european spallation source

ESS PROJECT: Foundation for the next European Spallation Source Sept. 2003

Achievements and status as of summer 2003 - a new time-schedule

In 1992 the Rutherford Appleton Laboratory and the Forschungszentrum Jülich started developing and designing a MW spallation neutron source, after a report for the European Commission had identified such a neutron source as one of the major new scientific infrastructural priorities for Europe. In 1997 by then some 10 labs and universities published the first design. The science case that was published at the same time was a joint publication of the ESS project and the European Science Foundation. The partners decided to start an R&D phase to investigate the technical challenges that had been identified. This phase was to last until mid 2000, and was followed by the Project Proposal Phase that was completed by the official European presentation of the science case and the design of the ESS facility with its 5 MW short pulse and 5 MW long pulse target stations. Also in Bonn five sites presented their ambition to host the ESS, most of them consortia involving regional governments. In the meantime, the partners from all over Europe had agreed to conclude a formal MoU with three major objectives:

1. To complete the proposal and formally present it, which happened in Bonn in May 2002;

2. To continue with a Baseline Design Phase that should result in a baseline engineering design by the end of 2003;

3. To get a political decision to construct the ESS late 2003/early 2004.

The time schedule was determined by the ambition to maintain without interruption Europe's lead in neutron science by providing the world's best facility. As a matter of fact much political and planning work had been carried out in previous years. In the mid nineties the UK instigated and provided chair and secretary of the OECD Megascience Forum Working Party that developed the global strategy for neutrons that was eventually endorsed by OECD ministers in 1999. One of its main elements was that the USA, Japan and Europe all needed a MW class spallation source. When the USA and Japan started construction of their MW spallation sources, in 1999 and 2000 respectively, it became clear that Europe would have a hard time to fulfil the ambition for continued leadership in the long run. Given the complexity of European decision making on large facilities a decision earlier than 2003/2004 did not appear to be realistic, as informal governmental consultations pointed out. However, as ESF's Secretary-General Enric Banda underlined in May 2002 in Bonn, a call upon governments to decide to build ESS in the timeframe indicated, seemed wholly appropriate. It was not to be.

The EU member states have established in April 2002 on the initiative of the European Commission a European Strategy Forum on Research Infrastructures (ESFRI) for consultation among governments on the need and the planning for new infrastructures for research in Europe. Its first case was the field of neutrons. A special Working Group was formed to analyse various scenarios for the top tier neutron facility in Europe. Benchmarking performance against a 1.4 MW SNS (to be operational in 2006) it concluded in its report of December 2002 that ESS would give Europe a lead in all relevant scientific fields, a staged approach with a long pulse 5 MW target station first would still give a lead in several fields, while a 1MW short pulse option (either by upgrading ISIS or as a green field AUSTRON version) would keep Europe competitive. If, as now seems likely, SNS would swiftly be upgraded to e.g. 2.5 MW, the Working Group noted that the competitive position of the various options would of course change.

The ESFRI Forum concluded, however, that there was no readiness among governments to decide now on a new source. The baseline scenario, which rests on ILL including its Millennium refurbishment programme and on ISIS with a second target station, will be the European road for the next period. There was an explicit conclusion that Europe needs a major new spallation source in the long run, but no timing for a decision was specified.

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Ongoing discussions in a number of countries have confirmed that a decision within the desired timeframe is impossible. On that basis the Council of the ESS Project has decided to discontinue the MoU as of 1 September 2003 and to disband the Central Project Team in Jülich. While the first objective of the MoU has been fully met, the Council judged a continuation of the detailed engineering and costing work no longer relevant in the face of an unspecified delay and the impossibility of achieving the third objective, that is a decision in 2003/2004. Similarly, no use will now be made of the readiness of the German Science Council to re-evaluate ESS and the agreement between the German partners and regional governments and the Science Council to do so in a two-step procedure.

Conclusion

So here is the European situation. The ESS project has been fully designed, apart from detailed engineering and costing in a number of areas. As the ESFRI analysis has shown, it exhausts the possible options for a next European Spallation Neutron Source, apart from the 1 MW short pulse options, and of course apart from decisions on the final power level and subsequent optimisations. Scientifically it looks doubtful, however, to have a 1 MW European top facility 10 years after the Americans and the Japanese have about or more than 1 MW, and maybe 5 years after the SNS could operate in a user mode at 2.5 MW.

The science case will be continually updated: in collaboration with SNS and J-PARC efforts will be mounted to broaden the case to new prospective communities. Technical capabilities at the main "ESS" laboratories will be maintained, if FP6 applications will be successful. At least one and, hopefully two European instruments at SNS will enable European labs to gain experience in developing and operating instruments at a MW source. The status and documentation of the ESS work is such that a 2-year period of baselining and construction planning before a formal decision allows to pick up again the 8-year construction planning for ESS or any future MW spallation source. Prototyping need not start until shortly after the beginning of this 2-year period, and may be postponed further at a price of slightly higher risks and cost uncertainties.

A simple organisation will be set up to instigate and co-ordinate the necessary activities on the part of the scientists and the labs involved, and to act as the interlocutor for policy responsibles. As a last recommendation the ESS Council members have expressed the hope that it could be based at ILL.

A new website (www.neutron-eu.net) is available to continue information provision on ESS, on new activities, as well as to cover the NMI3, ENSA, and the International Society Muon Spectroscopy Europe.

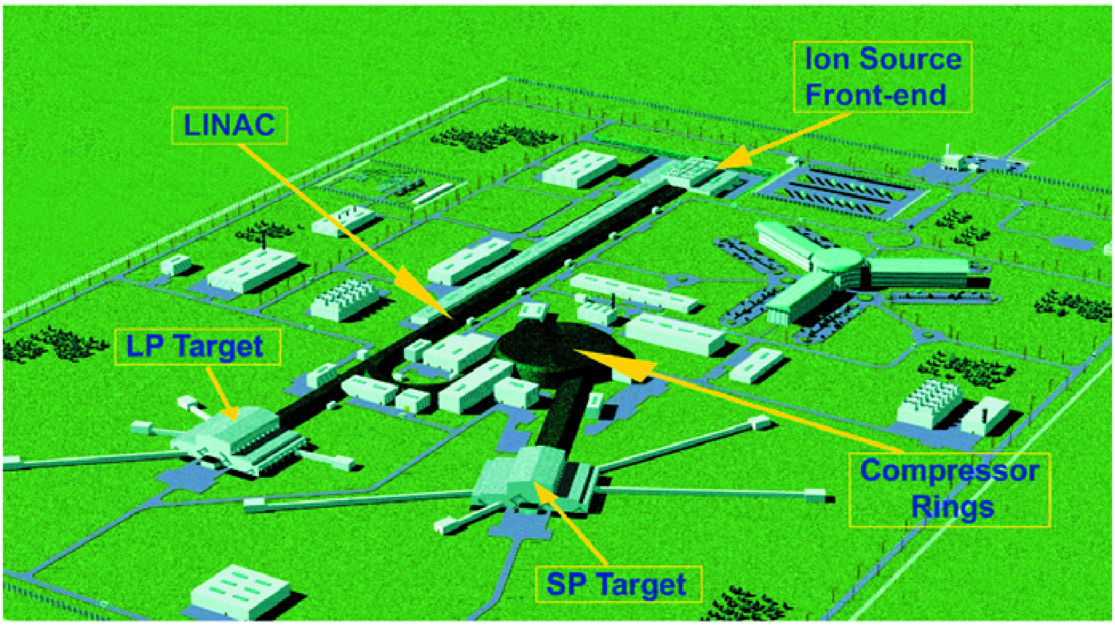
What remains is a tentative detailed time schedule. Could it be as follows?

To maintain the UK's outstanding position in neutron research, the UK government has committed itself to evaluate plans for a future top tier spallation facility, including ESS, with a view to eventually prepare a bid for the so-called UK Spending Review 2006. That implies that a UK judgement will essentially be available mid 2005. The UK government has, too, committed itself to consultations with its European partners to arrive at a common view as to what is desirable and feasible. This process will start with a meeting in the autumn of 2003.

If the next 2 years until mid 2005 are used for consultations, evaluations, broadening the science case and getting consensus on the scoping of the new facility on the basis of the further updated science case and informed views on what is realistic, a decision to start the 20 M€ 2-year baselining and construction planning could be taken late 2005. A decision to start prototyping, also estimated to cost 20 M€, can be taken any time afterwards. In this way a final decision to build the new facility is due for late 2007, which implies that major budgetary impacts begin to be felt in 2009/2010.

Europe and the ambitions it nourishes, deserve that all actors concerned try to agree on such a time schedule.

Peter Tindemans
Chairman, ESS Council



Layout of the ESS facility

The proposed ESS facility consists of a 570 m, 10 MW full energy H- linear accelerator (Linac), a double compressor ring for the provision of short pulses, two complementary 5 MW target stations – short pulse (SP) and long pulse (LP) respectively, and a total of 44 beam-lines each between 10 m and more than 200 m long.

The ESS site covers an area of about 1.2 square km.

Expression of interest to host the ESS.

Five regions in Europe expressed at the Bonn conference May 15-17, 2002 their interest to host the ESS facility. Three of these proposals came from newly formed consortia outside the ESS MoU partners. Regional initiatives have proved to be very active advocators for the ESS. The three new initiatives are:

Yorkshire ESS
The Yorkshire ESS (YESS) is a partnership between the White Rose University Consortium (the universities of Leeds, Sheffield and York in the North of England) and the regional development agency Yorkshire Forward. A proposed site in North Yorkshire has been identified and acquired by Yorkshire Forward.

ESS Scandinavia
ESS-Scandinavia is a consortium of Scandinavian universities, research institutions, transnational organisations, regional and local authorities working for the realisation of the ESS and its localisation in Lund in the Øresund region.

Sachsen & Sachsen-Anhalt
The governments of the states of Sachsen and Sachsen-Anhalt supported by scientists from the many scientific institutions in the two states and the wider region are supporting the case of ESS in the hope of seeing it built in the Halle-Leipzig area.

The two MoU partners displaying an interest in the ESS at the Bonn Conference were:

Forschungszentrum Jülich with support from the State of Nordrhine-Westfalia. Forschungszentrum Jülich has through the whole ESS project been one of the key technical centres, and is operating a 20 MW reactor facility for neutron scattering.

CLRC – another key player in the ESS project. CLRC has built and is operating ISIS, which at present is the worlds most powerful pulsed spallation source.

With the delay of the project a decision on the location for the ESS is not urgent.

The scientific case

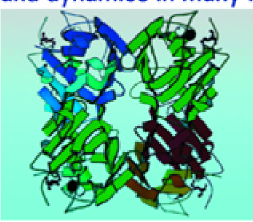
Research at ESS will be performed in areas ranging from materials science to soft matter science, from earth science to particle physics, from chemistry to engineering, from solid state physics to biology and medicine.

….. providing new knowledge …..

Research with neutrons serves first of all to expand our knowledge. The unprecedented improvements in effective intensity delivered by ESS will open new scientific opportunities in many fields:

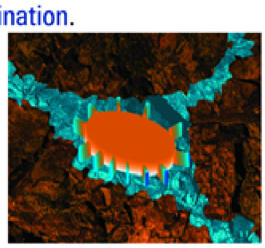
Biology and Biotechnology

Neutrons are particularly sensitive to the dynamics of molecules and single atoms. The relevant instrumentation at the ESS promises large gain factors, up to three orders of magnitude above what is available today. This will allow an unprecedented increase in experimental sensitivity, which, in combination with bio-simulation, will be applied to the study of atomic and molecular structure and dynamics in many fields of biology.



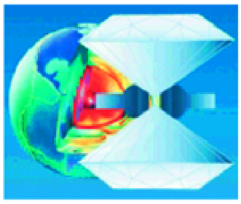
Polymers and Soft Matter

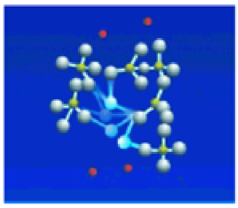
Complexity is one of the most common characteristics of soft condensed matter. The properties are often determined by key components that are dilute. Instrumentation at the ESS will allow the observation of such components under both equilibrium and transient conditions. One example is the exploration of the structure, dynamics and phase behaviour of multicomponent complex fluids in porous media, preparing the way for e.g. tertiary oil production or the remediation of soil contamination.



Earth and Environmental Science

Geological activity in the earth's upper mantle is responsible for geo-hazards such as earthquakes and volcanic eruptions. At the ESS, high temperature and high pressure studies of the structure and dynamics of minerals and magmas under earth mantle conditions will lead to significantly improved predictions of earth dynamics and the related geo-hazards.





Computer Simulation and Neutron Scattering

Neutron diffraction data is routinely used as the basis for structural models of crystals, glasses and liquids. In the future advanced modelling software will allow the production of dynamical models, e.g. 'movies' showing 'where the atoms are and what the atoms do', on the basis of inelastic neutron scattering data measured over a wide range of momentum and energy transfer at the ESS.

Engineering and Material Science

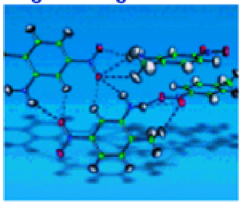
Structure sensitive imaging will add a new dimension to real scale tomography and radiography. Large field, high resolution images will display the distribution of structures in a material. Real time tomography of hidden objects, such as lubricants or cooling fluids, will become possible.

Amorphous and Disordered Materials

One of the major unsolved mysteries in the dynamics of amorphous solids, the origin and nature of the quantum mechanical tunnelling states, will be addressed. These states are ubiquitous in glasses but have so far proved elusive to microscopic measurement due to their extremely low density.

Chemistry and Chemical Structure

The study and understanding of the H-bonding holding together complex molecules, and arrays of molecules, will have an important impact on pharmaceutical materials and supra-molecular chemistry, allowing more rational molecular engineering.

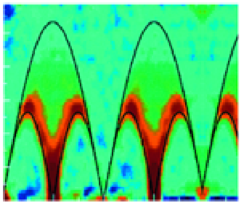


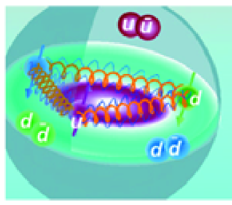
Solid State Physics

Neutrons provide unique access to the magnetic structure and dynamics of solids. Neutron beams at the ESS will provide maps of the magnetic polarisation and spin dynamics of nano-structured systems. Furthermore, the ESS will allow experiments under the extreme conditions required to explore quantum phase transitions.

Particle Physics

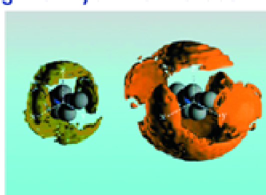
The neutron can be seen as a composite particle consisting of quarks, virtual pions and gluons. Its internal structure determines the decay process, the magnetic moment, and an anticipated electrical dipole moment that would indicate new physics beyond the Standard Model of particle physics. Related measurements can be performed using cold and ultra-cold neutrons. Essential contributions can be expected to the unification of fundamental forces in nature.





Liquids

Nowadays, three-dimensional liquid structure refinement can be carried out for liquids of small molecules. A challenge for the ESS will be to extend this to large molecules. ESS will enable the understanding of why some ion combinations or molecular species in solution induce protein folding, while others cause denaturation. ESS will also reveal the structural changes of water surrounding the macromolecule and deliver crucial information on the origin of hydration forces



… Contributions to European missions. …

Aside from its impact on basic sciences, neutron scattering at the ESS will also make a direct contribution to the solution of many problems more closely related to everyday life. The ESS will offer new and improved tools that will deepen our understanding of both the natural world and the world of artificial materials and enhance our ability to use this knowledge efficiently, for the benefit of European industry and society.

Magnetoelectronics

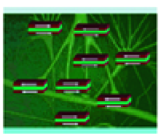
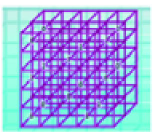
Magnetic sensors based on the giant magnetoresistance (GMR) effect can be found in hard disc reading heads, position sensors for precision tools and ABS systems. GMR sensors exploit the magnetic field dependence of the electrical resistance in layered magnetic structures, whose details were clarified by neutrons. The ESS will allow experiments on ultrathin and laterally confined films, in order to explore the magnetic structures and interfaces of reading devices as the lateral size of GMR heads shrinks to cope with increasing storage density.

Magnetic Neural Networks

GMR, together with the Exchange Bias (EB) effect that pins the direction of magnetic moments in a certain direction, allows the construction of spin valves, which are essential components of magnetoelectronics. On this basis, smart micro-magnetic-media can be envisaged that could become prototypes for magneto-neural-networks. The ESS will be an invaluable tool for the structural and dynamical evaluation of such systems.

Holographic Laser Discs

Liquid crystalline polymers with photosensitive side groups can undergo pronounced photo-induced structural rearrangements that could be exploited, for instance for three dimensional holographic laser discs with storage capacities of the order of 1000 GB. Structural and dynamical neutron studies at the ESS will help to direct systematic searches for new optimum formulations that meet the demands of a wide variety of applications.

Drug Discovery

Knowledge of the three dimensional structures and dynamics of proteins and nucleic acids, as receptors for drug molecules, opens a structure based path to new drug discovery. For instance, major diseases in aging, such as Alzheimers, are caused by the formation of insoluble amyloid deposits of proteins in the brain and neurofibral tangles in the nerves. A combination of x-ray and neutron crystallographic studies, both of the enzymes that catalyse processing of the amyloid precursor proteins and of the proteins that associate with the plaques, could make an outstanding contribution to the design of therapeutic agents.


Enzymes in Food Production

Improved knowledge of the active site structures in enzymes can be used to support their rational redesign. One of the most important enzymes in food production – glucose isomerase – isomerises glucose to fructose. Fructose is used extensively as a sweetener in the food industry, for instance in soft drinks like Coca-Cola. This is a billion euro industry. If the ESS were available today, it would allow a clearly resolved distinction between the magnesium and oxygen atoms in the enzyme and facilitate placement of the bound water molecules and cations that are involved in the enzyme's action.

Unveiling Ancient Technologies

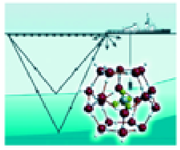
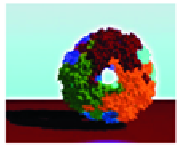
Neutron diffraction reveals novel information on archaeological artefacts and helps to unveil long forgotten ancient technologies. One recent example is an analysis of the Copper Age axe of the 5200 year old Iceman (Ötztal). Neutron scattering techniques have only recently been applied to such archaeological artefacts. Many goals are not yet achieved, mainly due to the limitations of present day neutron sources.


Hydrogen Energy Economy

Hydrogen is an ideally clean carrier of energy. A future hydrogen based energy economy will need substantially better ways of storing hydrogen in a safe, light and affordable manner. Metal hydrides, and ionic compounds of the lighter elements, appear promising candidates. Their relevant structural and dynamical properties can only be clarified by neutron scattering. The ESS will provide the means to study kinetic loading and unloading cycles in-situ, aging processes and associated diffusion mechanisms. This knowledge will be of great importance for rational materials design.

Methane Clathrates: Energy Resource and Marine Hazard

Methane-water clathrates contain the largest proportion of natural gas in the shallow earth (about 7 times the amount available in sedimentary rocks) and constitute an enormous energy resource. However methane release as a consequence of clathrate instabilities causes green house effects and marine geo-hazards. A full understanding of the crystal chemistry demands structural and dynamical studies under real conditions which are far from the reach of today's neutron sources, but will be within the reach of the ESS.

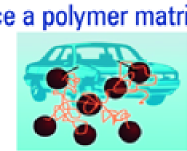



Templating of Nanostructures

With detailed control of chemistry and processing conditions, it is possible to fabricate complex nano-scale ordered block copolymer systems that can be used as templates for high quality fillers, fabrication of efficient catalysts, medical implants, pharmaceuticals, photonic and smart materials, novel nano-structured magnetic devices etc. The rational design of such materials needs to be based on knowledge. The structural complexity, the huge multidimensional parameter space involved, and investigations into the kinetics of structure formation require the high flux of ESS.

Nanomaterials for Transport and Traffic

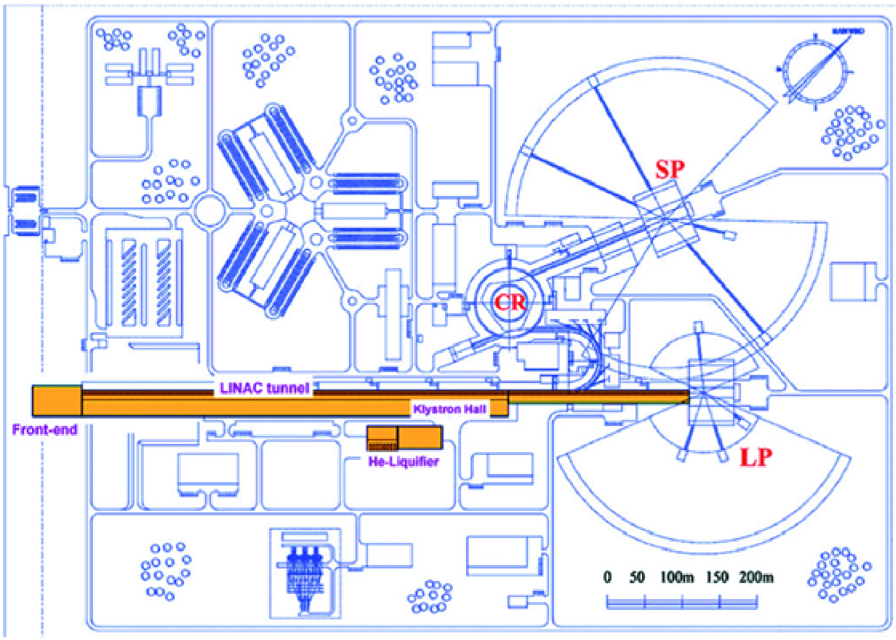
Rising energy prices and growing environmental awareness are intensifying the search for materials and processes with improved performance. The ESS will have an impact on the development of engine/propulsion technology and novel materials for transport. It will advance our understanding of component failures and of lubrication issues on an atomic/molecular level. One example is the production of light weight nanocomposites, where nanoscale fillers reinforce a polymer matrix.



ESS – Site layout and technical design

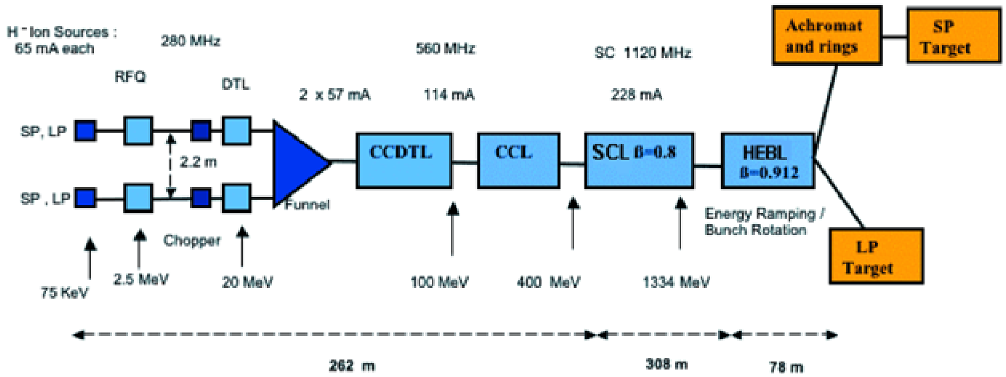
The ESS project consists of a 10 MW full energy H⁻ linear accelerator (Linac), a double compressor ring (CR), two complementary 5 MW target stations - short pulse (SP) and long pulse(LP) respectively, and a total of 44 beam-lines.

The ESS proposal has been scrutinized and deemed feasible by a technical advisory committee – a group of 17 independent world leading experts on linacs, rings, target stations, instrumentation and conventional facilities.



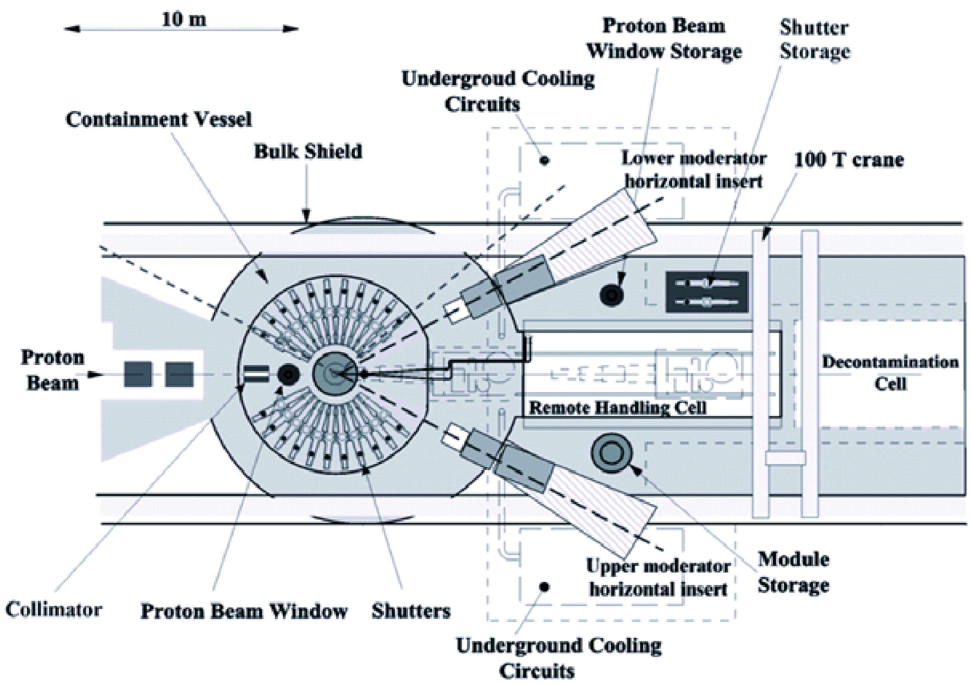
Superconducting reference design for the ESS Linac

The linac is based on a 280 MHz front end with two H⁻ lines funnelled at 20 MeV. Normal conducting structures at 560 MHz accelerate the beam up to 400 MeV, from where 1120 MHz superconducting structures take over until the full energy of 1.334 MeV is reached.

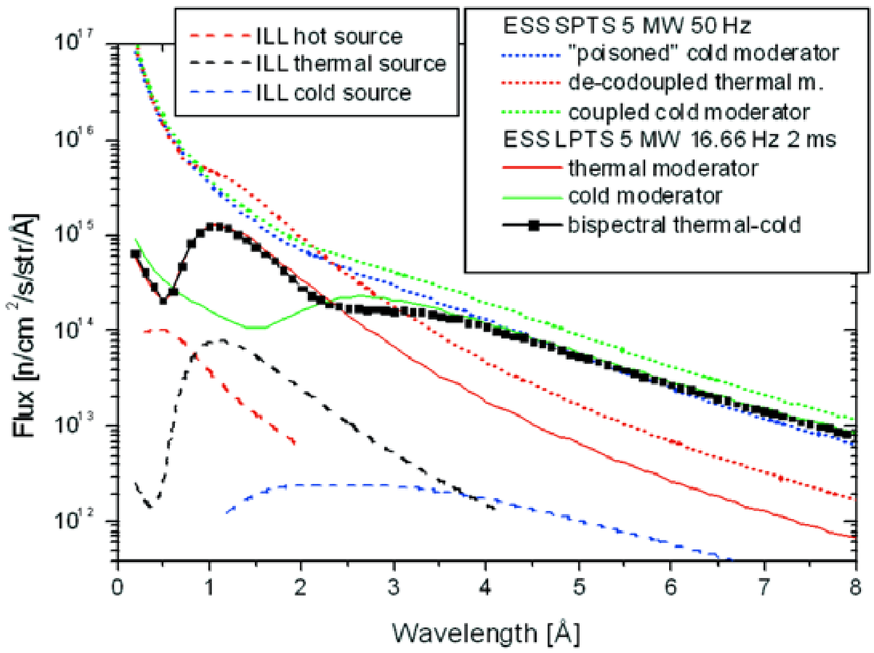


ESS target stations – Liquid Hg target

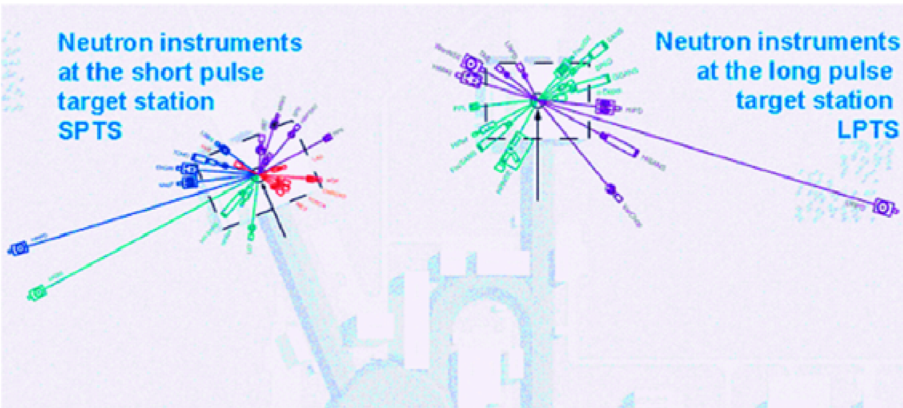
The two ESS target stations are basically identical. They are both based on a horizontally extended liquid Hg target, with a 1.5 m diameter rotating solid target as the fall-back solution. Each target station will have 22 beam channels (11 on each side) separated by 11°, and each fitted with a rotating shutter with a replaceable beam channel of outer dimensions 2.8 m long, 23 cm wide and 17 cm high. Guides and other optical elements can be mounted and aligned inside this channel from the top of the target station without moving heavy shielding. The closest distance between moderator and guide entrance is 1.6 m and the first choppers can be mounted 6 m from the moderators.



ESS main parameters	**SP** (Short Pulse)	**LP** (Long Pulse)
Beam power	5 MW	5 MW
Energy of protons	1.334 GeV	1.334 GeV
Time structure of proton pulse	2 x 0.6 μs	2.0 ms
Energy content of proton pulses	100 kJ	300 kJ
Repetition rate	50 Hz	16 $^{2}/_{3}$ Hz
Target type	Flowing mercury horizontal injection	Flowing mercury horizontal injection
Number of moderators (viewed faces)	2 (4)	2 (4)
Number of beam ports for instruments	22	22
Average thermal flux	3.1 x 10^{14} n/cm^{2}s	3.1 x 10^{14} n/cm^{2}s
Peak thermal neutron flux	1.3 x 10^{17}n/cm^{2}s	1.0 x 10^{16}n/cm^{2}s

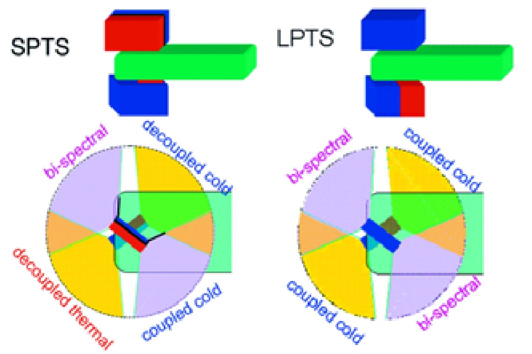


Expected ESS Peak flux from the different moderators compared to the continuous flux at ILL.



Footprint of the proposed ESS instrument suite. The SPTS excels in unprecedented high peak intensity and the LPTS in unprecedented high integrated intensity per pulse. The longest beam lines are about 200 m

Two moderator assemblies, each with two viewed faces are inserted horizontally above and below the target respectively. This allows for future use of advanced cold moderators. The reference design and estimate of the source performance is however based on optimised use of conventional water and cold liquid hydrogen technology only. Novel features are bi-spectral i.e. side by side cold-thermal moderators, substantial use of coupled moderators and finally a design with no conventionally poisoned moderators and the use of only two moderator assemblies at each target station.



Side and top view of the ESS moderator layout for the short and long pulse target station. The Hg target (green) is located between the two moderator assemblies top and bottom

ESS instrumentation

The selection and definition of instruments has been based on science demands from the ESS Science Advisory Committee and detailed performance calculations using Monte Carlo simulation techniques by the ESS instrumentation groups. The final design and decision on instrumentation will be a continuous process starting after the decision to build ESS has been taken. The proposed instrument suite is basically how ESS would be instrumented if it was available today. I.e. for the short pulse target station it is an extrapolation of ISIS instrumentation, and for the long pulse target station it relies heavily on the fact that neutrons can be transmitted over large distances with very low loss and that choppers can be used for pulse shaping, repetition rate multiplication and wavelength frame multiplication.

The moderator layout and the complementarity between the long and short pulse target stations ensure that all high priority instruments defined by the Science Advisory groups can be located at the facility without compromising the performance of any of them. If the ESS is built in stages or with only one of the target stations this will no longer be the case, and both the instrument suite and moderator layout will need re-optimisation.

The ESFRI Report:

Executive summary

European Strategy Forum on Research Infrastructures

Working Group on Neutron Facilities

Medium to long-term future scenarios for neutron-based science in Europe

"The Working Group on Neutron Facilities was established by the European Strategy Forum on Research Infrastructures (ESFRI) at its meeting on July 3, 2002.

Its mandate is to carry out a comparative study of different scenarios for the development of facilities for neutron-based science in Europe. The study will focus on scenarios that (1) include the building of the ESS (either now or in a timely manner) and (2) scenarios which have major upgrades of ILL and ISIS as key elements, with ESS as a subsequent option.

At its first meeting the Working Group learned that the Millennium Program at ILL and the plans for a Second Target Station at ISIS are well under way and decided to include these developments as a baseline for the scenarios considered. This report contains a strategic analysis of three medium to long-term future scenarios (10 – 20 years) for neutron-based science and technology in Europe. The analysis has focused on the existing and proposed top-rank facilities. The three scenarios are compared on the basis of their scientific and technical merits, socio-economic impacts, costs and timeliness seen in a global perspective. The aim of the report is to provide road maps for the decision-making by European governments in the spirit of the European Research Area, ERA.

Scenario 1 aims at a neutron landscape with ESS fully implemented as the new world leading facility, supplemented by a baseline including fully developed ILL and ISIS and a selected network of regional and national sources. ***This scenario would provide world-leading capability in all areas of neutron science and could serve a growing community of researchers.***

Scenario 2 aims at a situation where only the first long pulse phase of ESS is implemented and where the rest of the landscape is similar to scenario one. ***In this case, Europe would be world leading in some fields and have some leads in others. The total capacity for highest quality neutron beam research would be reduced compared with scenario 1.***

Scenario 3 is the least ambitious, with the initial implementation of a new 1 MW short pulse source. ***This corresponds to maintaining the over-all level of capability and capacity in a manner where Europe would remain competitive but not leading over a broad range of disciplines.***

The common trend for all three scenarios is that they focus on the most powerful sources and propose to make them into assets for the whole of the European neutron community in the ERA spirit. The need for a European strategy for neutron science infrastructure represents a challenge for decision making in Europe. There is a window of opportunity to go forward in a coherent manner with one of the proposed scenarios. At the very least this would maintain the momentum that Europe developed over the years, and in the most ambitious case will develop new opportunities for science and technology commensurate with both the standing of Europe in the world and the ambitions expressed by the European leaders in the Lisbon and Barcelona summits.

Elements for an ERA strategy for neutron science infrastructures

- It should be recognised from the outset that the neutron landscape is dynamically changing without any joint decisions at the ERA level. By 2020 it is estimated that only half of the current capacity for neutron experiments will be available, as existing facilities reach the end of their life span.

- A vital element of an ERA neutron strategy is the willingness of the present owners to recycle the funds from existing facilities to the new ones in the scenarios described here.

- The ERA strategy should follow the OECD recommendations with emphasis on the best performing facilities. The corollary is that efforts should be made to ensure that the least performing facilities are retired first.

- The analysis shows that the total recurrent operating costs for the existing (and newly retired) facilities in Europe are approximately 300 M€/year. Retaining the top four to five highest impact facilities would free only 100 to 120 M€ in recurrent spending. However, this would give an opportunity to cover the projected recurrent costs (including investments in instrumentation) in ***scenario 2*** and ***scenario*** 3. The realisation of ***scenario 1*** would require additional recurrent costs in the range of 20 M€.

Transition to any of the proposed scenarios will require a capital injection in the range 600 to 1500 M€. Such an investment would sustain the field for the next 25 to 40 years. Using a payback period of 40 years and 2.5% government borrowing rates, it would result in an additional annual spending of 75 M€ for the full ESS, 50 M€ for the Long Pulse Target Station (LPTS) first in a staged approach towards ESS, 42 M€ for AUSTRON and 31 M€ for ISIS upgrade.

The neutron science community is well organised on both national and European levels and through the support from the EU Framework Programmes the community is prepared to take advantage of the opportunities that a common strategy and investment plan would bring in the spirit of the European Research Area. Benefits from the ERA approach would be to:

- provide a viable avenue for decision making, taking into account the possible couplings to other science infrastructure decisions;

- make possible the realisation of the most ambitious scenarios, ***scenario 1*** or ***scenario*** 2;

- maximise the scientific return per unit cost. This is the only affordable way for Europe to maintain a strategic world lead in the broad disciplines and technologies underpinned by neutron science;

- provide unique and equal opportunities for European scientists, in particular for young scientists and scientists from the new EU member countries;

- Make a visible and credible major step towards the realisation of the Lisbon and Barcelona ambitions.

As an immediate step, the current incoherent landscape should be recast with a greater degree of joint responsibility for the development and utilisation of the best facilities. Such a step should include a decision on the scenario for the top tier with a realistic perspective on when to start actual construction."

The basis for a decision is available

Any new European neutron spallation source will to first order be described by its power level, pulse sequence (length and frequency) plus number of target stations. The instrument and moderator/reflector designs can for relevant source parameters be made to optimally exploit the source characteristics.

Pulsed spallation sources are presently comparable in performance to existing CW sources either based on fission (reactors) or spallation. The new MW pulsed facilities will clearly outperform all existing facilities. These new facilities will fall in one of two main categories:

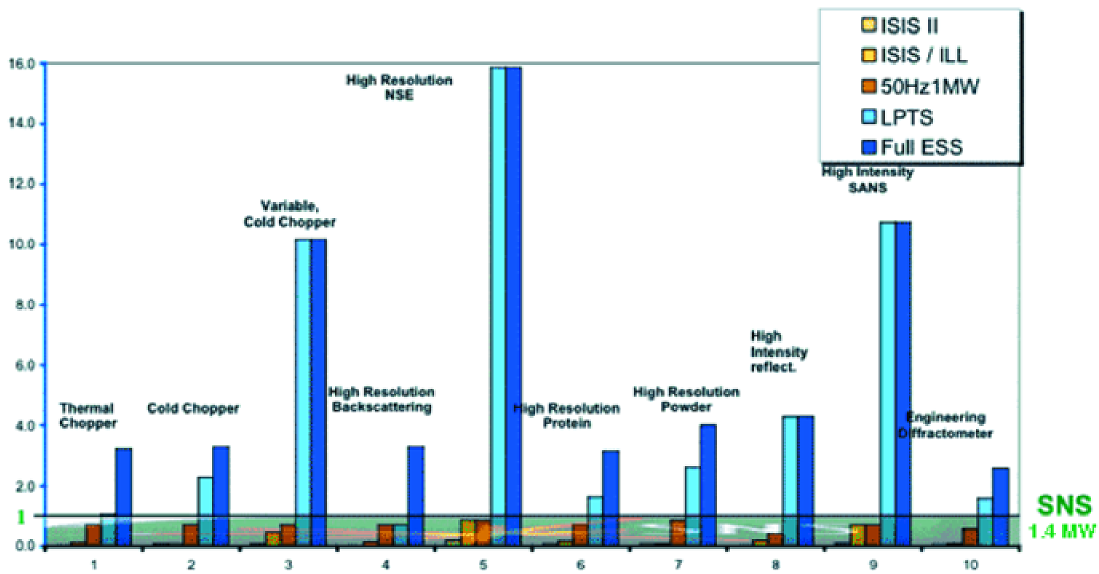
1 short pulse sources – where the pulse length of the neutron pulse from the target station is entirely determined by the target station (moderator – reflector design). For such a facility the incoming proton pulse must be about one µsec or less. Materials properties dictate the upper feasible technical limit to 100 kJ per proton pulse.

2 Long pulse sources – where the initial pulse length of the neutron pulse is dominated by the (long) proton pulse. The final neutron pulse length is then determined by choppers. For a long pulse target station the heat removal that is expected (i.e. the total beam power) sets the technical limit for the facility.

The available information on short pulse sources (ISIS, AUSTRON, J-PARC, SNS and ESS) covers the full range of power levels: 0.2, 0.5, 1.0, 1.4 – 2.5 and 5 MW i.e. from existing levels to the estimated technical limit. It also covers the relevant frequencies 10, 25, 50 and 60 Hz respectively.

The available information about long pulse sources is from the ESS study i.e. for 5 MW, 2 ms and 16 2/3 Hz. In the ESS update report the possibility to extend the present linac in power to 10 or 15 MW of beam power has been sketched. To go beyond the present 5 MW will however require modifications to the target station in order to cope with the higher level of radiation and the increased heat load.

A new European source must aim to be world leading as it will start producing neutrons only quite a few years after the SNS and the J-PARC will operate in full user mode. The continually updated science case will, together with affordability, eventually affect the scope of this new facility. As explained above, the options which are described in or can be derived from the ESS design work cover the full range for such a European top tier source. Together with the strategic analysis in the European Strategy Forum for Research Infrastructure (ESFRI) working group report on *Medium to Long-term Future scenarios for neutron based science in Europe*, the full basis for a future decision has thus been laid with the ESS project proposal presented in Bonn May 15-17, 2002, and subsequent work on the final selection of technology for the accelerator and target station, which will be published as *The ESS Project Volume III Update, Technical Report, Status 2003* by the end of 2003. Of course the experience from the ongoing construction projects (SNS and J-PARC) will, too, inform a final European decision.



Predicted performance for the full ESS, the ESS long pulse target station alone, a 1 MW AUSTRON or ISIS-upgrade, ISIS target station II and the best existing instruments at the presently world leading neutron facilities ILL and ISIS. All compared to a 1,4 MW SNS.

An SNS upgrade to > 2 MW is already been considered.

(Data from the ESFRI report)

Summary table of scientific performance for the three scenarios:.

The competitiveness indicators are measured against SNS at its current design level of 1.4 MW.

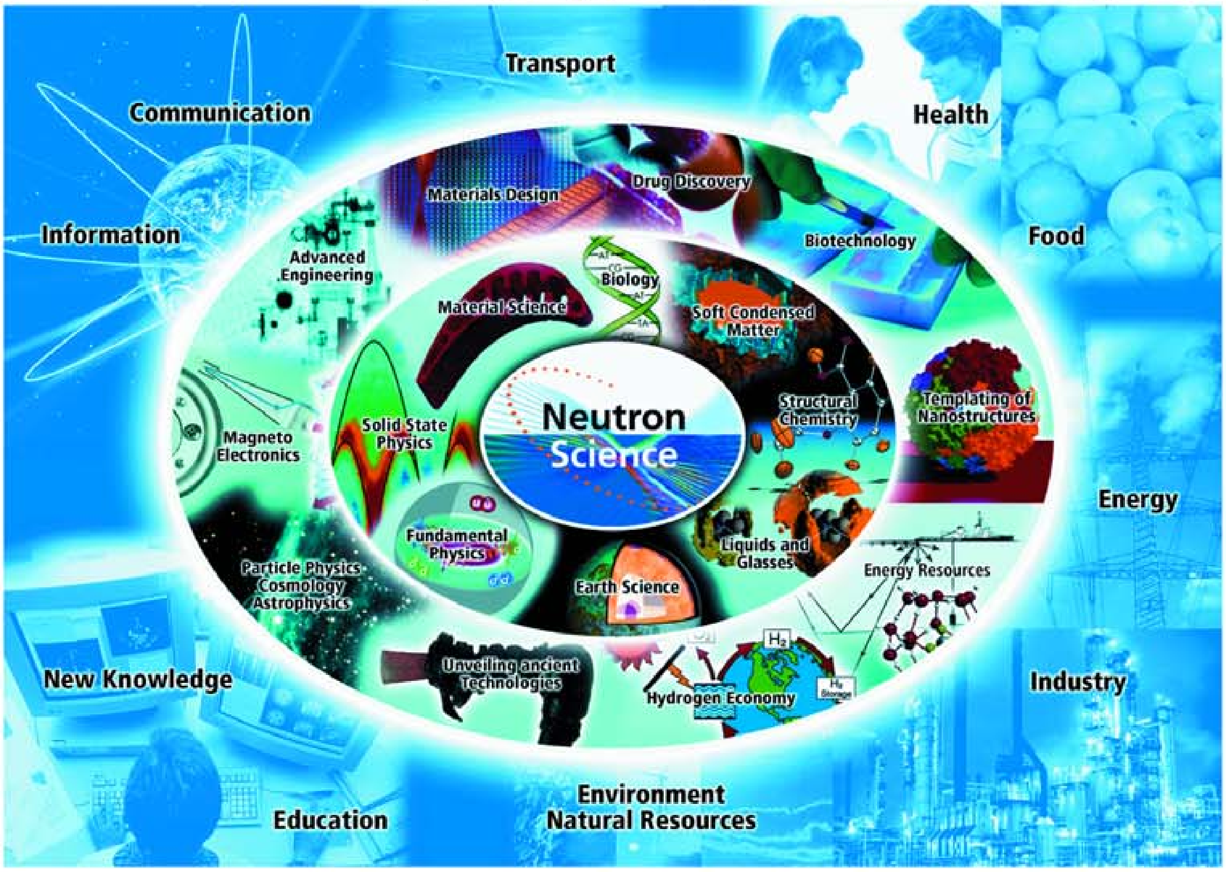
From the ESFRI NWG report http://www.cordis.lu/era/infrastructures_forum.htm

WL = World Lead
SL = Some Lead
C = Competitive

Important Contribution to European Priority Research Mission	*Flagship Field of Research*	*Scenario 1: ESS*	*Scenario 2: 5 MW Long Pulse*	*Scenario 3 a: 1 MW Short Pulse 10 Hz*	*Scenario 3 b: 1 MW Short Pulse 50 Hz*
Functional Materials, Microsystems and Information Technology, Nanotechnology	← Solid State → Physics	WL	SL	C	C
Microsystems and Information Technology, Functional Material, Nanotechnologies, Traffic and Transport, Sustainable Development	← Material → Science & Engineering	WL	SL	C	C
Functional Material, Nanotechnologies, Traffic and Transport, Sustainable Development	← Liquids &→ Glasses	WL	SL	C	C
Functional Material, Nanotechnologies, Traffic and Transport, Sustainable Development	← Soft → Condensed Matter	WL	WL	SL	C
Functional Material, Health, Sustainable Development	← Chemical → Structure Kinetics & Dynamics	WL	SL	C	C
Health and Biotechnology	← Biology & → Biotechnology	WL	WL	C	C
Traffic and Transport, Cultural Heritage, Sustainable Development	← Mineral→ Science, Earth Science, Environment and Cultural Heritage.	WL	SL	C	C
Cosmology, Origin of the Universe, Education, public understanding	←Fundamental→ Physics	WL	WL	SL	C

Socio-economic impact

Extract from the ESFRI Neutron Working Group (NWG) report - **http://www.cordis.lu/era/infrastructures_forum.htm**



How a neutron source may form the centre of a complex of activities. Around the central core, there is a ring of scientific spheres that are dependent on the activities that are conducted at the neutron source. Outside the ring of scientific spheres, there are several examples of technical applications and industries that can benefit from the scientific advances. Research and development are increasingly conducted within international networks that extend beyond national boundaries. Neutron science fits well into such networks of universities, research institutions and industries that are bound together in cross-border relations. Hence, the establishment of a new research centre should not be seen in a local or regional context only.

Investments in neutron science and its large experimental facilities will lead to different types of impacts:

1: direct, localised and short-term impacts, related to the economic activity generated by building, operating and using a large facility;

2: indirect, network-type medium- and long-term impacts, related to the potential for attracting other research institutions and high tech industries to the region that hosts a new large facility and strengthening its knowledge fabric;

3: global, diffused, public domain and long-term impacts, related to the science and technology that stems from the use of the facility.

Direct impact of the ESS:
Need for land is estimated to be 1.0 – 1.2 sq. kilometres and an investment expenditure of 1.5 billion €, translating into 3500 years of cumulative man-power needed during construction. The personnel requirements are expected to be of the order of 600 persons on a permanent round the clock basis. 4000 To 5000 scientists will make use of the facility every year. 1000 New employment opportunities could raise the working population by 2000-3000 in larger areas. In smaller places with limited labour markets, the employment multiplier could be as large as 5-6.

The indirect impacts from investments in neutron science and facilities will occur most quickly in agglomerated environments where institutional frameworks and social webs are already tight and well functioning. The indirect impact can be expected to grow over time.

The global impacts are of most importance to discuss and assess. The future of the advanced economies no longer depends to the same extent as in former days on natural resources and human diligence. Scientific excellence and communication of knowledge, together with the capacity to innovate, have become vital factors in promoting economic and social change. Neutron science is an important source of new knowledge that can feed long-term industrial innovation. Neutron-based science, such as material science, solid state physics, energy and biotechnology, has a long-term impact on industry mainly by understanding phenomena and translating this understanding in technology.

(ESFRI NWG report 2003)

Schedule for the realisation of a new MW spallation source

That Europe needs a new MW spallation neutron source is acknowledged by both scientists and decision makers. Prior to project baselining, discussions in Europe must lead to settling on a final strategy and concept for the facility. This activity may take weeks, if the Bonn concept with a 5+5 MW long and short pulse target stations is selected. But now that a delay of the project seems unavoidable it will more likely take at least a couple of years.

A continued strong user involvement with continued harnessing of the science case is of key importance for such a project. Furthermore the power of neutron scattering should continue to be demonstrated through optimal use of existing facilities to provide new breaktroughs in a wide a range of disciplines - and through expanding the scientific areas where neutron scattering is advantageously used.

Another important issue is to maintain technical competence/capability, through an advanced technology programme and to investigate a range of possible performance enhancing technologies for a delayed European facility. Such a programme will however not have a direct impact on the planning and construction time schedule.

After a decision to go ahead with baselining and construction planning for the project, it will take about half a year to assemble a project team and a further 1,5 year and about 20 M€ to carry through this construction planning and baselining. Candidate sites should also engage in more detailed site planning. Based on this a decision to construct the ESS can be taken and an operating facility could be ready after an 8 year construction period.

Prototyping activities amounting to approximately 20 M€ could be initiated immediately, but could also be carried out in parallel with or slightly later after the start of project baselining, and then continue into the construction phase. At some risk for a delay of the construction period and a somewhat larger uncertainty in construction costs, prototyping could be delayed until the start of the construction phase.

World-wide collaboration on both science and technology is in all cases essential for a healthy and cost-effective development.

ESS information available here:

WWW.neutron-eu.net

.... Your central gateway for access to neutron and muon information ...

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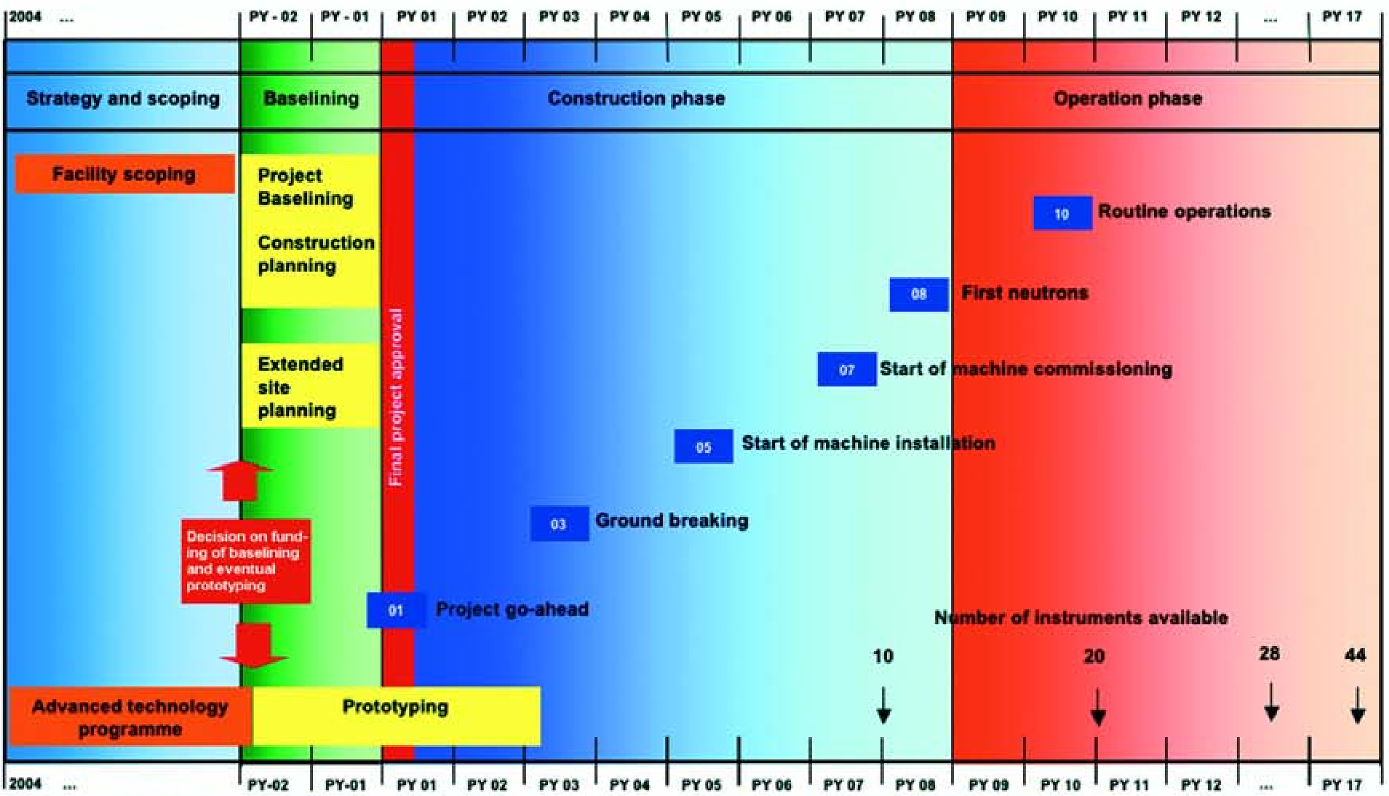
The "European portal for neutron scattering and muon spectroscopy" is a common entry point to facilities and information. It is a joint initiative by all European organisations engaged in neutrons and muons, and is supported by the European Commission through FP5 and FP6.



ESS time schedule in terms of project years (PY) relative to the year of a decision to build the facility. The strategy and scoping phase has no fixed length and could be from weeks to years in duration.

The ESS project proposal, technical documentation and science case are on the neutron portal **www.neutron-eu.net,**.