and it is essential that there are clear legal and fiscal arrangements in place, especially as contracts become more complex. A legal counsel has now been recruited to manage a wide range of ongoing legal matters. The majority of ESS contracts currently cover collaboration and research agreements with the ESS partner laboratories and universities, although other types of contracts are increasingly being issued for framework agreements within engineering services, technical work and project management.

Lars Anell, Chief Negotiator for the Swedish Government.

Lars Kolte, Chief Negotiator for the Danish Government and Co-Chair of the ESS AB Board.

Head of HR Division Lena Petersson analysing recruitment needs with Sven Havelius, HR Officer.

To the right Anne Säfström-Lanner, HR Officer, and Matti Tiirakari, Director for Administration. Tina Nilsson, Administrative Officer, on one of the new ESS bikes.



RECRUITING THE BEST

The organisation is growing at a rapid pace. During 2011, the number of ESS staff increased from 50 to nearly 100 employees, and it became clear that the organisation had outgrown its old offices at Stora Algatan in the centre of Lund. In early 2012, ESS moved its headquarters to Medicon Village in the north-east of Lund, which is closer to the future construction site. The move allowed all activities to be gathered under one roof, and will also allow for flexibility today and for future expansion. By the beginning of 2013, more than 150 staff will work at the headquarters, as well as in-house consultants and teams employed during construction.

Recruitment and relocation

Currently, ESS employees represent 26 nationalities, and the proportion of non-Swedish staff is growing as more technical and scientific staff are recruited. One of the key tasks for ESS has been to attract and recruit the best people. One channel used to reach potential candidates is via participation in international conferences as well as in specialised scientific job fairs. In September 2011, ESS took a booth at the Naturejobs Career Expo in London and attracted significant interest.

Prioritising staff well-being

Since a lot of effort is put into attracting competent and skilled staff to the organisation, ESS makes it a priority to provide an attractive work environment. A drive focusing on health and well-being was launched in early spring 2012, and several activities have been carried out since then, including health check-ups, the introduction of ergonomic tools and exercise possibilities. Bikes are now also available to encourage activity and sustainable transportation. Social events are especially important for staff moving to a new country, and those are therefore arranged continuously.

Chair of the ESS Steering Committee:

A GREAT SCIENTIFIC ADVENTURE

Having the support and participation of 17 partner countries in a large project such as ESS is a great achievement.

But the support and participation of our partners is also a necessity. For ESS to succeed in its mission we must rely on expertise from all of our European partners, as well as from others world-wide. The large network of laboratories, research institutes and universities that contribute to the ESS Programme is impressive. This will be even more pronounced when ESS enters its Construction Phase and co-financing in the form of in-kind contributions will increase.

Therefore I am particularly proud to be entrusted with playing a part in the international endeavour to shape the crucial first steps of this great scientific venture.

The Steering Committee is the main forum for the partner countries to discuss, plan for and agree on the core decisions that will steer the future of the ESS project. Over the past year, we have had very fruitful and rewarding discussions on the future international agreement, on details concerning in-kind contributions, and on the future organisational structure of ESS. We have meanwhile maintained a close dialogue with the Swedish and Danish chief negotiators, Lars Anell and Lars Kolte, on the progress of talks with the partner countries.

We have also made several major decisions on scientific and technical questions, not the least of which has been establishing the target concept. At the September 2011 Steering Committee meeting, ESS presented the design concept for the target station, which the Steering Committee examined in detail.

The decision on a baseline target concept has been a crucial step forward, in fact one of the most important in allowing the technical design and planning to progress according to plan.

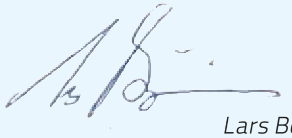
The ESS Programme has moved into its third year in a healthy state. The project is on track to deliver the documents that will fulfill its commitments to the international Memorandum of Understanding signed in February 2011. The important transition to the Construction Phase remains on schedule.

The outcome of the first review of the ESS Programme by international experts showed clearly that the project is on the right track, and will soon be ready to enter the Construction Phase. This outside review is reassuring. It has sent a strong positive signal to our 17 European partner countries just as negotiations on formal agreements and funding of the Construction Phase enter into a decisive period. As the chair of the international Steering Committee, I am particularly satisfied with this outcome.

ESS is a green field project, which is a challenge, but also a great opportunity to build up the facility and the larger scientific environment in the best possible way.

Looking forward, we stand at an exciting transitional moment for ESS, as its future organisational and governance structures are being shaped. I am convinced that by this time next year the ESS project will have moved yet another large step forward.

A great scientific adventure lies ahead of us.



Lars Börjesson
Chair of the ESS Steering Committee

ESS Steering Committee visiting ISIS, Oxfordshire, during their September 2012 meeting.

THE PROJECT LEADERS

Head of Design Division Peter Rådahl.

Project Planner for Neutron Scattering Systems Ann Stenberg, with Thomas Rod, ESS Data Management and Software Centre.

Director for Programme Kjell Möller.

Head of Programme Division Johan Brisfors.

PLM Administrator Christoffer Andréasson.

Susanne Sjögren, Financial Assistant, Agneta Carlecrantz, HR Officer and Elin Lilljebjörn, Financial Assistant.

Deputy Director for Administration Therése Welander.

Senior Procurement Officer Malcolm de Silva.

CAD engineer Håkan Hahn and Giobatta Lanfranco, accelerator scientist.

Helene Björkman, Head of IT Division.

KICK-STARTING THE ESS PROGRAMME

ESS will soon finalise the Pre-Construction Phase and enter into the Construction Phase. The Pre-Construction Phase has been an intensive period of project planning and establishing the appropriate project management tools and systems. In a short time, this work has paid off in a solid foundation for the large and complex ESS Programme. As the first international expert review concluded, ESS is in good shape!

Kent Hedin, Head of Conventional Facilities Division, Johan Lehander, Deputy Director for Programme, and Örjan Larsson, Senior Advisor – Conventional Facilities.

Constructing a large, international research infrastructure is a complex task, in all respects. Firm and structured project management is essential to lead the planning and construction to a result that will deliver scientifically and technically, while keeping to time plans and budgets, as well as creating and maintaining confidence.

ESS has chosen to attract several key staff – advisors and division heads – with a background in industry and with experience leading large, complex construction projects, such as the Swedish Gripen fighter jet, the Malmö metro and the Turning Torso skyscraper.

Programme Directorate

The establishment of the ESS Programme Directorate in 2011 has been a significant step for ESS in setting up the programme organisation that will take the project into the Construction Phase. There has been a rapid build-up of staff; we now have around 65 employees, as well as consultants, working in all areas of programme planning.

The Directorate's main focus has been to set up the organisational infrastructure, and to plan and cost the ESS project. A Programme Plan strategy was defined, together with a Framework Project to formalise internal PMO processes. Key achievements include project management methodology, plans and tools; a systems engineering strategy; a risk management policy; information management systems; and progress in developing building plans, licensing and energy management.

Therefore, the evaluation of the first international project review was particularly encouraging, concluding that, "In a very short time an efficient and professional organisation has been built up".

Pre-Construction: the Deliverables

In the international Memorandum of Understanding for ESS, signed in Paris in February 2011, the key deliverables of ESS during the Pre-Construction Phase were determined. These key deliverables consist of several documents, which first will be subject to internal review by ESS and the ESS advisory committees, with the final versions delivered to the Steering Committee and the Board for approval by the beginning of 2013:

Executive Report

The base document outlining the total scope of ESS through its three phases: Construction, Operations and Decommissioning. It will give a brief overview of the schedules, the cost and the scope for each of the phases.

Programme Plan

The top-level document for steering the ESS Programme, from Pre-Construction to the end of Construction in 2025.

Technical Design Report

The Technical Design Report (TDR) describes the functions and technical solutions chosen for ESS. It will be based on the Conceptual Design Report (CDR) (pages 36-37), which was published at the end of February 2012. The TDR will give the reader an in-depth knowledge of the performance and capabilities of the final ESS facility.

Project Specifications, Construction

Describes the scope, schedule, resources, etc., for the accelerator, neutron scattering systems, target station, energy systems, integrated control system and conventional facilities. Project specifications on all aspects of the facility have been completed and were agreed to by the Steering Committee in May 2012.

Preliminary Project Specifications, Operations
Will include all activities in the Operations Phase, from 2019 onwards, including organisation, availability, user time evaluation, etc.

Preliminary Project Specifications, Decommissioning
Will describe the activities needed in order to decommission ESS.

Transition Plan to Operations
Will cover all activities for the transition to the Operations Phase in the period 2016-2025.

Budget and Cost Report
Will contain complete cost estimates for the design and construction of the ESS facility with the updated TDR design, i.e., all activities taking place during the Pre-Construction and Construction Phases, 2010-2025.

Risk List Summary
The Risk Management Plan is a living document, and is the basis for day-to-day risk-related activities at all levels of ESS.

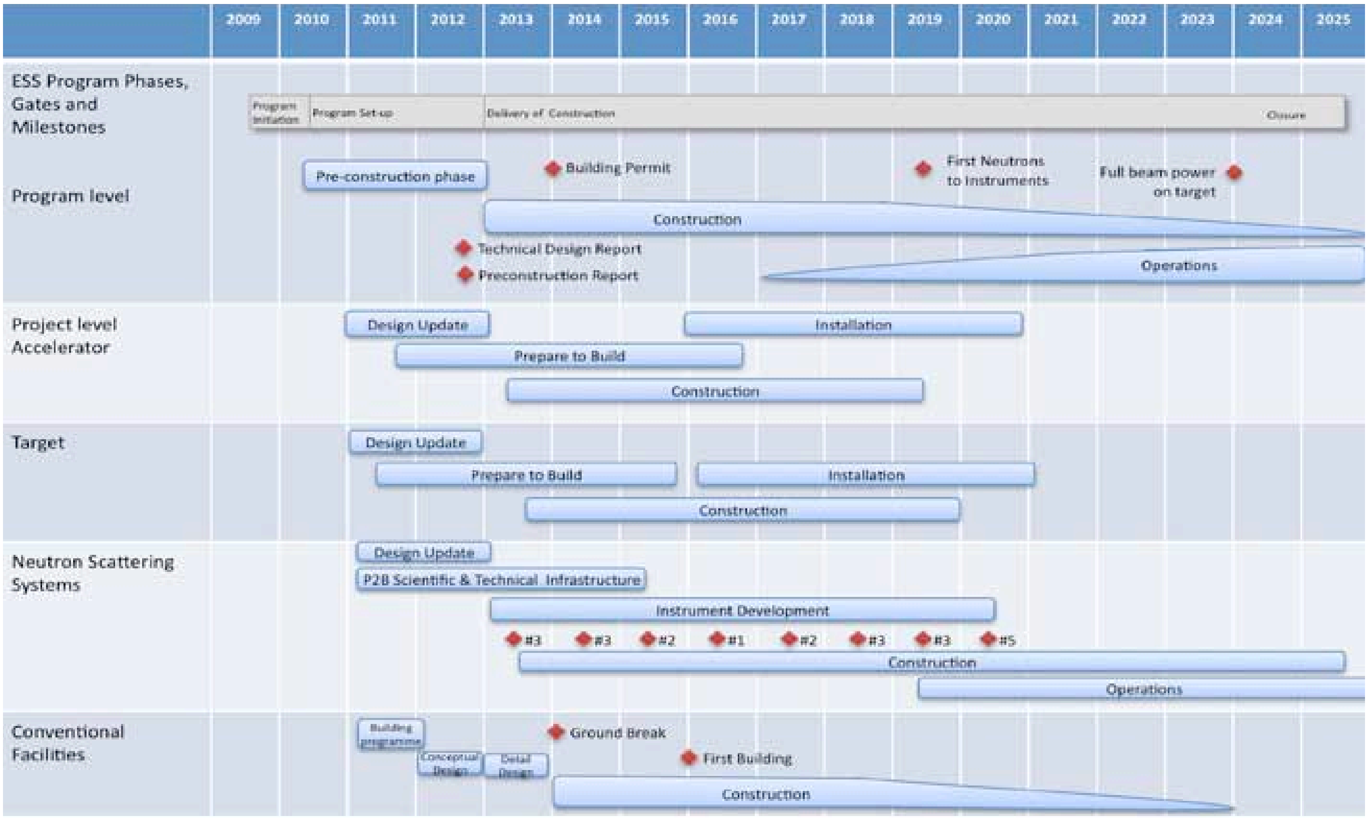
ESS Framework Project
Will provide the life cycle management tools required for the management of ESS AB, and the development and operation of the ESS facility.

Pre-Construction Key Deliverables

These key deliverables for the Pre-Construction Phase shall be produced and approved before February 2013:

- Executive Report
- Programme Plan
- Technical Design Report
- Project Specifications, Construction
- Preliminary Project Specifications, Operations
- Preliminary Project Specifications, Decommissioning
- Transition Plan to Operations
- Budget and Cost Report
- Risk List Summary
- ESS Framework Project

ESS has recruited several key staff with experience in leading several large-scale complex construction projects: the Malmö metro, the Gripen fighter jet and the Turning Torso sky-scraper, designed by Santiago Calatrava. From left to right: Örjan Larsson, Senior Advisor – Conventional Facilities; Kjell Möller, Director for Programme; Kent Hedin, Head of Conventional Facilities Division.



ESS Programme Master Schedule

The Programme Plan

The Programme Plan is the guiding document for the ESS Programme, i.e., the design, construction and commissioning of ESS, and is continually updated in terms of schedules and organisation. It describes the processes used, the tools chosen and the preparations that have been and will be made. Until recently, programme planning focused on the Pre-Construction Phase, in defining the baseline design in the Design Update, planning the staff needed, and project planning for the Prepare-to-Build Phase. The plan includes an overall Master Programme Schedule, and outlines the scope of ESS throughout its lifetime. The key deliverables for 2012 have been defined (pages 13-14), and ESS is in the process of making agreements with its external stakeholders. At the end of the Pre-Construction Phase, a baseline Programme Plan will be issued.

Activities are now ramping up for the planning of the Construction Phase. A preliminary building schedule is being drafted and a Strategic Supply Board has been established to oversee procurement both from direct sources and from ESS's contributing partners. A conceptual design for the layout of the machine and instruments has been developed, together with guidelines on functional and technical requirements to be used as input for a working architectural design (pages 18-19).

The ESS Framework Project

In autumn 2011, ESS set up an internal Framework Project to establish the supporting administrative infrastructure and processes for the management, development and operation of the facility, such as IT systems and project-management methodologies. The project is divided into five areas:

Governance and organisation

A governance chart for the organisational structure and roles within ESS is being drafted for the Construction Phase.

Project management

A project management methodology has been chosen, XLPM, which is a globally accepted commercial methodology for managing and controlling projects. A Programme Risk Management Policy has also been prepared and approved (page 16).

Systems engineering

Work with implementing a systems engineering strategy and method is ongoing.

Acquisitions management

During 2011, a first draft for the new ESS acquisitions policy was developed. Work with implementing the ESS procurement process and templates has continued during 2012. We have established a procurement unit, and two internationally experienced procurement officers have been recruited to manage the purchasing of services and goods. A procurement strategy is being developed to act as a guideline for the planning of the Construction Phase.

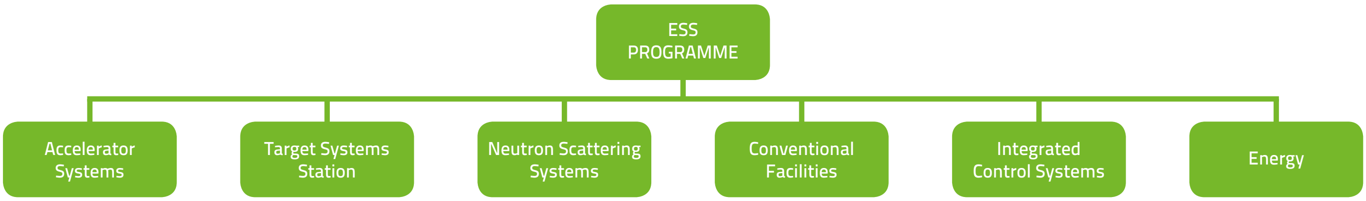
Information management

Integrated IT systems are being put into place (see below).

Project management and control

Project methodology

ESS has decided on XLPM as the project management methodology. XLPM is a globally well-known methodology for managing and controlling projects, programmes and project portfolios in a



Project Structure

The ESS Programme has a Work Breakdown Structure with Projects, Work Packages and Work Units. The Projects are:

- Accelerator
- Conventional Facilities
- Energy
- Integrated Control System
- Neutron Scattering Systems
- Target Station

project-based organisation. It has been adapted for the needs of ESS, and staff has been trained in its use during 2012.

The XLPM methodology supports and requires a detailed planning down to the lowest levels both in terms of budget and schedule. For the Construction Phase, ESS will have a detailed breakdown of all work to be performed. Such breakdown will be in the format of a Work Breakdown Structure (WBS). The Projects, Work Packages (WP) and Work Units (WU) will be broken down to suitable levels: in order to clearly specify the work to be performed, both regarding internal ESS work and external work in the form of individual contracts or in-kind packages.

Project management

The daily management and administration of the ESS programme is performed by the Programme Management Office (PMO). During the construction of ESS, the PMO will provide cross-programme functions such as cost estimation and control, project life cycle planning, specification change control and programme scheduling. An essential tool for this is the interface descriptions, which describe any interface in terms of which information should be exchanged and agreed on between the sub-projects neighbouring that interface, and more broadly when such an exchange is required.

Work-packages planning

Project support by the PMO and the project planning managers includes infrastructure and cross-programme functions such as project life cycle planning and control, and programme scheduling. The support will also handle interfaces between the various sub-projects and the technical integration of these within the major projects and the programme itself. Contract management focuses on partner administration and monitoring and control of contractual collaboration, such as in-kind and other large contracts.

Systems engineering

A Systems Engineering Office (SE) has also been set up, organisationally located in the PMO. The office is responsible for the technical cohesiveness of all individual ESS elements. It is responsible for establishing the overall framework and procedures for the management of the ESS technical requirements, design process and verification process, and for orchestrating the evolution of the design through all ESS lifecycle phases. It is also responsible for setting up and maintaining an ESS centralised model, which will hold all results of the SE activities.

Updating the costing

The PMO is also responsible for managing the costing process. A preliminary Costing Report, based on the 2008 technical design, was produced and approved by the Steering Committee in 2011. The aim was to provide an estimate for Pre-Construction and Construction costs, as well as the whole life-cycle cost. Three major costing exercises, based on both top-down and bottom-up principles, were carried out to plan for the Construction Phase, and include both cash requirements and in-kind contributions. These exercises will continue in step with the writing of the final Technical Design Report, so that the final Costing Book is delivered at the same time as, as well as based on, the TDR at the end of 2012.

Handling the risks

Risk management is an important ingredient in any large-scale project and is part of the planning work needed for the Cost Book. The ESS Risk Management Policy was approved by the ESS Project Group in June 2012. It contained the framework, instructions, roles, responsibilities and methods for managing risks, but also opportunities, from 2012 until the start of operations. Risks include events such as delays in licensing or in supplies for construction, or uncertainties in costs due to currency fluctuations, as well as technical risks.

ESS has held several risk-management workshops and assessments covering the whole facility, as well as the different projects. A list of risks was compiled for each area, and a strategy implemented to reduce the likelihood of the risk becoming a reality.

Information management, systems and tools

Information management is crucial in a large-scale, complex project such as ESS. Selecting, evaluating, procuring, installing and implementing the powerful systems and tools needed to manage the project have therefore been important tasks during the past year, since the outcome will influence the long-term performance and sustainability of ESS project management.

A powerful planning tool

ESS has selected, procured and installed an IT solution for the forthcoming challenge of planning, budgeting, controlling and monitoring the ESS programme and its different projects, sub-projects and work packages. Primavera P6 was chosen for this purpose and is now set up and configured in order to support ESS in the best possible way. All planning and costing staff at the ESS Programme office have been through two days of basic training and more will follow. Schedules, resources, cost of material and risk will all be handled in this IT solution.

A new collaboration platform

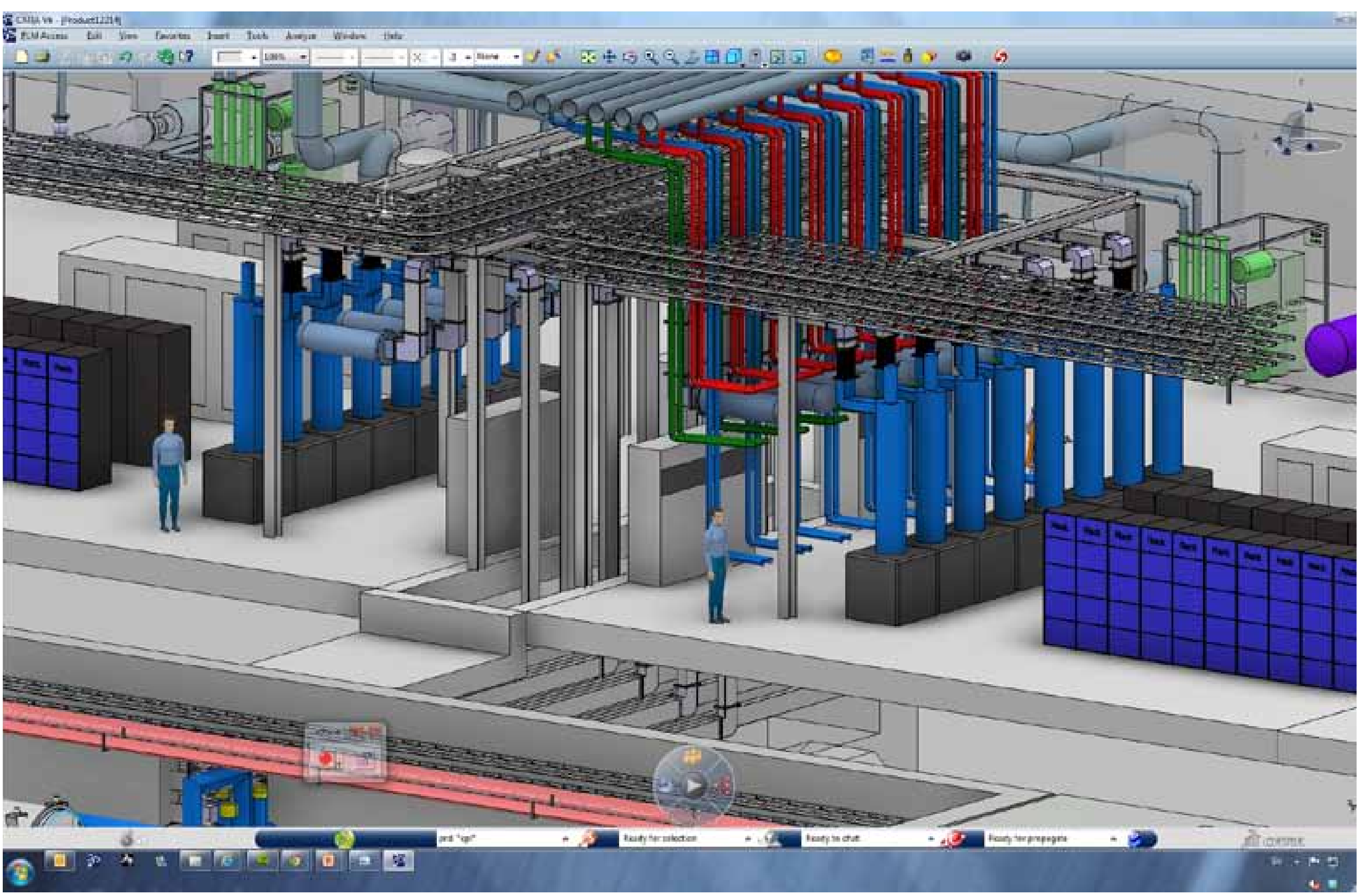
ESS has launched the first release of a new product management platform, CHESS, which will support the needs of the total life-cycle of ESS. In CHESS, based on the Enovia system, ESS and its collaboration partners will be able to create, update and reuse information related to building and maintaining the ESS facilities in a controlled and trackable manner throughout the design, manufacturing, commissioning, operation, maintenance and decommissioning phases. This is the first time that a life-cycle approach has been applied to a neutron facility.

Product management and CAD vaulting modules have been implemented and rolled out within the organisation. This allows for the creation and storage of documentation in the context of the line organisation, the programme and the plant breakdown structure. The next module to be put in place will support the engineering process, allowing for parts management and engineering change management.

Powerful design tools

The ESS Design Division has been expanding through 2012. A large effort is taking place to deliver the needed layouts and drawings to support the production of the Technical Design Report. The goal is to obtain a strong baseline and to be well prepared to enter into the Construction Phase. The Division supports all major projects within the ESS programme in Lund, and is now focusing on finding good collaborative ways of working with all the ESS partner labs throughout Europe.

In parallell with the development of the technical design, CAD drawings help visualise the future ESS facility. Below is the klystron gallery.



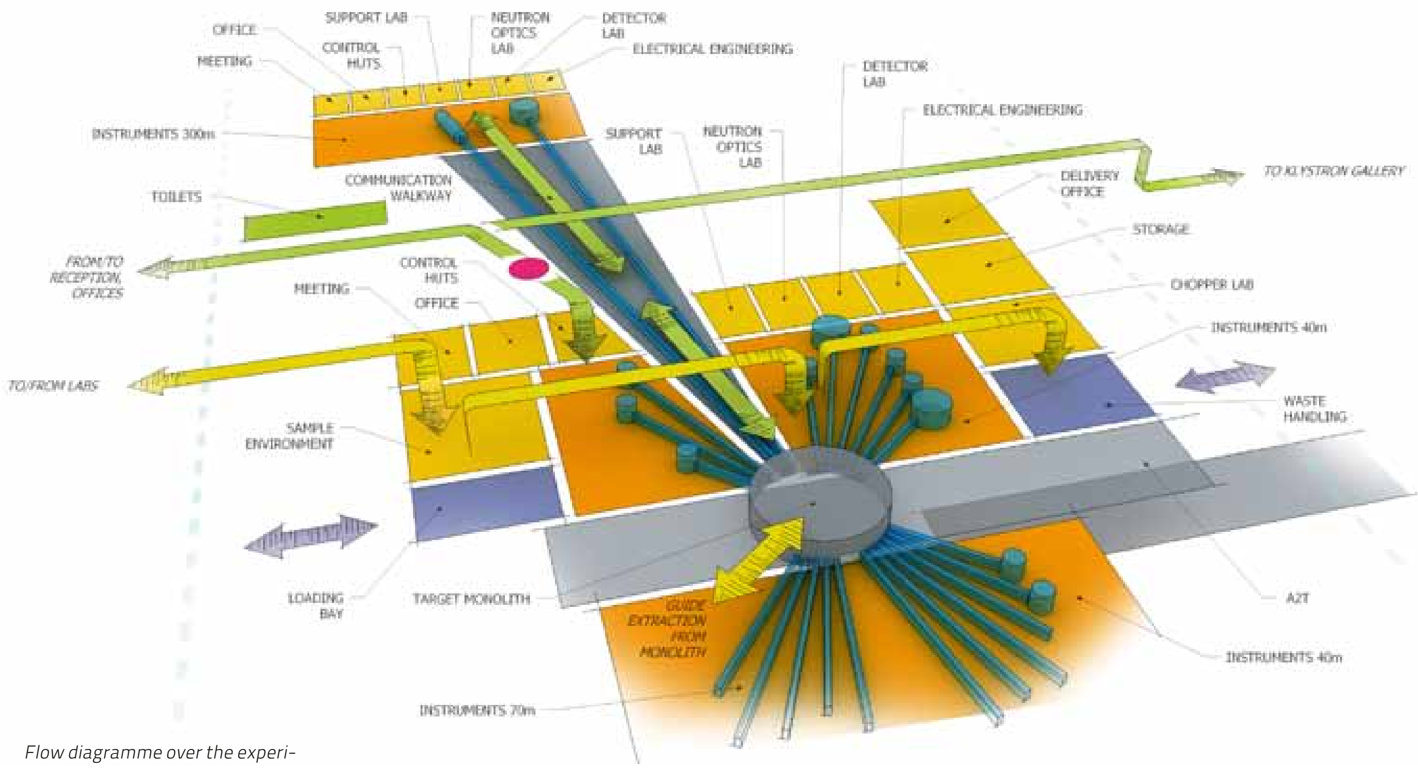
THE BUILDING PROGRAMME

Anders Thonäng, Planning Coordinator; Kent Hedin, Head of Conventional Facilities Division; and Karin Svedin, Design Coordinator Facilities.

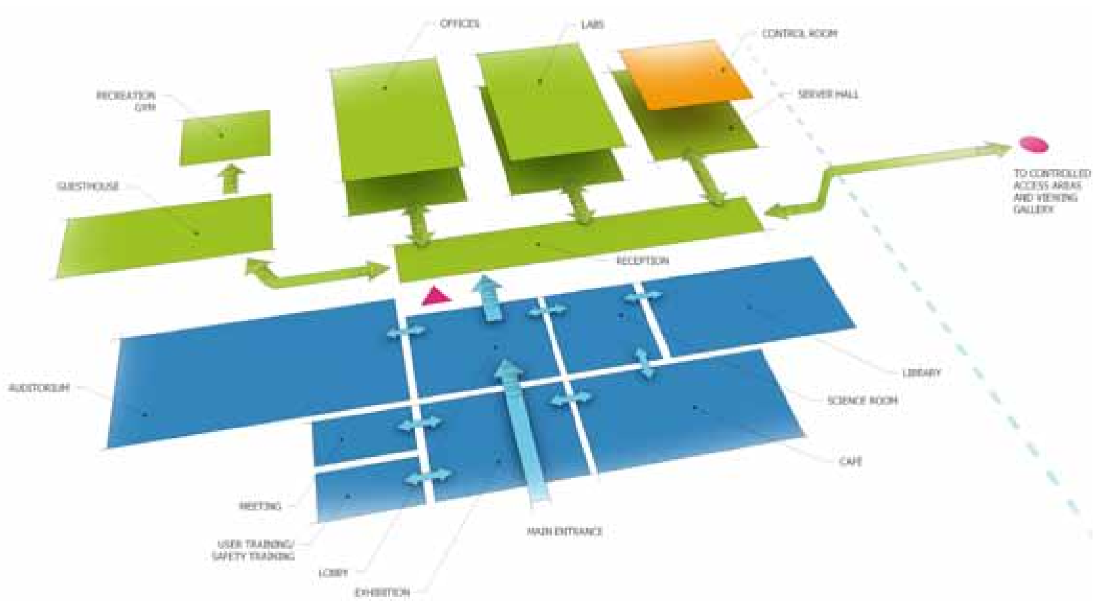
A unit to manage the design and development of the conventional facilities (the building infrastructure housing the accelerator, clystrons, target, instruments, support laboratories, offices, restaurants, guest and recreational facilities) was set up in the summer of 2011. It is rapidly expanding, with currently 16 employees likely to grow to 30 over the next 12 months. A large number of consultants is also needed to cover all aspects of the Building Programme.

We have prepared an outline building programme and facility layout covering the conventional facilities for the accelerator, target and instrument buildings. The three-dimensional conceptual designs indicate how the site will be configured, taking into account all the scientific and operational requirements. They cover the reception area and public spaces, offices, the experimental hall, laboratories and workshops, the target block and the accelerator building.

The architectural design of the buildings will be vital for the visual impression of the research centre and for the scientific and technical functions, as well as for the integration into the surrounding landscape and the future Science Village. A central goal is to create a coherent design that allows an easy flow of people and materials. It should incorporate good transport and access, optimise the use of the building volume, and provide attractive surroundings for staff and users of the facility with appealing landscaping. Sustainability is particularly important and can be achieved by good design following the three R's of "Responsible, Renewable, and Recyclable" already established for the energy requirements of the facility (page 21), for example by using solar panels and high-efficiency windows. Support facilities such as laboratories will need to be flexible to accommodate changing needs.



Flow diagramme over the experimental halls, describing the flows of users, samples, and supplies.



The main entrance to ESS should be located together with public areas such as exhibition spaces, auditoriums, meeting rooms, a café and maybe a library and a science club.

Safety on several levels is vital in the planning of a complex, large-scale, high-energy facility. The configuration of the target area is a key issue, as is the safe storage of activated materials and components. The facility is likely to be divided into four zones, designating access ranging from free to highly controlled.

Architect companies have now been invited to bid via competitive tender through a design contest, with the aim of developing the best architectural and landscaping ideas for the future ESS facility. Five consortia of highly recognised architect bureaus, landscape architects and laboratory designers have been chosen to develop and present design ideas for the site layout and buildings for the ESS facility, and the surrounding landscaping. The winning proposal will be selected around the year-turn 2012-13.

The five selected consortia are:

- Benthem Crouwel, West8, Arup, Mandaworks
- Bjarke Ingels Group, HOK International Limited, Topotek1/man made land
- Foster + Partners, Peter Walker and Partners, Research Facilities Design, Ramboll Group, Berg/CF Møller Architects
- Henning Larsen Architects A/S, COBE ApS, SLA A/S, NNE Pharmaplan A/S
- Tengbom, Mecanoo Architecten, Buro Happold

LICENSING AND PERMITS

Obtaining the appropriate licences from government and public agencies is essential to start the Construction Phase. We spent the past year in preparing and finalising the documentation for permit applications in three areas: radiation safety, environmental impact and buildings planning permission.

Preliminary Safety Analysis Report

Although ESS is to be classified a non-nuclear facility, it must submit a Preliminary Safety Analysis Report (PSAR) to the Swedish Radiation Safety Authority (SSM), which is the national licensing authority for radiation safety. The PSAR and the application were sent into SSM in mid-March 2012. The document provides information on the suitability of the site, machine design and methods for constructing a spallation source in terms of radiation safety. The SSM is expected to give a response by the beginning of 2013. Further information will have to be provided on operational aspects and on decommissioning. A strategy for managing radioactive waste is important, and can be finalised now that the decision of the conceptual design for the target has been taken (page 43). A specific Decommissioning Plan must be submitted.

Environmental impact assessment

Before construction can begin, ESS also needs to submit an environmental impact assessment to the Land and Environmental Court. This covers elements such as noise, emissions and other environmental impact factors both during construction and operations; it also includes impacts on the landscape, geology and water supply, and effects on local communities. We carried out several geological investigations of the site to obtain the necessary information about groundwater conditions and soil composition. The document was also sent to the Environmental Court in mid-March 2012. Depending on decisions from the SSM on radiation safety, the court is expected to make its ruling on a permit by the end of 2013.

Gitte Myhré, in charge of licensing process according to the Environmental Act.

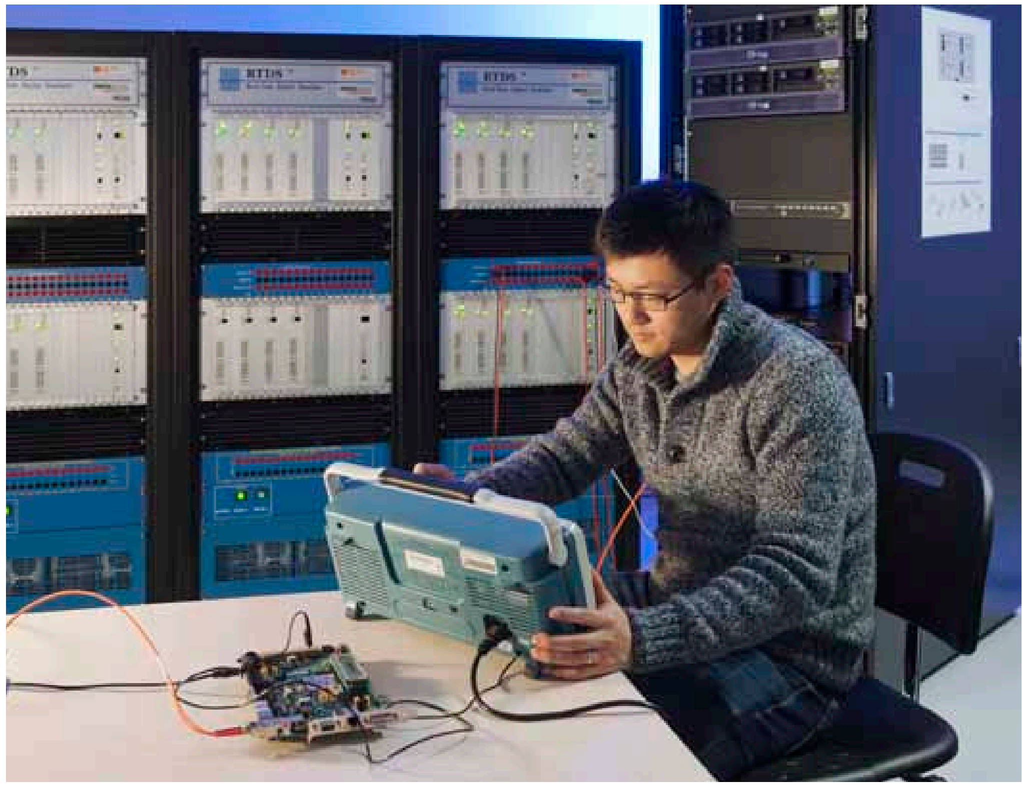
Building permit

ESS has to comply with local planning and building regulations. In accordance with the Planning and Building Act, Lund Municipality's work on the development of a detailed plan for the site is ongoing. The plan will be made available for public scrutiny later in the year. We expect the building permit to be issued in 2013 along with the Environmental Court permit.

SETTING THE ENERGY AGENDA

One of the most exciting aspects of the ESS design concept is the goal to make ESS the first environmentally sustainable research facility in Europe. ESS is implementing an energy concept known as "Responsible, Renewable and Recyclable", which translates into energy efficiency, renewable energy sources, and recycling of waste heat, all while maintaining an operationally stable science facility.

ESS will use only renewable energy sources, such as wind power and biofuel, to power the accelerator and the laboratories, saving about 3-4 M€ annually and reducing CO_2 emissions by 135,000 tonnes per year. Energy requirements at ESS have been reduced by more than 20%, thanks in part to the inclusion of high-efficiency superconducting components in the accelerator design (page 39). Seventy percent of the energy consumed at ESS will be recovered as usable heat. The heat generated by the facility will be recycled and used to heat ESS work areas, and will also be passed to Lund's municipal heating system.



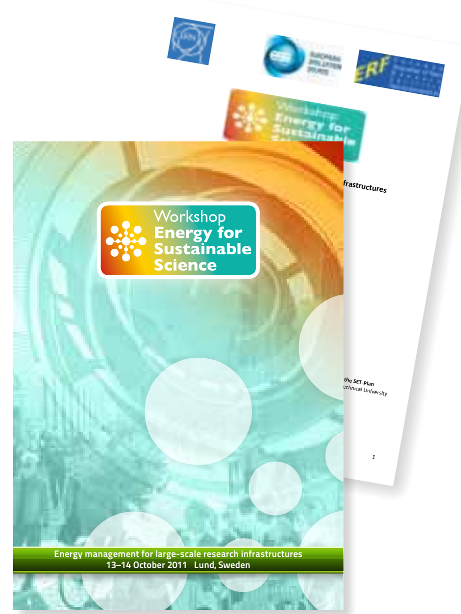
Simulation at the University of Aachen of the ESS electrical system and its interaction with the regional grid.

The main challenge is to design power systems for the accelerator components that operate at the appropriate temperature scale (75–100°C) while maintaining a suitable temperature difference (10°C) between the cooled operating temperature and that of the excess heat. ESS will produce about 180 GWh of heat annually, of which about half will be hot enough to be piped via heat exchangers into Lund's heating system, while the rest will either be converted to higher temperatures using heat pumps, or be recycled for local heating purposes as low-grade heat.

The ESS energy solution has been developed in cooperation with E.ON and Lunds Energikoncernen. To ensure that the power supply system will be reliable and meet the needs of the accelerator, ESS has initiated a simulation project with the Engineering School at the University of Aachen, in Germany, that will test the power grid across southern Sweden.

The final report on the implementation of the ESS power system will be presented in early 2013.

The ESS sustainable energy scenario has already begun to set the "green" agenda for other scientific research facilities. In October 2011, ESS, CERN, and the European Research Forum (the organisation of national laboratories in Europe), organised a well-attended workshop on energy management for large-scale infrastructures. There are around 30 European research infrastructure facilities, each consuming as much electricity as a small town (hundreds of GWh a year), so there are now strong incentives to adapt these power systems to operate sustainably.



First workshop on Energy for Sustainable Science, co-organised by ESS, CERN and the European Research Foundation in October 2011.

REACHING OUT TO THE STAKEHOLDERS

As a large and complex future facility for advanced science, placed in a complex organisational and scientific setting, and also in an early stage of construction, public relations is an essential part of ESS activities, and has been a continuing effort. Work is being focused mainly on three fronts: communication towards the ESS scientific and other stakeholders around the world, towards the press and towards the local community.

Easily understandable

Maintaining good relations with external actors is a priority for ESS. The ESS approach is to be open, pro-active and accessible. Because of the complexity of the project, facilitating broad understanding is an important strategy. Hence, our focus on reaching out to non-scientists with easily understandable information about the complex ESS project has continued over the past year.

Press relations is another crucial aspect of ESS activities. Interest from the press is high, and ESS seeks to provide the mainstream press and the specialised science press with regular news about ESS progress. It is sometimes a challenge to explain the complex ESS project to journalists, and much work is being done to make the ESS project accessible.

Public affairs

As a large, high-visibility, intergovernmental project, public affairs are also a priority. Over the past year, visits by several government ministers and politicians have been arranged. The Swedish EU Minister Birgitta Ohlsson was the first minister to visit the ESS site. Every year, ESS also arranges events targeted at politicians during the Political Week in Visby, Gotland.

External relations

The support for the ESS project in the local and regional community is now impressive. Acknowledgement of worrying issues and seeking to give adequate answers, has been prioritised. We hold a large amount of talks to many different audiences and have broad interfaces with public authorities and the general public. This has contributed to building up good relations with the local and regional community, which will be very valuable for the project during the Construction Phase.

Seminar "Spring Time for Life Science! How Can We Get the Most out of Sweden's Largest Research Investments Ever?" held on 5 July 2012 during the Almedalen political week. In the photo: Thomas Frostberg, Lars Börjesson, Jenni Nordborg, Pia Kinhult, Gunther Schneider, Tomas Lundqvist, Derek Logan and Crister Ceberg.

The ESS exhibition has also been an important tool in our communication with the general public. ESS has also initiated dialogue groups with local residents and NGO's, and issues regular newsletters to the neighbours.

An example of the wide support enjoyed, is the project "ESS MAXIV in the Region", aiming at preparation for the establishment of ESS and MAX IV. The project is partnered by 33 municipalities, all universities in the region, and the regional authority, and has a budget of almost 5 M€. The project will provide valuable support for ESS as regards planning of infrastructure, support facilities, innovation management and receivement of international staff, and will thus benefit the building-up of a leading science centre for European researchers.

Science communication

Alongside the communication efforts towards non-scientists, the scientific communication has been developed and strengthened. The dialogue with the science community today is crucial for the building up of a strong scientific facility in ten years time.

The communication towards the ESS stakeholders is conducted via many different channels, both through the web, newsletter, talks and exhibition booths at conferences, et cetera, and through direct contacts with the ESS committees, partner laboratories and partner countries. During the past months, the development of the new ESS web site has been intensive. This will be the most important tool both for communication with stakeholders within the science community and for reaching out with popular scientific information.

At the 14th Baltic Development Forum Summit, ESS co-organised a large conference together with the BDF and Region Skåne: "Brains & Bridges – Research, Innovation and Growth in the Baltic Sea Region", with the sub-title "Macro-regional Effects of the European Spallation Source (ESS)/MAX IV on Growth and Competitiveness in the Baltic Sea Region". In the photo: Pia Kinhult, First Governor of Skåne; Anna Stenstam, CEO of Colloidal Resource; and partly visible, Lars Kolte, Denmark's Chief Negotiator for ESS, and Helmut Dosch, Prof. Dr., Chairman of the DESY Board of Directors.

International collaboration

In the current building-up of the international partnerships, the communication with the partners will be strengthened. Over the coming period, communication activities will be built up within the large networks of the Instrument, Target and Accelerator Collaborations and with the many ESS Partner Labs. ESS also takes an active role in the new Neutron & Muon PR Network, set up within the NMI3 project. This network will be important for raising awareness of neutron science and disseminating good science stories.

Challenges ahead

As the ESS project grows and develops, so must the ESS communications activities. With the new ESS Head of Communications Allen Weeks in the lead, the ESS PR and Communications work will take on new challenges.

In a strongly growing, heterogenous and geographically distributed organisation such as ESS, the internal communication will be an increasingly important task. With the development of the new ESS intranet, we now have a good base for strengthening internal information. Internal communication must also take on different forms in a fast expanding and complex workplace. To an increasing extent, cross-divisional working groups and knowledge-building activities are taking place within ESS.

Public relations will remain a high priority for ESS. Naturally, future plans will include a focus on international out-reach. In addition, in-depth scientific and technical communication must be further developed. Another crucial task will be the development of information content for the complex activities being launched within the Construction Phase.

Press cuttings from Ny Teknik, Financial Times, Sydsvenska Dagbladet and Kemivärlden Biotech.

A UNIQUE SCIENCE FACILITY

ESS will provide a uniquely bright source of neutrons for research that will enable experiments on materials to be carried out that were not previously possible. The intense neutron pulses will allow progress to be made in cutting-edge areas of science and technology, including the life-sciences, fundamental physics and chemistry, electronics and information technology, green energy and engineering.

The aim of the Science Directorate is to take full advantage of the intense, long-pulse neutron source to meet the scientific needs and aspirations of the user community – both current and prospective users. This means developing advanced instruments of potentially innovative design, supported by suitable neutron technologies and experimental infrastructures.

The Directorate consists of four divisions covering instrument development, neutron technologies, neutron science activities, and data analysis. Data analysis operations will begin in 2013 at the ESS Data Management and Software Centre (DMSC) based at the University of Copenhagen.

During the past year and a half, progress in instrumentation and infrastructure has advanced to the extent that a strategy for delivering ESS science is coming together.

The Science Directorate has established a series of innovative technical initiatives that will allow it to collaborate with ESS partners, respond to the ESS scientific drivers, and actively engage with the European scientific community.

A vigorous programme of recruitment has resulted in staff levels growing substantially from three to around 40 full-time people. The Science Directorate is now able to monitor the progress of and interact with the many European partners who are now enthusiastically participating in the conceptual design of more than 30 instrumentation and component projects through the ESS in-kind contributions programme. Each division of the Science Directorate now has a leader. The team now includes six instrument scientists able to work on the selected instrument concepts, both in-house and with other collaborating laboratories.

The Science & Scientists @ ESS conference, held in Berlin in April 2012, gathered scientists from all over the world to discuss how to build up the best science and instrumentation opportunites at ESS.

LOOKING AT THE FUTURE OF SCIENCE

The unique ESS high-energy, long-pulse structure will give scientists unprecedented research opportunities. ESS has established a number of routes to advising and consulting the potential user community about the science that will be possible – in particular via international conferences. The aim is to provide input into the ESS science and training strategy document that is currently being prepared. In this way, ESS will be able to design instruments that offer the best possible opportunities for research advancement.

Science & Scientists @ ESS

As part of the consultation process for the Design Update, ESS held the first two meetings in a series called Science & Scientists (Prague, July 2011, and Berlin, April 2012). The aim is to reach out to researchers working in a very broad range of areas from biology to fundamental physics, and explain the scientific opportunities and challenges that ESS offers and the progress made in delivering the facility. Scientists are encouraged to "get involved" in formulating the science that will be done at ESS by proposing new ideas for instruments. These meetings are proving very successful with 200 to 300 attendees.

ESS Science Symposia

During 2011 and 2012, ESS has also been sponsoring regular symposia across Europe, each covering a scientific topic where neutron techniques can make major contributions. They enable ESS to engage directly with the scientific community, and they attract large numbers of people. A call for proposals from European scientists is made once or twice a year, and ESS provides a grant of €12,500 to approved workshops. At these workshops, prominent members of the relevant scientific community are able to describe their research, while ESS staff explain the relevant potential of ESS.

ESS Science Symposia

June/July 2011
• First Annual NBIA Meeting on ESS Science
The Niels Bohr International Academy, Copenhagen, Denmark
This was the first of a series of annual workshops to promote advanced training for postgraduates, postdoctoral researchers and scientists in neutron scattering.

October 2011
• Topological materials
ILL, Grenoble, France

December 2011
• Materials engineering at a long pulse source
ISIS, STFC Rutherford Appleton Laboratory, UK

January 2012
• Next-generation instrumentation for the investigation of three-dimensional structures in thin films
Fondation Universitaire, Free University of Brussels, Belgium

January/Febr. 2012
• Neutrons and food
TU Delft Reactor Institute, Delft, The Netherlands

February 2012
• Spin dynamics of correlated electron systems – recent developments and future trends
STFC Rutherford Appleton Laboratory, The Cosener's House, Abingdon, UK

• Non-equilibrium SANS on soft materials
ESS AB, Lund, Sweden

April 2012
• In-situ chemistry
Chalmers University, Gothenburg, Sweden

Scientific networking

With our scientific activities we are becoming increasingly part of the neutron research community both on a European and a regional level. To this end, we participate in the scientific life of the surrounding universities where several ESS colleagues hold adjunct positions. Some university colleagues also have part-time involvement in the ESS science programme. We actively participate in the various scientific networks, clusters and outreach programmes. For example, we have established the ESS New Science Seminar series at Lund University, which covers the use of both neutron and X-ray methods (they provide complementary information about materials and are often used together in research). The aim is to attract regional university research groups, who are not necessarily familiar with neutron scattering, to come and listen to leading European scientists who use these techniques in specific fields.

Research and education at ESS

In-house research is essential to establishing the identity of ESS as a major scientific institution with a good publication record. Most of our scientists are now working with regional universities on individual research projects. As part of this initiative, ESS has established a PhD programme which is open to collaborating partners. The subject must lie within the core interests of ESS – accelerator and target science and technology, instruments, neutron techniques and science. The aim is to provide an additional research resource, while forging closer links with universities. Five PhD projects started in 2011 and another six in 2012.

Arno Hiess, Head of Neutron Science, Ken Andersen, Head of Instruments Division, Axel Steuwer, Senior Researcher, Dimitri Argyriou, Director for Science.

Discussion of instrument proposals, Science & Scientists @ ESS conference, Berlin, April 2012.

ESS Conceptual Design Report:

“ESS will offer neutron beams of a brightness unparalleled by what has been achieved before in dedicated neutron sources: five times more powerful than any other spallation source and 30 times brighter than the world’s most powerful reactor-based neutron source. To achieve this performance, ESS will use new technology and novel approaches in neutron scattering. Due to the novelty of the technology, the longer, brighter neutron pulses of ESS bring unique opportunities to the design of appropriate neutron scattering instrumentation. These opportunities will be exploited by calling on the experience of instrument designers in Europe, on both pulsed and continuous sources. The instrument developers and scientists in the community have already begun to take advantage of these opportunities, capitalising on recent advances in neutron optics and instrument design. The key question for the scientific community now is how to use the brightest neutron pulses in the world. Which are the key areas of science that will benefit most from the bright ESS beams, and how do we best prepare to address them? Predicting the future frontiers of science is a precarious endeavour, but it is clear that neutrons can directly address some of the grand scientific and technical challenges that face our society today.”

> **“The key question for the scientific community now is how to use the brightest neutron pulses in the world.”**

NEW INSTRUMENTS FOR NEW SCIENCE

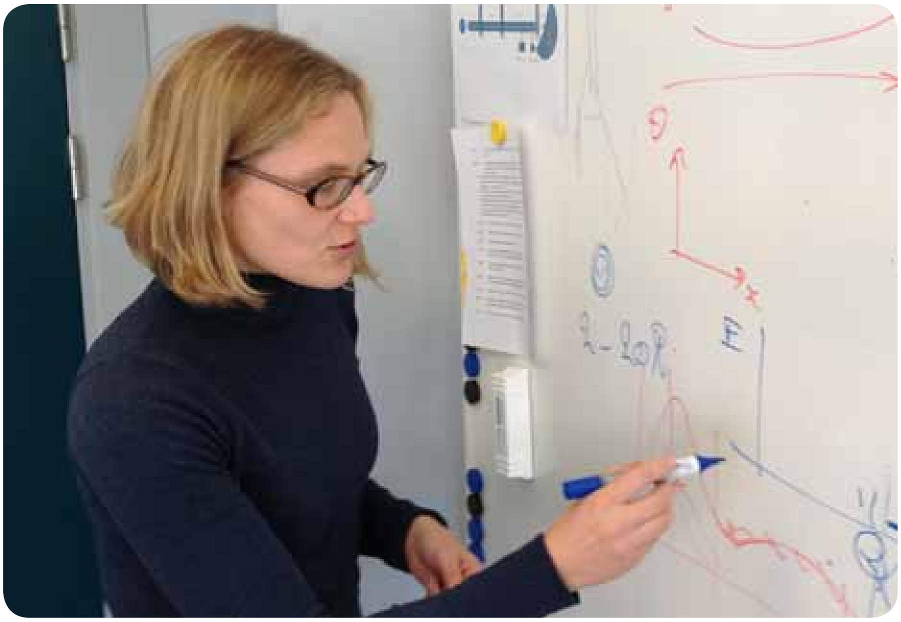
ESS INSTRUMENT TEAM IN PLACE

The brilliance of the generated neutron beams at ESS will enable many instruments to achieve a factor of 10 to 100-fold gains in performance over similar instruments at other facilities. This will transform the way in which neutrons are used and broaden the reach of their scientific potential. The challenge for ESS and its partners is to develop the best suite of instruments that can take full advantage of the high-brightness, long-pulse structure of ESS.

The long pulses will enable the beam to be structured in a variety of ways, benefitting many types of instruments, including those designed for time-resolved experiments. They will enable faster and more complex experiments to be carried out. The increase in intensity means that samples can be much smaller, and flux-intensive polarised neutron techniques can be exploited more fully. More sophisticated experiments investigating dynamics and function at the microscopic and mesoscopic scales will also be possible.

ESS will host 22 instruments to serve the neutron-user community. The first seven instruments will be online by 2019, when the first neutrons are available. The full suite will be available for the user programme in 2025.

In addition, instrument concepts for experiments such as those on fundamental physics will be developed.



ESS has now gathered a complete team of instrument scientists, each of them in charge of one instrument class. To the left: Paul Henry, powder diffraction; Pascale Deen, direct geometry spectroscopy.

To the right: Melissa Sharp, neutron spin-echo (1); Nikolaos Tsapataris, indirect geometry spectroscopy (2); Ken Andersen, Head of Instruments Division (3); Andrew Jackson, small angle neutron scattering (4); Hanna Wacklin, reflectrometry (5); Werner Schweika, magnetic single crystal diffraction (6); Markus Strobl, imaging (7); Esko Oksanen, macromolecular crystallography (8).

Work packages: Eleven Instrument Concepts

Instrument development is taken forward via the Instrument Design Update (IDU) programme, which is part of the Pre-Construction Phase. It consists of work packages, managed by a work-package coordinator from ESS, and subdivided into various work units involving specific projects carried out either at our partner laboratories or in-house.

- **IC1 – Management**

- **IC2 – Small Angle Neutron Scattering (SANS)**

Work units: conventional SANS, small-sample SANS, spin-echo SANS, compact SANS and broad-band SANS.

- **IC3 – Reflectometry**
Work units: horizontal reflectometer, vertical magnetism reflectometer, high div. reflectometer, multi-beam reflectometer, optimised spin-echo labelling in polarised reflectometer.

- **IC4 – Macromolecular Diffraction**
Work unit: macromolecular diffraction.

- **IC5 – Single-Crystal Diffraction**
Work unit: magnetic single-crystal diffractometer.

- **IC6 – Powder Diffraction**
Work units: hybrid diffractometer including SANS and imaging, bispectral powder diffractometer, extreme environment instrument, thermal powder diffractometer, pulsed monochromatic powder diffractometer, Larmor labelling in diffraction (TOFLAR).

- **IC7 – Materials Engineering Diffraction**
Work units: engineering diffraction, CEED, highly flexible materials and engineering diffraction.

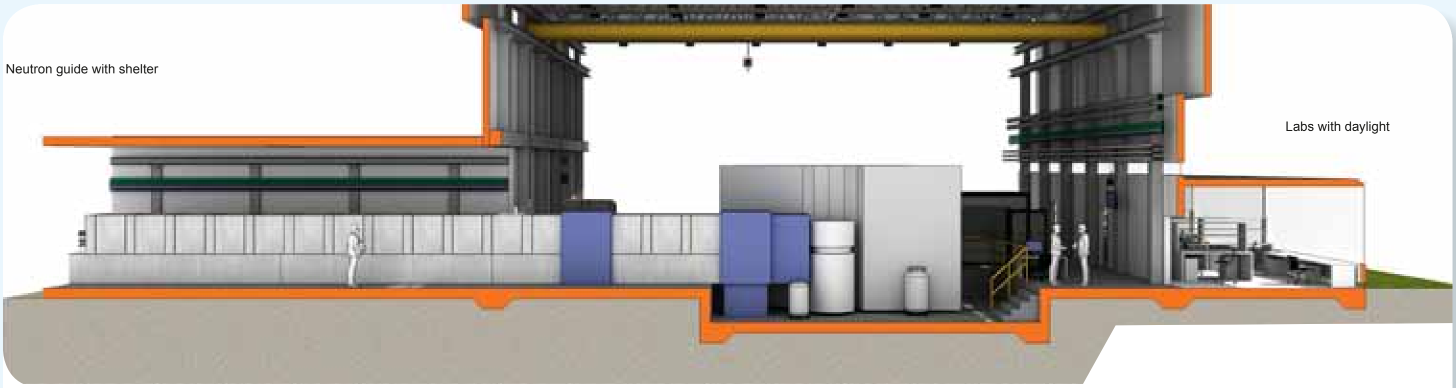
- **IC8 – Imaging**
Work units: three work units working on multi-purpose high-resolution imaging, and one work unit on add-on on Larmor-precession-labelled imaging.

- **IC9 – Direct Geometry Spectroscopy**
Work units: cold chopper spectrometer, bispectral chopper spectrometer, thermal chopper spectrometer, crystal monochromator spectrometer.

- **IC10 – Indirect Geometry Spectroscopy**
Work units: phase-space transformers, cold crystal analyser, backscattering spectrometer, vibrational spectrometer.

- **IC11 – Neutron Spin-Echo (NSE)**
Work units: high-resolution NSE, wide-angle NSE, alternative NSE & add-ons, focusing for spectrometers.

- **IC12 – Others**
Work units: fundamental physics, test beamline, ultra-cold neutron (UCN) production and instruments for UCN experiments.



Conceptual images of building types for experiment hall (large image) and neutron guides (small image).

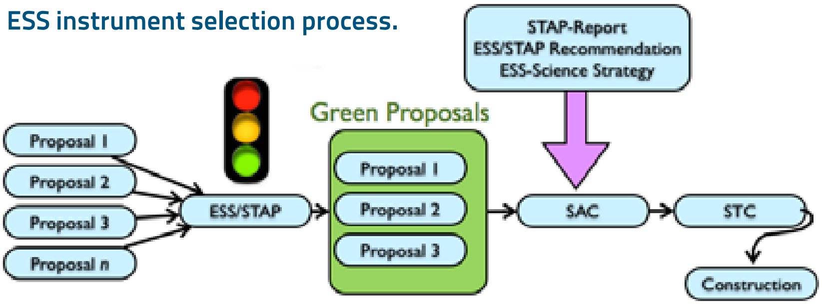
Instrument selection

During the past year, we have put in place the decision-making process for instrument selection. In September 2011, the ESS Steering Committee (STC) proposed that the scientific instruments should be selected by an open process involving the whole user community, as well as our partner laboratories. Instrument concepts and proposals are prepared in discussion with the ESS work-package leaders, and will be evaluated and accepted on a yearly basis until 2020.

The design concepts are discussed by the user community and the potential builders of the instruments at workshops, conferences and seminars (see below).

A number of Scientific and Technical Advisory Panels (STAPs) have been set up that are each responsible for advising on the selection of an instrument in a particular class. They represent the user community for that instrument, advising on the science drivers for the instrument class and the requirements for its design. In tandem, instrument experts from laboratories around the world evaluate the technical feasibility of the design.

ESS instrument selection process.



Once an instrument proposal has reached a sufficient level of maturity, it will be presented to the ESS Science Advisory Committee (SAC), which will evaluate it according to the following criteria:

- scientific impact of work that could be carried out on the instrument;
- user base and demand, which includes the potential for introducing a new user community to neutrons;
- instrument performance: the concept has to be sufficiently mature to compare it with benchmark instruments at other facilities;
- technical maturity and feasibility;
- likely cost.

STC will take the final decision on the choice of instruments. ESS management will provide a proposal for funding the construction: either in-house, or in-kind by identified scientific partners, or by opening a call to identify additional in-kind scientific partners.

Concepts for the first seven instruments, which will service a broad range of science, are being discussed by our partners. The first three instruments will be chosen by the middle of 2013, based on the criteria above.

Four scientists taking part in the development of instruments for ESS. IKON 1 meeting, September 2011.

IKON meetings

One of the main vehicles for exchanging ideas and discussing progress on instrumentation and neutron technology are the IKON meetings, which will be held twice a year, in February and September. The first three meetings were held in 2011 and 2012, and more than 130 scientists involved in developing instruments for ESS attended. Research groups working on specific instrument classes were able to present their achievements. These meetings are proving to be a huge success – not least because, for the first time, they bring together a large community of neutron scientists, stimulating the cross-fertilisation of ideas and new collaborations that will benefit neutron science in general.

The Instrument Design School

In addition, the Science Directorate organised a two-week Instrument Design School in 2011 aimed at training the next generation of instrument scientists. Experienced instrument designers described both traditional analytical methodologies and computer simulation methods.

Why a new pulse length and frequency?

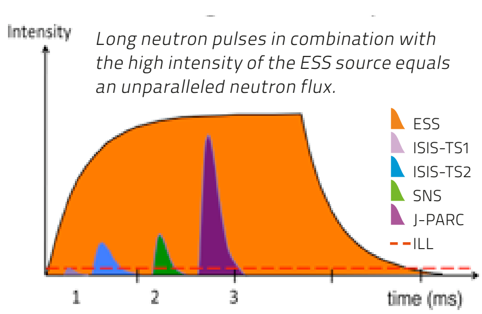
In 2011, the Science Directorate asked for and obtained an agreement for the ESS pulse-length to be lengthened to 2.86 ms, and the repetition rate to be lowered to 14 Hz. Along with rationalising the instrument layout in the experimental halls so that instruments may be of similar length, this new baseline also enhances their scientific and technical performance. Experiments using cold neutrons at longer wavelengths to investigate slowly-moving, large-scale molecular structures particularly benefit from the new specifications.

Dropping the frequency of pulses increases the bandwidth by allowing more neutrons per pulse to be captured and counted. This ensures that a much wider range of momentum space can be accessed in a single pulse, thereby extending the range of length-scales and energies over which measurements can be made. It will allow, for example, the evolution of complex changes in biological samples to be followed using just one instrument, in one experiment.

Making the pulse longer means that its shape is flattened and more of it is useable as it is sliced into shorter pulses for specific experiments. This will further increase the flexibility in time structuring offered by the ESS novel long-pulse concept, and so increase the efficiency of instrumentation.

Data Management, Computing and Software Centre (DMSC)

Data acquisition, analysis and archiving, user work-flow, simulations and other computer-based support are based at the DMSC at the University of Copenhagen.



Long neutron pulses in combination with the high intensity of the ESS source equals an unparalleled neutron flux.

The DMSC is part of the Danish contribution to the ESS project. The DMSC is currently serving as a computing centre for the groups involved on the ESS Design Update. It is also working to establish its scientific, technical and operational parameters from 2013 onwards, when the DMSC will be fully integrated into the ESS Science Directorate, interfacing with the Electrical Engineering Group.

Once ESS comes online, the DMSC will make available user-friendly software for instrument control, data acquisition and analysis, with high-speed remote access to ESS from users' home laboratories. It will also provide the required computing power for data processing and secure data-archiving, as well as modelling capabilities and theory support. Training will be offered to new users in instrument operation and data analysis.

Susana Gota-Goldmann, French Ministry of Higher Education, member of ESS Steering Committee, and Christiane Alba-Simionesco, Director LLB, Paris, and member of ESS SAC. IKON 1 meeting.

During 2011 and 2012, the DMSC expanded through the addition of several new staff members, both software engineers and physicists. A new computer cluster for ESS, with 500 cores and a storage system of 50 terabytes, was delivered towards the end of 2011. The DMSC aims to join the MANTID data reduction and analysis software project, currently conducted by ISIS at the STFC Rutherford Appleton Laboratory in the UK and SNS at the Oak Ridge National Laboratory in the US. The instrument control software will be based on the Experimental Physics and Industrial Control System (EPICS) to be used for the accelerator and target control. The DMSC is currently seeking partners for its development.

Neutron technologies

A neutron scattering instrument consists of several types of components: rotating discs called choppers that impose or alter the time structure of the source; neutron optical devices that transport, guide and focus the neutron beam; sample-environment components; and a detecting system for measuring neutrons after they have been scattered from the sample. In addition, accurate electrical engineering and mechanical systems are needed to move the sample and instrument components as required.

The unique long-pulse time structure and high neutron-flux environment present particular challenges in the development of supporting systems. The long pulses mean that instruments will likely be longer than those at existing spallation sources, and so will require new concepts in creating neutron guides, choppers, and large-area detectors. The high-radiation environment surrounding samples and instrumentation is also a major factor in design.

In 2011, the Instrument Support Division set up five groups covering detector systems, chopper systems, neutron optics systems, sample environment and electronic hardware to commence development of these critical areas.

Detectors

Developing new detectors is a major priority. Many detectors will cover large areas up to 140 m^2. The rare isotope, ^{3}He – traditionally used to detect neutrons – is now in very short supply, so new kinds of large-area detectors are urgently needed. There are various candidates, including detector systems based on ^{10}B thin films, boron trifluoride, scintillation devices and gas electron multipliers.

Choppers

Sophisticated chopper systems are crucial to exploiting the full potential of the long-pulse structure. A variety of different choppers will be needed, such as fast-rotating disc choppers and Fermi choppers. The choppers will potentially be large and heavy, and will be designed to require little maintenance by using, for example, wear-free bearings. Around four to five choppers might be needed per instrument, but these cannot be fully specified until the instruments are selected.

Phillip Bentley, group leader, neutron optics.

Neutron optics

At around 150 m on average, most instruments will be longer than those at other sources, and the high-flux neutron beams will need to be transported as efficiently as possible onto sample areas as small as 1 mm^2. This will require innovative guide and focusing elements and techniques to optimise the beam quality, such as compound lenses and adaptive optics (AO), and also new devices for polarising neutrons needed for specific experiments.

Sample environment

Parameters like temperature, magnetic or electric field, pressure, humidity or gas flow are often an essential part of a neutron experiment, so systems such as superconducting cryo-magnets, shear cells or stopped-flow devices, reaction chambers, pressure cells and furnaces are required. While some equipment can be bought commercially, more specialised devices will have to be developed for the ESS sample environment.

Sample handling and storage will also be an important consideration, especially for radioactive materials, hazardous biological and chemical materials. Laboratories for sample preparation – for example, the deuteration of soft matter and biological samples, and also their characterisation – will be needed, as well as machine shops for making dedicated pieces of equipment.

Electrical and electronic systems

Data-acquisition systems, motion control, safety interlock systems and automated systems for sample manipulation and instrument control will be standardised so that they are compatible across instruments.

Current status

The technical groups are being established, with group leaders being recruited. Four of the posts are filled, and the detector group, in particular, is now well-established; postdoctoral researchers have now been taken on to join the neutron optics and detector groups through the EU NMI3 neutron/muon funding initiative and the CRISP programme. Technicians are also being sought. Eventually, the Instrument Support Division will consist of about 60 people.

Oliver Kirstein, Head of Instrument Support Division, and Ann Stenberg, Project Planner.

Input is also being provided to Conventional Facilities for the Construction Phase – on the workshop and support laboratory space required and on cost and licensing requirements.

The Division is also maintaining and forging links with Swedish universities as well as coordinating collaborations with partner laboratories through the ongoing work packages. ESS is working with other neutron facilities such as the Institut Laue-Langevin (ILL), in France, and the Paul Scherrer Institut (PSI), in Switzerland, which is developing neutron focusing optics using adaptive optics.

Work packages for neutron technologies

- **IS1 – Management**
- **IS2 – Detector systems**

Work units: detectors, semiconducting pixelated neutron detectors, detector testing facility, ^{10}B thin films, detector laboratory, detectors & data acquisition.

- **IS3 – Chopper systems**

Work units: choppers, systems for neutron scattering instruments.

- **IS4 – Neutron optics**

Work units: polarisers (^{3}He), neutron optics, neutron shielding and background calculations, development of focusing optics with extreme environments, enhancement of neutron beams.

- **IS5 – Sample environment**

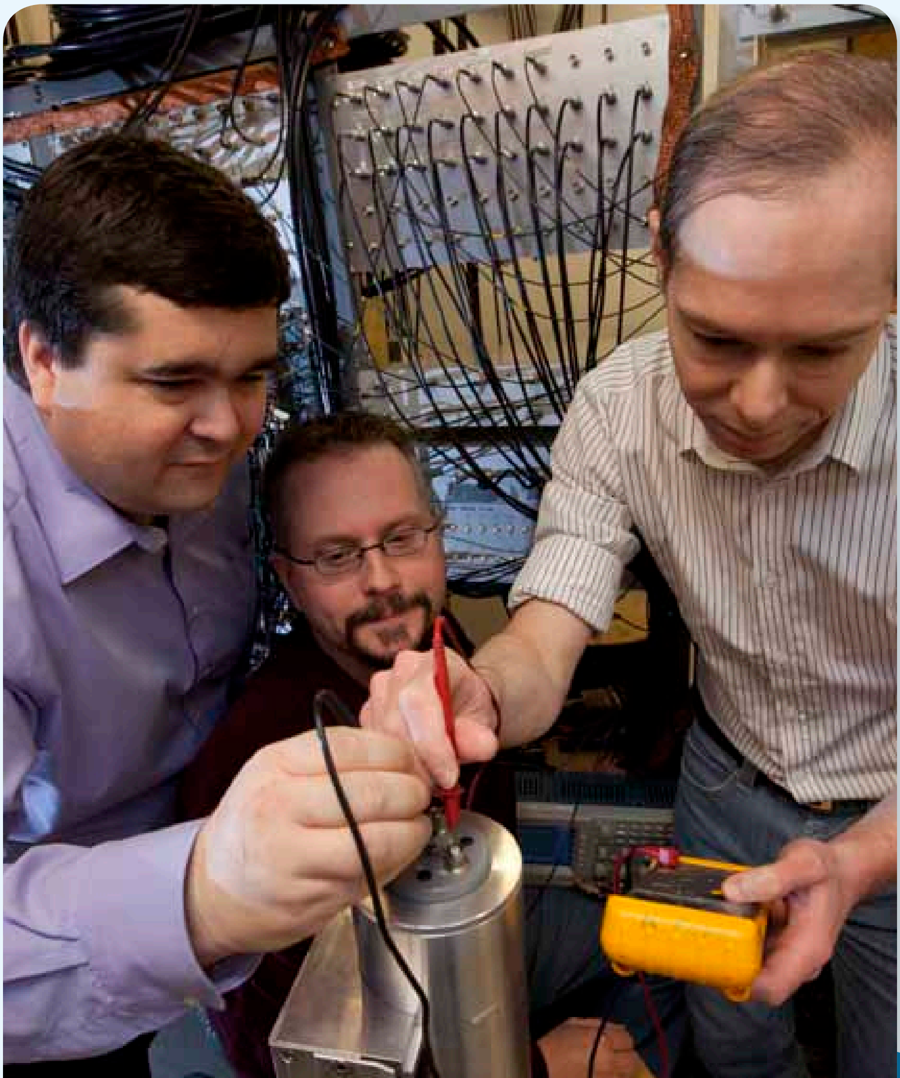
Work units: ESS specifications for sample environments.

- **IS6 – Electrical engineering**

Work units: definition of motion control systems.

- **IS7 – Data management and scientific computing**

Work units: ESS data acquisition and software, design update of the DMSC, DMSC computing facility, HDRI communication platform, simulation code development & help-desk.



Richard Hall-Wilton, ESS Group Leader for Detectors, Kevin Fissum, Lund University and Björn Nilsson, ESS and MAX IV Laboratory, with a prototype neutron detector.

THE FIRST ESS LABORATORY

ESS has had collaboration agreements relating to detectors with ILL and with Linköping University since 2010. Work on building a demonstrator for a ^{10}B large-area detector will continue at Linköping, but other projects will start in the new Joint Detector Laboratory, which was set up in 2011. This is a joint facility shared between ESS, the MAX IV laboratory – a next-generation synchrotron radiation (X-ray) facility being built nearby – and the nuclear physics group in the Department of Physics at Lund University. The arrangement, currently based at the existing MAX-lab, pools expertise and equipment in addressing mutual needs for novel advanced detectors. ESS is jointly supporting a PhD student at Lund working on scintillator technologies. The laboratory is the first step towards the building-up of a joint infrastructure in the future Science Village to be located between MAX IV and ESS. These activities will expand over the next four years.

A GLOBAL DESIGN EFFORT

Accelerator Design Update Collaboration

Participating institutes in the collaboration:

- Aarhus University, Denmark
- CEA Saclay, Paris
- CNRS Orsay, Paris
- ESS Bilbao
- INFN, Catania
- Lund University, Sweden
- Uppsala University, Sweden

Institutes participating in the work packages:

- Argonne National Laboratory, Chicago
- Accelerator Science and Technology Centre, Daresbury and Oxford
- Brookhaven National Laboratory, Long Island
- CERN, Geneva
- Cockcroft Institute, Daresbury
- DESY, Hamburg
- ESS Bilbao
- Fermi National Laboratory, Chicago
- Jefferson Lab, Virginia
- John Adams Institute for Accelerator Science, London and Oxford
- Laval University, Quebec City
- Maribor University, Slovenia
- National Centre for Nuclear Research, Swierk
- Oslo University
- Rostock University
- Stanford Linear Accelerator
- Spallation Neutron Source, Oak Ridge
- Stockholm University
- Techical University of Darmstadt
- TRIUMF, Vancouver

Target Station Design Update Collaboration

Institutes participating with in-kind contributions:

- AEKI, Hungarian Academy of Science Centre for Energy Research, Budapest
- CEA, Saclay, Paris
- ESS Bilbao
- Forschungszentrum Jülich
- Helmholtz-Zentrum Dresden-Rossendorf
- IPUL, University of Riga
- J-PARC, Tokai
- Karlsruhe Institute of Technology
- NRI Rez, Prague
- Paul Sherrer Institute, Zurich
- Risö DTU National Laboratory for Sustainable Energy, Roskilde

Other institutes participating in the Target Station Design Update:

- Budapest Neutron Centre
- CERN, Geneva
- China Spallation Neutron Source, Beijing
- CNR, Rome
- CRS4, Sardinia
- Institute for Energy Technology, Halden/Oslo
- ISIS, Rutherford-Appleton Laboratory, Oxford
- J-PARC, Tokai
- Los Alamos National Laboratory, New Mexico
- Lund Technical University
- Oak Ridge National Laboratory,
- Studsvik, Nyköping

Instrument Design Update Collaboration

- Aarhus University, Denmark
- Czech Technical University, Prague
- Denmark Technical University, Copenhagen
- École Polytechnique Fédérale de Lausanne
- Forschungszentrum Jülich
- ILL, Grenoble
- Institute for Energy Technology, Halden/Oslo
- Helmholtz-Zentrum for Materials and Energy, Berlin
- Helmholtz-Zentrum Geesthacht
- Linköping University, Sweden
- Mid-Sweden University
- NRI Rez, Prague
- Paul Scherrer Institute, Zurich
- Sincrotrone Trieste
- Technical University Delft
- Technical University Munchen
- University of Copenhagen
- University of Southern Denmark
- University of Perugia
- University of Milano-Bicocca


CSNS, Beijing
J-PARC, Tokai
Laval University, Quebec City
TRIUMF, Vancouver
BNL, Long Island
Argonne National Laboratory, Chicago
Fermi National Laboratory, Chicago
Jefferson Lab, Newport News
Stanford Linear Accelerator
SNS, Oak Ridge
ORNL, Oak Ridge
LANL, Los Alamos
Oslo University
IFE, Halden/Oslo
Uppsala University
Stockholm University
Studsvik, Nyköping
Linköping University
University of Riga
Aarhus University
Risö, Roskilde
DTU, Copenhagen
University of Copenhagen
Lund University
Accelerator Science and Technology Centre, Daresbury and Oxford
Cockcroft Institute, Daresbury
Rostock University
DESY, Hamburg
HZ, Geesthacht
ISIS, Oxford
John Adams Institute for Accelerator Science
TU Delft
HZ, Berlin
National Centre for Nuclear Research, Swierk
FZ Jülich
HZ Dresden-Rossendorf
TU Darmstadt
NRI Rez, Prague
Charles University, Prague
CEA Saclay, Paris
CNRS Orsay, Paris
KIT, Karlsruhe
TU München
AEKI, Budapest
Budapest Neutron Centre
PSI, Zürich
ÉPF, Lausanne
CERN, Geneva
Maribor University, Slovenia
ILL, Grenoble
Sincrotrone Trieste
ESS Bilbao
University of Milano-Bicocca
University of Perugia
CNR, Rome
CRS4, Sardinia
INFN, Catania

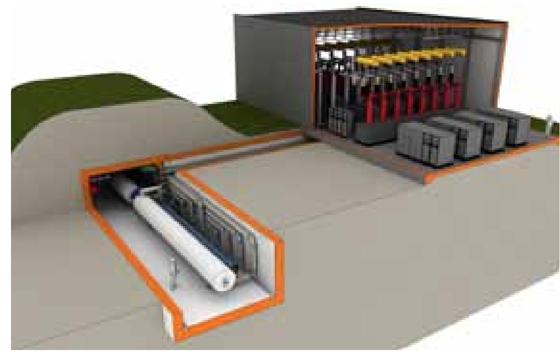
"This Conceptual Design Report represents the work of about 250 individual scientists and engineers around Europe and the rest of the world, with about 100 of them located in the central team in Lund in southern Scandinavia where the facility is to be built, with Sweden and Denmark as co-hosts. As this team has grown over the past two years, the work intensity and output has risen considerably. (...)

Over the next 12 months, work will be engaged upon which will result in a Technical Design Report being produced together with a series of other documents such as an updated Costing Report. These documents will demonstrate the sound foundation upon which the project is to be constructed and are a necessary, but not sufficient, achievement to lead on seamlessly to construction. Sufficiency would require our 17 partner countries to reach a political and financial agreement. We are confident that it is within their capabilities and resources to do so, and we look to them for such a signal."

Colin Carlile, ESS Director-General
In the foreword to the
ESS Conceptual Design Report

A NEW TECHNICAL DESIGN

The Machine Directorate, which is comprised of the Accelerator and Target Divisions, has, during 2011 and 2012, made substantial progress in coordinating the planning and development of the machine design. It has grown into an active and functioning organisation, able to evaluate and contribute to the R&D needed to ensure the success of the ESS project.



Cut-through of the ESS klystron hall and accelerator tunnel.

The number of ESS staff within the Machine Directorate has doubled to 53, with experts recruited in key areas from all over the world. The group now consists of highly qualified engineers and physicists with considerable experience, as well as several PhD and Masters students.

The main accomplishment has been the completion of the planning and design of the machine, with the publishing of the Conceptual Design Report (CDR) in the first quarter of 2012. We have also completed the first iteration of scheduling and costing of the construction phase. The updated Technical Design Report (TDR) and Cost Report will be ready in early 2013 and will form the basis for the decision to enter the Construction Phase.

The Conceptual Design Report

The CDR, published in February 2012, brought together a single integrated design covering all aspects of the ESS, but especially focusing on the target and accelerator. This guiding document has allowed us to move towards developing a detailed technical design, along with a costing and schedule for construction.

Steve Peggs, Deputy Head of Accelerator Projects, and editor of the ESS Conceptual Design Report.

Wolfgang Hees, Senior Engineer, Cryogenics; Rebecca Seviour, RF Systems Phycisist – Theory; and Stephen Molloy, researcher, ESS Accelerator Division.

THE ESS LINEAR ACCELERATOR

With the Conceptual Design fixed, the Accelerator Design Update (ADU) will soon be completed and the Technical Design Report is now being finalised. Work is being carried out by a pan-European collaboration of partner countries and ESS staff in Lund (pages 34-35, and 40).

A new baseline design

A key development has been the decision on a new baseline design that will generate proton pulses 2.86 ms long at a repetition rate of 14 Hz. The macro-pulse current of 50 mA will remain the same.

The accelerator configuration

The production of neutrons requires a complex machine infrastructure. An ion source is required to generate a beam of protons. A linear accelerator consisting of a long string of accelerating devices, then accelerates the protons up to a specified energy towards a target where neutrons are generated. The emitted neutrons are then focused and guided down beamlines to the experimental areas.

Designing an accelerator layout to achieve the required parameters – a beam power of 5 MW delivering a pulsed proton beam of 2.5 GeV energy – is challenging. Once the protons leave the ion source, they will be accelerated by alternating radio-frequency (RF) fields, first at 352.21 MHz and then at 704.42 MHz. Two important goals are that the acceleration efficiency is high and that there is enough flexibility in the configuration to allow for a future energy/power upgrade to perhaps as high as 3.5 GeV.

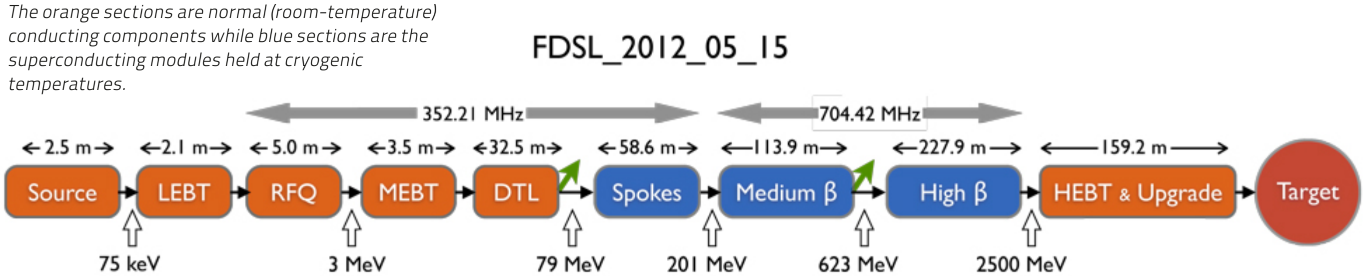
The accelerator will therefore be somewhat longer than in the initial new ESS design from 2009 – 590 m from the ion source to the target – to allow for the addition of further accelerating elements at a later date. The extra length will also enable the proton beam to be shaped so as to be able to alter the peak power levels at the target.

The various components of the accelerating infrastructure represent the major cost element in the ESS design, so a great deal of effort is going into obtaining the most efficient and cost-effective configuration. The accelerating elements of the linear accelerator consist of strings of different types of RF cavities, some of which are superconducting and so require cooling to liquid-helium temperatures. Their design has been optimised to achieve the shortest possible accelerator.

The ion source for ESS will be a compact electrons cyclotron resonance source (ECR) in which electrons are stripped from hydrogen gas to generate protons.

The first model of an ESS cryo-module, in the hands of its constructor, Wolfgang Hees.

General layout of the ESS accelerator infrastructure. The orange sections are normal (room-temperature) conducting components while blue sections are the superconducting modules held at cryogenic temperatures.



The proton beam from the ion source is then transported through a Low Energy Beam Transport (LEBT) section to the Radio-Frequency Quadrupole section (RFQ) where the protons are "bunched" and accelerated up to 3 MeV. The proton beam then passes through the Medium Energy Beam Transport (MEBT) section where it is matched to the first normal-conducting Drift-Tube Linac (DTL) structures, and reaches an energy of 70 MeV.

The superconducting sections

The first superconducting RF (SCRF) section contains double-spoke resonator cavities that take the 50 MeV beam to 200 MeV. These are a new type of RF cavity not yet used in large accelerator projects, and they are expected to be robust and efficient. Beyond this, the first family of superconducting elliptical cavities will take the beam to 600 MeV and the second to the full energy of 2.5 GeV. Up to eight RF cavities will be housed in a cryomodule, each of which will be separated by normal-conducting quadrupoles in a segmented design. This is a recent change from a previous design incorporating a continuous or hybrid cryosystem, and it facilitates any repairs and adjustments.

The new, longer pulse-length specification means that the RF pulses have to generate more power for a longer time. In large particle-accelerating systems, each RF cavity consists of a klystron and modulator. New types of modulators are now being investigated that will give the required, very high power.

An important aspect of the accelerator design is to achieve a sustainable research facility (page 21) through the minimisation of power consumption and the recycling of all heat released in the process of cooling. The accelerating infrastructure is of course the major contributor to power consumption, and efficiency as well as upgradeability of the modulators is a key factor in the choice of design. Experience from other spallation neutron sources indicates that the RF accelerating components are responsible for most of the heat emission from the accelerator. As explained on page 21, the aim is to use these hot systems to deliver water hotter than 70°C for commercial use in the regional district heating system.

We have also taken the decision not to synchronise the accelerator system operation with the AC power grid (at 50 Hz), which – though traditionally used to drive an accelerator's timing structure – can adversely affect the performance of the neutron choppers.

A GLOBAL DESIGN COLLABORATION

The design of the ESS accelerator is almost complete, and work is now ongoing to finalise the Technical Design Report. The work is being carried out by a pan-European collaboration of partner laboratories and ESS staff in Lund. The Technical Project Plan contains seven major work packages, each led by a different partner institution working with other collaborating institutes. Each work package contains several work units, with leadership distributed among all participants.

A Collaboration Board has been set up to act as a direct link between the participating institutes and universities and ESS as they develop the accelerator projects. The board includes representatives from all institutes and universities that have a contract with ESS. Philippe Chomaz from CEA Saclay was elected chairman.

Second Open Collaboration Meeting on Superconducting Linacs for High Power Proton Beams (SLHiPP-2), Catania, May 2012.

Andreas Jansson, group leader Beam Instrumentation; Thomas Shea, senior scientist; Caroline Prabert, personal assistant, ESS Accelerator Division.

Accelerator Design Update Collaboration

The work package leaders are responsible for:

- Delivering the TDR by the end of 2012;
- Estimating the accelerator cost with a precision better than 20% in most cases;
- Providing a safe baseline design with technical choices that will enable an immediate 2013 start on the generation of engineering design specifications, detailed drawings and the construction of "late prototypes";
- Assuring a viable critical path to commissioning and operation by beginning work on "early prototypes" to be completed before the end of 2012, and also on other prototypes;
- Working with the lead institution directorate to manage and monitor work package performance;
- Taking into account energy budgets and sustainability.

The ADU is also drawing extensively from the wide experience of institutes and laboratories around the world. Several seminars on accelerator technology have been held at ESS, given by experts from other accelerator laboratories. Many of them are potential partners in ESS, and are already participating in the work packages.

Work packages for the accelerator design

(coordinating institution within brackets)

- **WP1– Management coordination (ESS)**
Project management, technology coordination, systems engineering, quality assurance and configuration control.

- **WP2 – Accelerator science (ESS)**
Beam physics, control systems, beam instrumentation, and RF modelling.

- **WP3 – Infrastructure services (Tekniker, Bilbao)**
HVAC, cryogenics system, supply of cooling water, electricity and networking (now part of the Infrastructure Design Update Project and not part of the Accelerator Design Update Project).

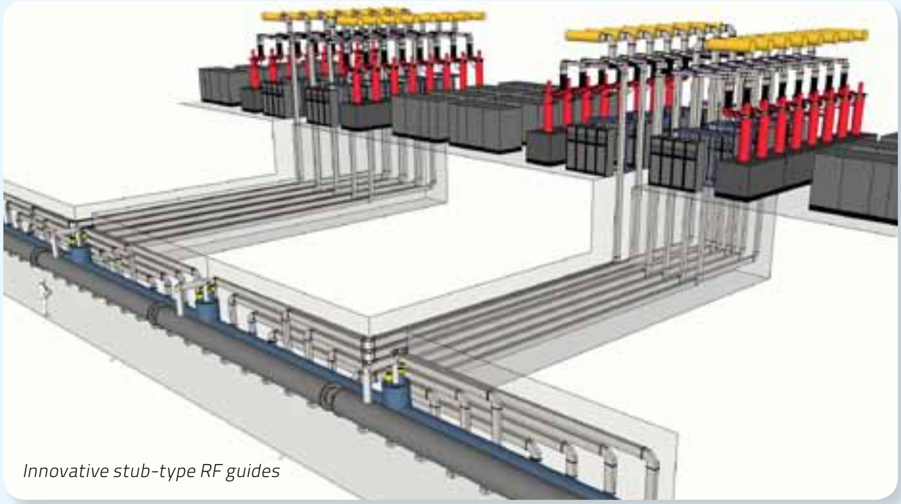
- **WP4 – Superconducting RF spoke cavities (IPN Orsay, Paris)**
Spoke cryomodules, including the cavity and the couplers.

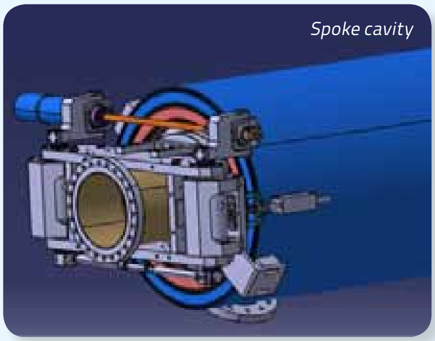
- **WP5 – Superconducting RF elliptical cavities (CEA Saclay, Paris)**
Cryomodules for medium and high beta elliptical cavity sections.

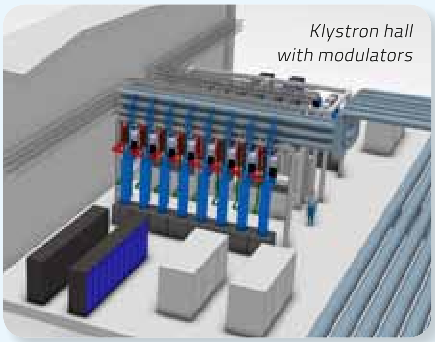
- **WP6 – Front-end and normal-conducting (NC) accelerator (INFN, Catania)**
Front-end elements, up to the warm-to-cold transition in the accelerator (proton source, beam transport system, radio-frequency quadrupole and drift tube linac).

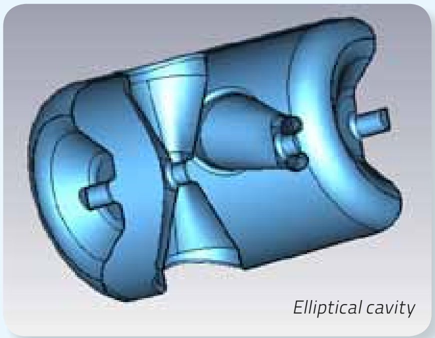
- **WP7 – Beam transport, normal-conducting magnets and power supplies (Aarhus University)**
High-energy beam transport (HEBT) system, a steering and a focusing concept, definition of standards for the normal conducting magnets, the corresponding power supplies, beam dumps and collimators, and sustainability of power supplies.

- **WP8 – Radio-frequency systems (Uppsala University)**
Coordination of a strategy for the power supplies and modulators for the RF systems.


Innovative stub-type RF guides


Spoke cavity


Klystron hall with modulators


Elliptical cavity

FROM PLANNING TO EXECUTION

The majority of research collaborations for the accelerator work have now been formalised. All the main contracts have been signed for the Accelerator Design Update project; some of them also include contributions to the Accelerator Preparation-To-Build (AP2B) phase. Of particular importance are the contracts signed with IPN Orsay (WP4), CEA Saclay (WP5), Aarhus University (WP7) and Uppsala University (WP8). They cover the prototyping and testing of the acceleration elements, which are a major priority for the ADU/AP2B phases.

The majority of the deliverables are so far on schedule and collaborations are working well. The baseline design for the accelerator has been refined, with end-to-end simulations, and some of the transition energies between accelerator sections have changed. We are now building up a broader network with all our collaborators, including CERN, DESY in Germany and Laval University in Canada. Prototyping of components has started and should be complete by the end of 2012.

The AP2B sub-project planning is making progress and a project plan for the first two years of this project, which ends in 2016, was put in place in November 2011.

Prototyping and testing

The first work package to be launched was the RF testing at Uppsala University (WP8). A test stand is being built. The ESS AD-RF group (WP2) is presently working on the specifications in collaboration with the University of Laval.

Prototyping of the superconducting RF cavities has started with several cavities already manufactured. Plans and contracts are being adjusted so that cavity prototypes can feed information into the Construction Phase.

The RF elliptical cavity prototypes are under commissioning and being tested at CEA Saclay. Discussions are now taking place with CEA Saclay and DESY on the possible re-use of the production and testing facilities used for DESY's free electron laser facility (XFEL) in Hamburg. This facility could now be used for the production of ESS RF cavities and cryomodules.

A joint ESS/CERN prototype spoke cryomodule has been designed by IPN Orsay and reviewed in 2011. It will be assembled and tested at CERN after 2012. ESS is contributing four engineers for the SCRF work at CERN and a modulator for the test stand. The CERN prototype cryomodule will also be a learning platform for ESS engineers and designers. Discussions with potential partners for these cryomodules are also in progress. Possible partners are JLAB and Fermilab in the US, and RRCAT in Indore, India.

Modulators

Two of the largest budget items for the accelerator are the two types of RF modulators which need to provide very high peak power. ESS has procured and ordered one modulator from Puls Plasmatechnik Gmbh, Germany, for the testing of the joint ESS/CERN prototype cryomodules at CERN. It is of a bouncer type and should be close enough in specifications to the ESS modulators to serve as a first prototype, and will ease the process towards the large order on modulators for ESS in 2013.

Another modulator, of the resonant type, will be designed and constructed for the RF test stand in Uppsala. The ESS AD-RF group is setting up a strategy for the modulators in close collaboration with Laval University to ensure that we have options for these critical components. The second prototype can be built either at one of the collaborating institutes or built-to-print by industry.

Procurement

The schedule requires ESS to place orders on major systems such as modulators, klystrons and cavities by 2013. An equipment list has been drafted, and costing of these items has been done. A small task force – with a procurement specialist, the programme office and technical specialists – has been set up to analyse when and how the first large orders of key equipment can be placed.

The first ESS accelerator – built in ice.

TARGET CONCEPT: A DESIGN MILESTONE

The Target Station Division – Luca Zanini, group leader neutronics; Atefeh Sadeghzadeh, junior control engineer; Francois Plewinski, group leader, target engineering; Konstantin Batkov, neutronics simulation specialist; Yong Joong Lee, system engineer for project support; Rikard Linander, system engineer (partly visible).

The target station is where the neutron beams are produced for experiments. Fast, high-energy neutrons are released by spallation from a target consisting of neutron-rich material – a heavy metal – when a high-energy beam of protons from the accelerator impinges on it. The neutrons, which are travelling at 10% of the speed of light, are then slowed down to roughly the speed of sound, using moderators and reflectors, to provide intense pulses of neutrons at velocities and energies that are useful for experiments. These are delivered to the instrument suites through beam ports radiating from the shielded target area.

Key features of the target station are therefore the target itself, the neutron moderator, pre-moderator and reflector system, and the beam-extraction system. The target station must also incorporate a powerful cooling system able to absorb the heat generated by the powerful 5 MW proton beam hitting the target. Besides the large amount of neutrons generated by the spallation process, radioactive isotopes and radiation is also generated by both spallation and by general activation of components. The shielding material inside the 12 m diameter of the target monolith will prevent unwanted ionising radiation from escaping into the environment from the target station.

A major technical decision

The baseline for the target design has been one of the major technical decisions for the ESS. The decision to propose a rotating tungsten target was taken by ESS in May 2011, and endorsed by the Steering Committee in September 2011. This allowed further detailing of the target station design update (TSDU), including moderators and the beam extraction, but most importantly, the main parts of the licensing documentation could be completed (page 20). The beam extraction has been engineered and the moderators specified during 2012.

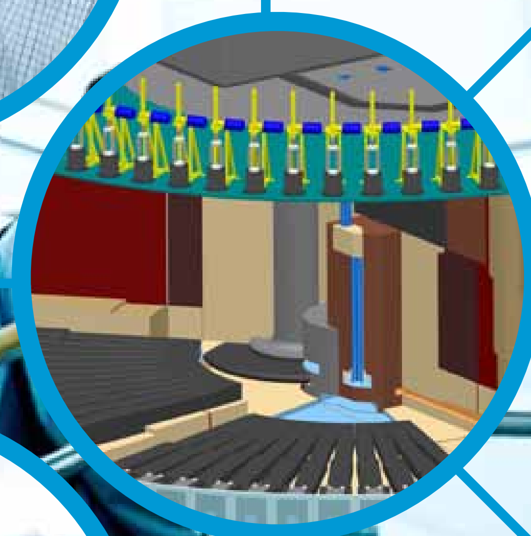
A decision on the cooling mechanism has been a recent major focus of the Target Division. Following the Steering Committee recommendations, both water cooling and helium cooling have been studied in parallel. A Water Cooling Task Force, consisting of experts from partners in our collaboration, was established to look at the key technical and safety issues. A permit to use helium cooling has already been applied for. In February 2012, a baseline conceptual design for helium cooling, including the necessary containment systems and barriers, was evaluated by the TAC as the most viable option. This was presented to the STC in May 2012.

The new target station design

The performance of the target station in terms of both neutron yield and safety critically depends on the choice of the target material used and the provision of adequate cooling. A further critical requirement is that the target station operates efficiently in full compliance with legal safety standards with respect to the release of radioactivity and disposal of radioactive waste. The design must allow for the control and mitigation of potential operational accidents, and be robust enough to withstand severe external impacts such as earthquakes or plane crashes.

The target

A rotating tungsten wheel is the baseline option for the target, which distributes the irradiation over a large volume of target material. Metallic liquid lead-bismuth eutectic (LBE) is being retained as a comparative target for licensing purposes. Both of these options offer comparable neutron-yield performance, and satisfy the ESS safety goals in terms of waste release and disposal under normal operation and in case of accidents. After periods of operation, the target emits a significant amount of "after-heat", which gradually decays. Both technologies are new for spallation sources, none of the established target designs being adequate for the higher power level of ESS.



*From the top: Ferenc Mezei, Head of Target Station Division.
Francois Plewinski, group leader, Target Engineering, and
Yong Joong Lee, system engineer for project support.
Conceptual cross-section of target building with instrument hall.
Design of the target monolith with rotating tungsten wheel,
moderators and beam ports.
Konstantin Batkov and Alan Takibayev, neutronics simulation
specialists, and Luca Zanini, group leader, Neutronics.
Patrik Carlsson, Director for Accelerator
and Target Station.*

The moderators

The ESS target station will contain two liquid-hydrogen moderators with a volume of about 2.5 l each, partially surrounded by water pre-moderators of comparable volume. The moderators are placed inside an inner reflector of about 1 m^3 of beryllium. These components will be kept at their desired operational temperature by dedicated cooling systems. These systems will not emit significant after-heat.

Beam extraction

The beam-extraction system will consist of more than 40 beam tubes arranged in four sectors with a 60° to 65° horizontal angular spread. Each beam tube will be equipped with a beam shutter within the target monolith to assure that the residual radiation escaping through the closed beam line when the target station is not in operation is reduced to safe working levels at the wall of the target monolith. This monolith will be surrounded by a combination of integrated and individual radiation shielding for each beam line, which guarantees safe working access to the areas outside of these shielding structures at all times, including full power operation.

Containment of radioactivity

The target monolith will provide two barrier layers of containment against the escape of volatile and airborne radioactive materials, both at normal operation and in case of incidents, and will be continuously vented and filtered. The unavoidable residual escape of radioactive effluents in amounts below the limits authorised in the operational license will be ventilated after having been collected from all facility buildings housing equipment, including the target.

Safe replacement of components

The mechanical parts exposed to the proton beam and the high-radiation environment around the target will have a limited lifetime ranging from a few months to several years, which is short compared with the several decades of ESS operation. These components will become highly radioactive during operation. Their periodic replacement, handling and storage before disposal will be achieved using remote control and adequate protective equipment, including hot cells and casks at various locations around the target monolith.

The cooling system

The ESS proton beam represents a five-fold leap in power over other neutron spallation sources such that cooling presents considerable challenges. Two cooling systems have been considered. Water has been used to cool previous tungsten targets but could be less effective and safe at the power level of ESS. An effective water-cooled system is likely to be complex and would take longer to license. An inherently safer and simpler-to-license alternative is helium-gas cooling. Helium has not been used for cooling spallation neutron sources before, so there is less experience to build on in the design and development of appropriate engineering systems.

The Target Design Update Collaboration

In 2012, a lead engineer and deputy division head were recruited to lead the transition to the Construction Phase. Most of the efforts of the Target Division has been focused on engineering and systems development. A world-wide network of collaborations has been built up to provide additional expertise. These include specialists from ESS Bilbao, CERN, Forschungszentrum Jülich and the Karlsruhe Institute of Technology in Germany, the Institute of Physics at the University of Latvia, ISIS at the STFC Rutherford Appleton Laboratory in the UK, the Paul Scherrer Institute in Switzerland, the Technical University of Denmark, the National Research Council (CNR) in Italy and the Budapest Neutron Centre (BNC) in Hungary. Leading neutron spallation sources outside Europe are also contributing: the Spallation Neutron Source at Oak Ridge National Laboratory, and Lujan Neutron Scattering Center at the Los Alamos National Laboratory in the US, and the Japan Proton Accelerator Research Complex, J-PARC.

At the beginning of 2012, the collaboration for the target-station design update finalised its project specification, and the Steering Committee gave a mandate to negotiate and sign the contracts for the Target Collaboration. Detailed work-package and work-unit structure, and technical-task sharing between ESS and the collaboration partners, have been established:

Work packages (WP) and work units (WU) for the target station design

(coordinating institution within brackets)

- **WP01 – Project management, coordination of global design efforts and overall system integration (ESS, Lund)**

Work units: QA, cost-time estimation, codes and risk analysis, operating modes, system integration, nuclear safety, systems simulation of the coupled target station, CDR and TDR.

- **WP02 – Target performance modelling and optimisation (ESS, Lund)**

Work units: database on spallation source performance and layout, software evaluation, neutronic studies of target-reflector-moderator performance and of reflector performance, advanced moderators, optimisation of beam extraction, coupling to the accelerator, neutronic calculations for engineering design.

- **WP03 – Material properties (PSI, Switzerland)**

Work units: materials database content, spallation materials parameters, properties of structural materials, of non-structural materials for solid target and for reflector, corrosion/erosion properties.

- **WP04 – The rotating tungsten helium-cooled target, RoTHeTa, concept (replaceable systems) (ESS, Lund)**

Work units: conceptual design of the target wheel and of the beam entrance window and target envelope, instrumentation.

- **WP05 – The RoTHeTa concept (permanent systems) (FZJ, Germany)**

Work units: design of the target wheel-connection, support, design of the helium cooling circuit.

- **WP06 – Liquid metal target (KIT, Germany)**
Work units: conceptual engineering design, instrumentation of liquid metal flows, trolley design and interface to monolith, ancillary systems, benchmarking of pressure-wave propagation models.

- **WP07– Premoderator, moderator and reflector engineering design (FZJ, Germany)**
Work units: collection or data for moderator and reflector, engineering design of premoderator plug and of premoderator permanent circuits.

- **WP08 – Shielded target monolith system and beam extraction (FZJ, Germany)**
Work units: beam extraction system, second barrier-proton-beam window, target monolith design, irradiation ports design.

- **WP09 – Infrastructure services and utilities (ESS, Lund)**
Work units: cooling systems, supply and storage of gas and liquids, heating, ventilation and air-conditioning, fire protection system, cryogenic helium, secondary cooling systems.

- **WP10 – Hot cell, handling of used PMR outside TG shielding monolith and beam dumps (ESS, Lund)**
Work units: design of hot cells, high-bay shielded casks and beam dump.

- **WP11 – Waste disposal, emissions, dismantling and decommissioning (ESS, Lund)**
Work units: assessment of radioactive inventory derivation of wastes, waste classification, management of operational emissions and wastes and of waste from decommissioning, preliminary IEA analysis and derived release limits for operation, preliminary radiological impact assessment for conceivable accidents.

- **WP12 – Control systems for target station (ESS, Lund)**
Work units: target station sequences, target station main control description, control system and instrumentation of target loop.

ESS INNOVATION AND INDUSTRY STRATEGY

Juan-Tomás Hernani, ESS Secretary-General for Innovation.

As the largest current scientific infrastructure project in Europe, which relies on the generation of advanced technologies, ESS provides exciting opportunities for wealth and employment creation. We are now implementing a wide-ranging but focused integrated strategy for stimulating growth of the European economy through working in close collaboration with industry, governments and our scientific partners. ESS has a new Secretary-General for Innovation, Juan Tomás Hernani, who is leading the ESS innovation and industry strategy, which will continue through all phases of ESS construction and operation to the benefit of all partner countries and society in general.

THE GOALS OF THE STRATEGY:

Governance and communication

ESS wants to bring industry directly into the ESS Programme. An important goal is to set up an Industry Board representing 20 to 30 major industries whose competitiveness will be enhanced by involvement with the various phases of ESS development. ESS also hopes to involve start-up businesses and SMEs.

Knowledge transfer

Knowledge transfer through a continuous cooperation between scientists and engineers, as well as between ESS and industry, is a significant component of our innovation and industry strategy.

ESS expects to play a significant role in stimulating employment in Europe. ESS itself will employ about 500 people, but it is also expected that the long-term growth effect on jobs through technical know-how, scientific breakthroughs, innovations and spin-offs will be significant. There are several studies made by public authorities which have analysed this question in depth.

These initiatives are being launched during the next few months with the aim of having them all up and running in the beginning of 2013.

Investment

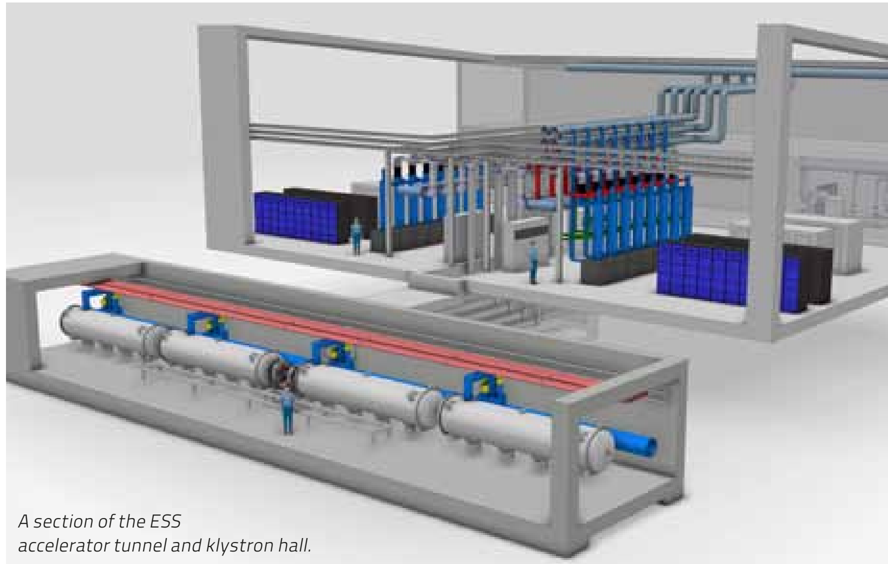
ESS aims to stimulate industry investment across a wide range of technological sectors relevant to its programme – from construction and energy provision to the development of new technologies emerging from the R&D programmes aimed at meeting the challenges of ESS science. These include the support of spin-off companies as well as technology transfer to existing businesses.

Industrial Liaison Officers

A key element of procurement from industry is to enhance opportunities for the supply of goods and services through a network of Industrial Liaison Officers located in partner countries.

SCIENTIFIC-INDUSTRIAL LIAISON OVER THE PAST YEAR

ESS will provide significant new opportunities for European industry in many areas: advanced materials development, electronics, chemicals and pharmaceuticals, energy supply and transport, engineering, domestic and personal products, foods and healthcare. The combination of ESS and other large-scale research facilities in the Baltic region, such as MAX IV in Lund and DESY in Hamburg, offers a powerful research infrastructure for the support of innovation and skills development in Europe.



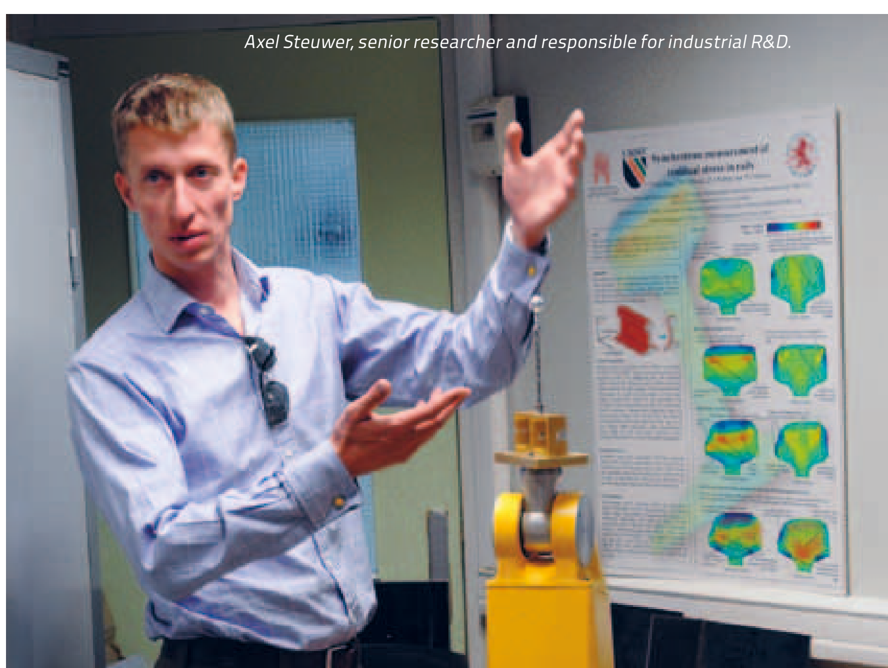
A section of the ESS accelerator tunnel and klystron hall.

Through presentations and lectures, ESS is already alerting organisations and companies to its role as an advanced R&D tool for enhancing technological competence. During the past year, ESS engaged with many organisations that share a similar purpose in promoting technological competence and global competitiveness, and who recognise the positive impact of the ESS and MAX IV facilities on industry and development. These included:

- "ESS MAX IV in the Region", an EU-supported project to prepare for the establishment of ESS and MAX IV in the Skåne (Scania) province in southern Sweden (page 22);
- Science Link, also part-financed by the EU through the European Regional Development Fund, which aims to build a network of neutron and photon (X-ray) facilities to foster innovation and entrepreneurship in the Baltic region;
- The Danish-sponsored Big Science Secretariat, whose goal is to build a bridge between Danish companies, research institutions and large international research infrastructure projects;
- Packbridge, an international network for the packaging industry in Scania, which is very strong in Sweden and is likely to benefit from materials research carried out at ESS;
- Øresund Materials Innovation Community (ØMIC), which aims to develop a common innovation strategy to exploit the Øresund region's strengths in materials R&D;
- VINNOVA, the Swedish Governmental Agency for Innovation Systems, which invests in R&D, and brings together industry, academia and the public sector.

ESS also made presentations to Swedish companies:

- Scania, which makes trucks, coaches and engines;
- SCA, which produces and markets personal-care products, tissue, packaging, publication papers and solid-wood products;
- ABB, which is a leading supplier of products and systems for power transmission, and process and industrial automation;
- Swerea IVF, which offers advanced R&D and consulting services to the manufacturing and engineering industry.



Axel Steuwer, senior researcher and responsible for industrial R&D.

ESS STAFF

As of 15 November 2012

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Maria Herbst	Personal Assistant
Tina Nilsson	Administration Officer
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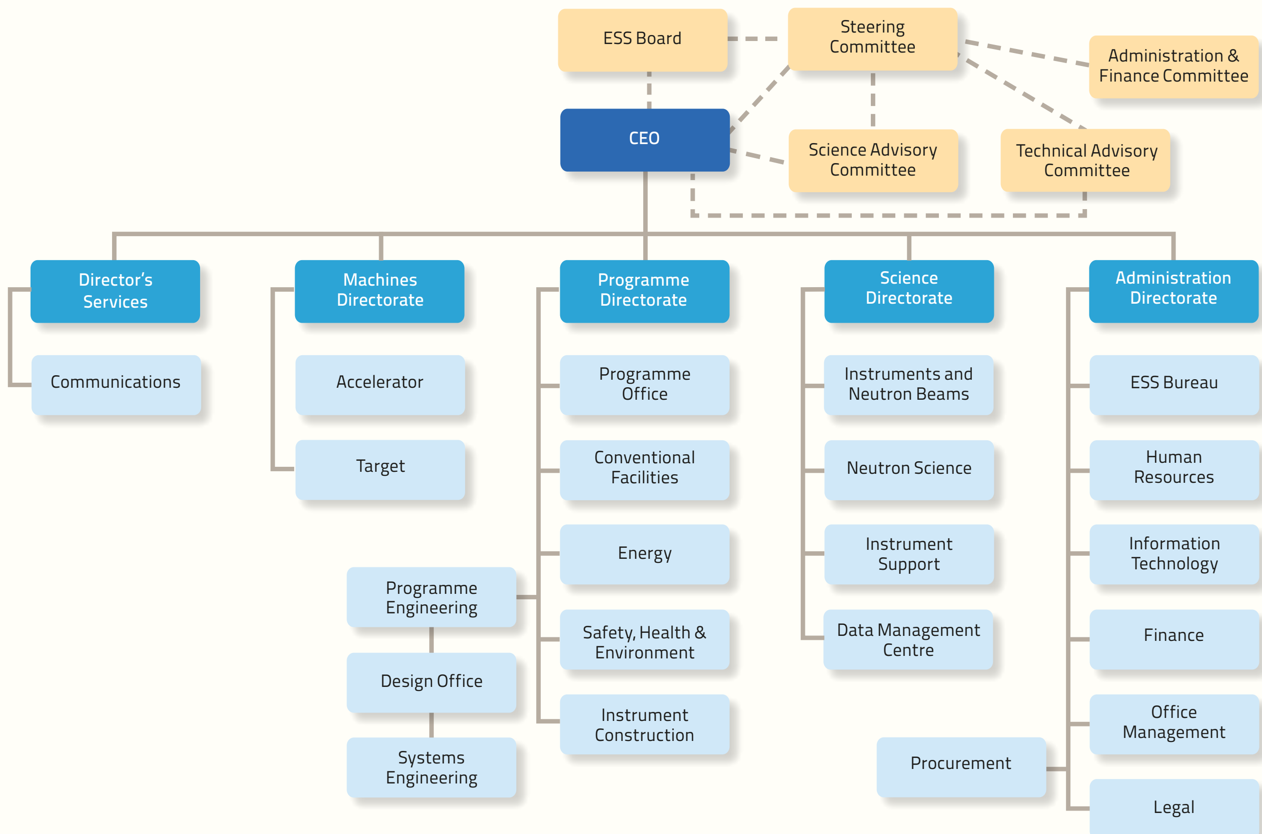

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ESS SEMINARS, WORKSHOPS & CONFERENCES

CONFERENCES

Science & Scientists @ ESS, Prague, July 2011.

Science & Scientists @ ESS, Berlin, April 2012.

Brains & Bridges – Research, Innovation and Growth in the Baltic Sea Region. Co-organised with Baltic Development Forum and Region Skåne. Malmö, June 2012.

IKON MEETINGS

IKON 1. First In-Kind Contributions Meeting for Neutron Science at ESS, Lund. 8 September 2011.

IKON 2. Second In-Kind Contributions Meeting for Neutron Science at ESS, Malmö. 9-10 February 2012.

ESS SCIENCE SYMPOSIA

(see page 22).

NEW SCIENCE AT ESS AND MAX IV SEMINARS

"Neutrons in the quasi-particle zoo", Henrik Rønnow, Laboratory of Quantum Magnetism, École Polytechnique Fédérale de Lausanne. September 2011.

"Magnetic response of functionalised lipid bilayers", J. Kohlbrecher, Laboratory for Neutron Scattering, Paul Scherrer Institut, Switzerland. September 2011.

"Exploring subtle structures – neutron and synchrotron diffraction studies of electronic materials", J. Paul Attfield, Centre for Science at Extreme Conditions and School of Chemistry, University of Edingburgh, UK. October 2011.

"From single crystal diffractometry to femtosecond nanocrystallography", Inger Andersson, Department of Molecular Biology, Swedish University of Agricultural Science, Uppsala, Sweden. November 2011.

"The quintessence of X-ray microscopy", David Attwood, University of California at Berkeley, US. January 2012.

"New methods to understand steady and transient flows in complex fluids", Norman J Wagner, University of Delaware, USA. 13 August 2012.

"Extending Crystallographic Data Management to Include the Routine Archiving of Raw Experimental Data ; Implications for neutron and synchrotron radiation facilities", John R Helliwell, University of Manchester. 21 November 2012.

OTHER SEMINARS, WORKSHOPS, ETC

Neutron Instrument Design School, Lund & Simrishamn, 7 June – 17 June 2011.

Technical Challenges Workshop on LU ESS MAX IV partnership, Lund. 30 November 2011

"Spring Time for Life Science! How Can We Get the Most out of Sweden's Largest Research Investments Ever?", Seminar held during the Almedalen political week, and co-arranged with MAX IV Laboratory, Lund University, Lundamark AB and Medicon Village. 5 July 2012.

ENERGY WORKSHOPS

"Which fish make the best scientist?". A seminar on energy, food and science, Lund. 21 June 2012.

Workshop on Energy for Sustainable Science, Lund. Co-organised by ESS, CERN and ERF. October 2011.

ESS TARGET STATION AND SAFETY SEMINARS

"Safety and Licensing of Large Nuclear Facilities in an International Environment", Jean-Philippe Girard, ITER, Cadarache. 9 June 2011.

ESS ACCELERATOR WORKSHOPS

ESS/SPL (Superconducting Proton Linac) Costing Meeting, CERN, Geneva. 30 May 2012.

Second Open Collaboration Meeting on Superconducting Linacs for High Power Proton Beams (SLHiPP-2), Catania, Sicily. 3 - 4 May 2012.

ESS Klystron Modulator Workshop, Lund. 24 - 25 April 2012.

Beam Diagnostics Mini-Workshop, Lund. 20 - 21 March 2012.

ESS End-to-End Beam-Dynamics Workshop, Lund. 31 October - 1 November 2011.

ESS Warm Linac Meeting, Legnaro, Italy. 28 February 2012.

ESS and SPL Collaboration Meeting, Paris. 30 June - 1 July 2011.

RF Power Source Workshop, Lund. 13 June - 14 June 2011.

ESS ACCELERATOR SEMINARS

Accelerators, Giant and Compact – for Science, Industry and Society. Andrei Seryi. 12 May 2011.

Timing and Open Hardware, Javier Serrano. 12 May 2011.

RF Cavity Studies at RHUL: Simulation and Measurement, Rob Ainsworth. 19 May 2011.

Beam Diagnostics for Project-X, Manfred Wendt. 20 May 2011.

Review of Heavy-Ion Induced Desorption Studies for Particle Accelerators, Edgar Mahner. 27 May 2011.

Design of Project-X LINAC, Nikolay Solyak. 9 June 2011.

Online Modeling at Fermilab LINAC, David McGinnis. 27 June 2011.

Data Management by Cube, Suzanne Gysin. 27 June 2011.

The Story on Advancing Linear Accelerator ... and Keeping it Straight, Deepak Raparia. 28 June 2011.

Insights and Lessons Learned: Large Facility Construction, Daniel R. Lehman. 21 Sep 2011.

CW SRF Systems with Ingot Niobium and Their Applications, Ganapati Myneni. 11 Oct 2011.

Construction of the SPIRAL 2 Buildings and Conventional Facilities, Jean-Michel Lagniel. 2 Nov 2011.

Personal Summary of Work Carried Out at Daresbury Laboratory: ILC/CLIC, NLS, ALICE and ITER, Juan Fernandez Hernando. 16 Nov 2011.

Building Large Scale Facilities; Lessons Learned at ITER and SNS, Norbert Holtkamp. 18 Nov 2011.

Machine Protection Systems and Its Realisation at LHC, Rüdiger Schmidt. 15 Mar 2012.

Safety Issues at a High Energy Physics Lab, Lessons Learned from CERN, Ralf Trant. 30 Mar 2012.

Ingot Niobium Technology for Future SRF Linacs, Ganapati Myneni. 7 May 2012.

PUBLICATIONS BY ESS STAFF

MONOGRAPHS BY ESS STAFF WITH ESS AFFILIATION, JUNE 2011 - JULY 2012

"The assembly of casein proteins and implications for casein micellar structure". S Ossowski. Licentiate thesis, Department of Physical Chemistry, Lund University, and European Spallation Source, 2012.

REFERENCED PUBLICATIONS BY ESS STAFF WITH ESS AFFILIATION, JUNE 2011 – JULY 2012

"RNA and DNA Association to Zwitterionic and Charged Monolayers at the Air-Liquid Interface". A Michanek, M Yanez, H Wacklin, A Hughes, T Nylander, E Sparr. Langmuir, vol. 28, issue 25, 2012.

"Short-range order of Br and three-dimensional magnetism in (CuBr) $LaNb_2O_7$". AA Tsirlin, AM Abakumov, C Ritter, PF Henry, O Janson, H Rosner. Physical Review B, vol 85, issue 21, 2012.

"Low-temperature ferroelectric phase and magnetoelectric coupling in underdoped La_2CuO_{4+x}". Z Viskadourakis, I Radulov, AP Petrovic, AP , S Mukherjee, BM Andersen, G Jelbert, NS Headings, SM Hayden, K Kiefer, S Landsgesell, DN Argyriou, C Panagopoulos. Physical Review B, vol. 85, issue: 21, 2012.

"Systematic investigation of residual strains associated with WC-Co coatings thermal sprayed onto metal substrates ". AM Venter, T Pirling, T Buslaps, T , OP Oladijo, A Steuwer, TP Ntsoane, LA Cornish, N Sacks. Surface & Coatings Technology, vol. 206, issue 19-20, 2012.

"Charge Order at the Frontier between the Molecular and Solid States in $Ba_3NaRu_2O_9$". SAJ Kimber, MS Senn, S Fratini, H Wu, AH Hill, P Manuel, JP Attfield, DN Argyriou, DPF Henry. Physical Review Letters, vol 108, issue 21, 2012.

"A new IQ detection method for LLRF". F Qiu, J Gao, HY Lin, R Liu, XP Ma, P Sha, Y Sun, GW Wang, QY Wang, B Xu, RH Zeng. Nuclear Instruments & Methods in Physics Research Section A – Accelerators Spectrometers Detectors and Associated Equipment, vol 675, 2012.

"Pressure-dependent spin fluctuations and magnetic structure in the topologically frustrated spin glass alloy Y(Mn0.95Al0.05)(2)". MTF Telling, KS Knight, FL Pratt, AJ Church, PP Deen, KJ Ellis, I Watanabe, R Cywinski. Physical Review B, vol 85, issue:18, 2012.

"B4C thin films for neutron detection". C Höglund, J Birch, K Andersen, T Bigault, JC Buffet, J ; Correa, P van Esch, B Guérard, R Hall-Wilton, J Jensen, A Khaplanov, F Piscitelli, C Vettier, CW Vollenberg, L Hultman. Journal of Applied Physics, vol. 111, issue 10, 2012.

"Lattice anisotropy in uranium ternary compounds: UTX". S Maskova, AM Adamska, L Havela, NTH Kim-Ngan, J Przewoznik, J Danis, K Kothapalli, AV Kolomiets, S Heathman, H Nakotte, H Bordallo. Journal of Alloys and Compunds, vol. 522, 2012.

"Collapsed tetragonal phase in $Ca(Fe_{1-X}Co_X)_2As_2$ stabilized by pressure: Structural studies using single-crystal neutron diffraction". K Prokes, B Ouladdiaf, L Harnagea, S Wurmehl, DN Argyriou, B Buchner. Physical Review B, vol 85, issue 10, 2012.

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"Synchrotron diffraction study of dissolution and precipitation kinetics of hydrides in Zircaloy-4". O Zanellato, M Preuss, JY Buffiere, F Ribeiro, A Steuwer, J Desquines, J Andrieux, B Krebs. Journal of Nuclear Materials, vol. 420, issue 1-3, 2012.

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"First experimental implementation of pulse shaping for neutron diffraction on pulsed sources". M Russina, G Kali, Z Santa, F Mezei. Nuclear Instruments & Methods in Physics Research Section A – Accelerators Spectrometers Detectors and Associated Equipment, vol 654, issue: 1, 2011.

"Structure of DNA-Cationic Surfactant Complexes at Hydrophobically Modified and Hydrophilic Silica Surfaces as Revealed by Neutron Reflectometry". M Cardenas, H Wacklin, RA Campbell, T Nylander. Langmuir, vol 27, issue 20, 2011.

"Metamagnetism and soliton excitations in the modulated ferromagnetic Ising chain CoV_2O_6". SAJ Kimber, H Mutka, T Chatterji, T Hofmann, PF Henry, HN Bordallo, HN, DN Argyriou, PJ Attfield. Physical Review B, vol 84, issue 10, 2011

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"Spectroscopic explorations of the nature of protein dynamics". F Mezei. European Biophysics Journal with Biophysics Letters, vol 40, suppl 1, 2011.

"An investigation into the effect of weld technique on the residual stress distribution of 3CR12 (DIN 1.4003) built-up structural sections". JJ Klopper, RF Laubscher, A Steuwer, MN James. Proceedings of the Institution of Mechanical Engineers Part L – Journal of Materials Design and Applications, vol. 225, issue L3, 2011.

"Mixing thermodynamics of $TM_{1-X}Gd_XN$ (TM=Ti, Zr, Hf) from first principles". B Alling, C Hoglund, R Hall-Wilton, L Hultman. Applied Physics Letters, vol 98, issue 24, 2011.

"First Implementation of Novel Multiplexing Techniques for Advanced Instruments at Pulsed Neutron Sources". M. Russina, F. Mezei, G. Kali, Journal of Physics, conference series, 340 (2012) 012018

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"The ESS accelerator". M. Lindroos, S. Molloy, S. Peggs, K. Rathsman, R. Zeng, R. Duperrier, R. Ruber and R. Ainsworth, Proc. SRF2011, Chicago, IL, USA, p. 994.

"Bead-pull test bench for studying acceleratoing structures at RHUL". R. Ainsworth, G. Boorman, A. Lyapin, S. Molloy A. Garbayo, P. Savage, A.P. Letchford and C. Gabor, Proc. IPAC 2011, p. 187.

"RF modeling plans for the European Spallation Source". R. Ainsworth, M. Lindroos, S. Molloy, R. Zeng and R. Ruber, Proc. IPAC2011, San Sebastián, Spain, p. 56.

"Layout of the ESS linac". H. Danared, M. Eshraqi, W. Hees, A. Jansson, M. Lindroos, S. Peggs and A. Ponton, Proc. IPAC2011, San Sebastián, Spain, p. 2631.

"Compensation of effect of malfunctioning spoke resonators on ESS beam quality". M. Eshraqi, Proc. IPAC2011, San Sebastián, Spain, p. 2643.

"Design and optimization of the ESS linac". M. Eshraqi, Proc. IPAC2011, San Sebastián, Spain, p. 2634.

"ESS linac, design and beam dynamics". M. Eshraqi and H. Danared, Proc. IPAC2011, San Sebastián, Spain, p. 2637

"Design and beam dynamics study of hybrid ESS linac". M. Eshraqi, H. Danared, W. Hees and A. Jansson, Proc. IPAC2011, San Sebastián, Spain, p. 2640.

"Challenges for the low level RF design for ESS", A.J. Johansson and R. Zeng, Proc. IPAC2011, San Sebastián, Spain, p. 460

"Upgrade strategies for high power proton linacs". M. Lindroos, H. Danared, M. Eshraqi, D. McGinnis, S. Molloy, S. Peggs, K. Rathsman, R. Duperrier and J. Galambos, Proc. IPAC2011, San Sebastián, Spain, p. 2646.

"Multipacting analysis for the superconducting RF cavity HOM couplers in ESS". S. Molloy, R. Ainsworth and R. Ruber, Proc. IPAC2011, San Sebastián, Spain, p. 190.

"The RF power source for the high beta elliptical cavities of the ESS linac". K. Rathsman, H. Danared, R. Zeng, R.J.M.Y. Ruber, C.A. Marins, C. Lingwood and A.J. Johansson, Proc. IPAC2011, San Sebastián, Spain, p. 397.

"ESS parameter list database and web interface tools". K. Rathsman, S. Peggs, P. Reinerfelt, G. Trahern and J. Bobnar, Proc. IPAC2011, San Sebastián, Spain, p. 1762.

"The European Spallation Source". S. Peggs, Proc. IPAC2011, San Sebastián, Spain, p. 3789

"High power proton linac front-end: Beam dynamics investigations and plans for the ESS". A. Ponton, Proc. IPAC2011, San Sebastián, Spain, p. 690.

"Overview of ESS beam loss monitoring system". L. Tchelidze and A. Jansson, Proc. IPAC2011, San Sebastián, Spain, p. 1329.

"Status of the ESS control system". G. Trahern, Proc ICALEPCS2011, Grenoble, France, p. 1345.

"The ESS accelerator". D. McGinnis and M. Lindroos, Proc. ICANS XX, Bariloche, Argentina.

"HOM coupler optimisation for the superconducting RF cavities in ESS". R. Ainsworth, S. Molloy and R. Calaga, Proc. IPAC2012, New Orleans, LA, USA, p. 2182.

"Design of the ESS accelerator". H. Danared, Proc. IPAC2012, New Orleans, LA, USA, p. 3904.

"Accelerator physics and technology for ESS". H. Danared, Proc. IPAC2012, New Orleans, LA, USA, p. 2073.

"End to end beam dynamics of the ESS linac". M. Eshraqi, I. Bustinduy, L. Celona, M. Comunian, H. Danared, A.S. Holm, S.P. Møller, A. Ponton, J. Stovall and H.D. Thomsen, Proc. IPAC2012, New Orleans, LA, USA, p. 3933.

"Beam diagnostics for ESS". A. Jansson, C. Böhme, B. Cheymol, H. Hassanzadegan, T. Shea and L. Tchelidze, Proc. IPAC2012, New Orleans, LA, USA, p. 882.

"Time and phase synchronization at ESS". A. J. Johansson and R. Zeng, Proc. IPAC2012, New Orleans, LA, USA, p. 2927.

"ESS end-to-end simulations: A comparison between IMPACT and MAD-X". E. Laface, R. Miyamoto, C. Prior and C. Plostinar, Proc. IPAC2012, New Orleans, LA, USA, p. 3841.

"The ESS control box". E. Laface and M. Reščič, Proc. IPAC2012, New Orleans, LA, USA, p. 3884.

"Numerical study of a collimation system to mitigate beam losses in the ESS linac". R. Miyamoto, H. Danared, M. Eshraqi and A. Ponton, Proc. IPAC2012, New Orleans, LA, USA, p. 541.

"Thorium energy futures". S. Peggs, W. Horak, T. Roser, G. Parks, M. Lindroos, R. Seviour, S. Henderson, R. Barlow, R. Cywinski, J.-L. Biarotte, A. Norlin, V. Ashley, R. Ashworth, A. Hutton, H. Owen, P. McIntyre and J. Kelly, Proc. IPAC2012, New Orleans, LA, USA, p. 29.

"Control performance improvement by using feedforward in LLRF". R. Zeng, D. McGinnis, S. Molloy and A.J. Johansson, Proc. IPAC2012, New Orleans, LA, USA, p. 3476.

"Investigation of feedback control for klystron ripple". R. Zeng, D. McGinnis, S. Molloy and A.J. Johansson, Proc. IPAC2012, New Orleans, LA, USA, p. 3479.

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