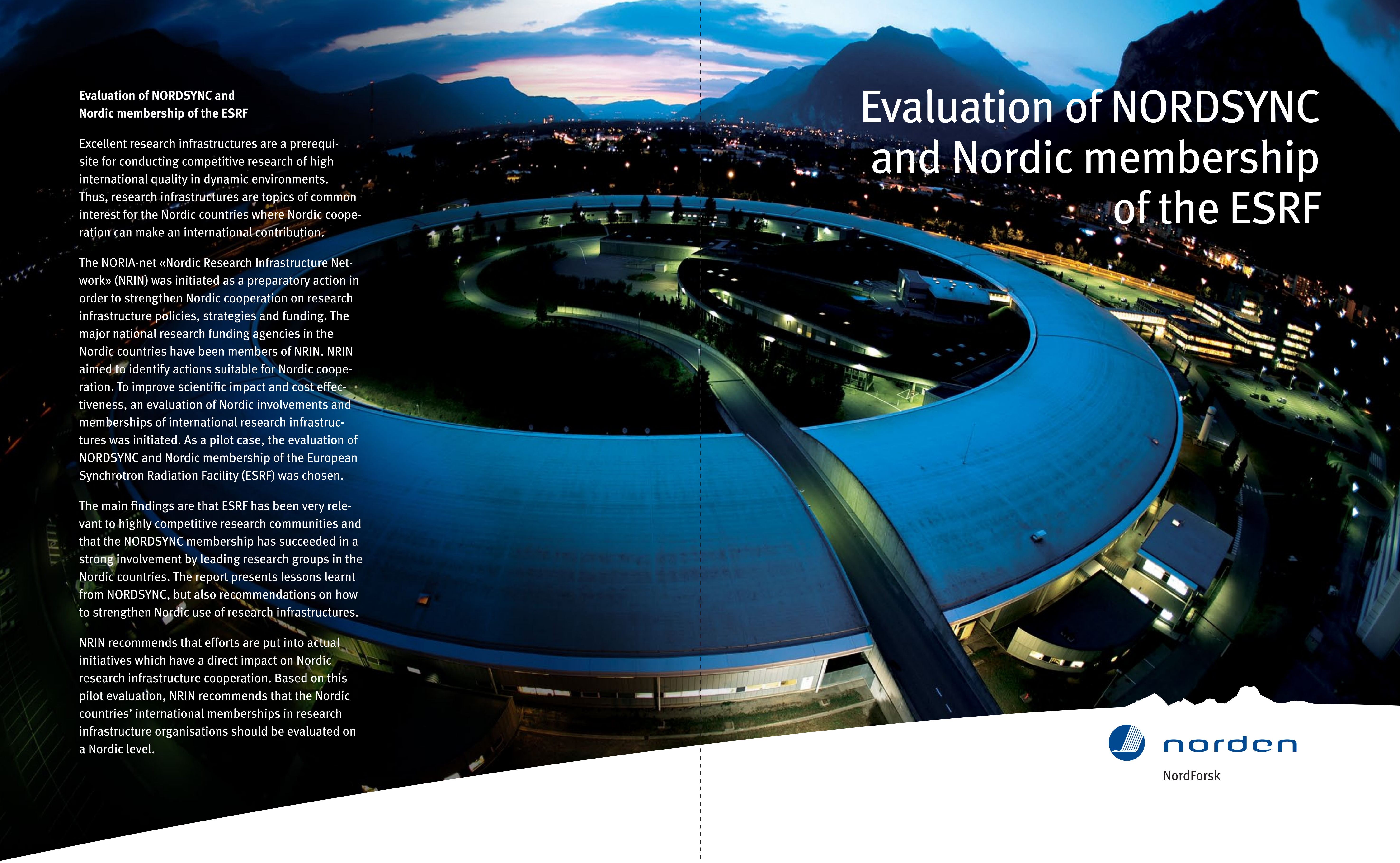

Evaluation of NORDSYNC and Nordic membership of the ESRF

Excellent research infrastructures are a prerequisite for conducting competitive research of high international quality in dynamic environments. Thus, research infrastructures are topics of common interest for the Nordic countries where Nordic cooperation can make an international contribution.

The NORIA-net «Nordic Research Infrastructure Network» (NRIN) was initiated as a preparatory action in order to strengthen Nordic cooperation on research infrastructure policies, strategies and funding. The major national research funding agencies in the Nordic countries have been members of NRIN. NRIN aimed to identify actions suitable for Nordic cooperation. To improve scientific impact and cost effectiveness, an evaluation of Nordic involvements and memberships of international research infrastructures was initiated. As a pilot case, the evaluation of NORDSYNC and Nordic membership of the European Synchrotron Radiation Facility (ESRF) was chosen.

The main findings are that ESRF has been very relevant to highly competitive research communities and that the NORDSYNC membership has succeeded in a strong involvement by leading research groups in the Nordic countries. The report presents lessons learnt from NORDSYNC, but also recommendations on how to strengthen Nordic use of research infrastructures.

NRIN recommends that efforts are put into actual initiatives which have a direct impact on Nordic research infrastructure cooperation. Based on this pilot evaluation, NRIN recommends that the Nordic countries' international memberships in research infrastructure organisations should be evaluated on a Nordic level.

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Evaluation of NORDSYNC and Nordic membership of the ESRF

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Coverphoto: The experimental hall and storage ring building of the ESRF.
(Courtesy: P.Ginter/ESRF)

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Funded by NordForsk. October 2011

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Preface

NordForsk is an organisation under the Nordic Council of Ministers which aims at facilitating cooperation in all fields of research and research-driven innovation when this adds value to work being conducted in the Nordic region. Priority is given to thorough analysis as a basis for funding of research that is judged to have considerable potential to result in long-term knowledge-based progress. Some of NordForsk’s preparatory actions are carried out by our «Nordic Research and Innovation Area networks» (NORIA-nets).

Research infrastructure is a topic of mutual interest for all the Nordic countries and an area where Nordic cooperation can make a contribution. The NORIA-net Nordic Research Infrastructure Network (NRIN) was initiated in 2009 in order to strengthen Nordic cooperation on research infrastructure policies, strategies and funding. The major national research funding agencies in the Nordic countries have participated in NRIN. NRIN has worked to identify actions suitable for Nordic research infrastructure cooperation. To improve scientific impact and cost effectiveness, an evaluation of Nordic involvements and memberships of international research infrastructures was initiated. As a pilot case, the evaluation of NORDSYNC and Nordic membership of the European Synchrotron Radiation Facility (ESRF) was chosen.

The main findings are that ESRF has been very relevant to highly competitive research communities and that the NORDSYNC membership has succeeded in a strong involvement by leading research groups in the Nordic countries. The report presents lessons learned from NORDSYNC but also recommendations on how to strengthen Nordic use of research infrastructures.

NRIN presented recommendations on actions aiming to expand and add value to Nordic research infrastructure cooperation in its final report “Enhancing Nordic Research Infrastructure Cooperation” (NordForsk Policy Paper 3, 2012). The recommendations are addressed to NordForsk, but also to Nordic politicians and research funding agencies. Based on this pilot evaluation, NRIN recommends that the Nordic countries’ international memberships in research infrastructure organisations should be evaluated on a Nordic level.

NordForsk would like to forward our sincere thanks to the enthusiastic and knowledgeable NORIA-net team; Troels Rasmussen, Project Coordinator from Danish Agency for Science Technology and Innovation; Eeva Ikonen from the Academy of Finland; Þorvaldur Finnbjörnsson from Rannís, Iceland; Friðrika Harðardóttir from the Ministry of Education, Science and Culture, Iceland; Odd Ivar Eriksen from The Research Council of Norway, and Per Karlsson from The Swedish Research Council. In addition, NordForsk forwards our thanks for an excellent contribution to Jørgen K. Kjems, senior consultant, civ. ing. lic. tech of Kjems R&D consult who was engaged as an expert secretary and was responsible for the evaluation and for writing the report.

Gunnel Gustafsson
Director of NordForsk

Experimental setup on ESRF beamline ID09 for the study of ultra fast processes: sample support (right) and detector (left). (Credit: P. Ginter/ESRF)

1 Executive summary

1.1 Brief project description and context

This evaluation concerns the European Synchrotron Radiation Facility (ESRF) in Grenoble and the Nordic membership through NORDSYNC. The ESRF is a prominent international research infrastructure (RI) with a large user community covering a very broad range of sciences, from biology, life sciences and medicine to engineering, materials science, geophysics, chemistry and fundamental physics. The ESRF has 30 insertion device beamlines and 19 bending magnet beamlines, and the facility caters to a large European and international scientific community with more than 7 000 user visits per year. The annual budget for 2010 was EUR 98 M, including investments in the upgrade programme. All Nordic countries except Iceland have been members of the ESRF through the NORDSYNC consortium since 1987, and the Nordic scientific communities have played an active role in all phases of the ESRF project, from its inception in the 1980s to the development of the beamline and instrumentation and the current expansion of use in both established and new fields of research. NORDSYNC's regular share of the budget is 4%. An estimated 1 000 scientists (including Ph.D. students) from the Nordic countries are currently engaged in synchrotron-based research. Since the inauguration of the ESRF, the Nordic user communities have consistently been awarded about 6% of the beam time through the peer-reviewed access system. As a consequence, NORDSYNC has agreed to pay an additional fee for overuse according to the rules for corrective measures adopted by the ESRF Council in 2005 and 2010. The ESRF is currently implementing an ambitious upgrade programme, which is part of the ESFRI Roadmap for the development of research infrastructure in Europe. This report presents a brief history, status and future outlook for the ESRF and synchrotron radiation-based research in Europe as the background and context for the evaluation of Nordic membership of the ESRF through NORDSYNC.

1.2 Purpose and expected use of the evaluation

The evaluation of NORDSYNC and Nordic membership of the ESRF has been commissioned by the Nordic Research Infrastructure Network (NRIN), a NORIA-net *(www.nordforsk.org/en/funding/finansieringsformer/noria-net?set_language=en)* funded by NordForsk. The purpose of the evaluation is to enable the individual Nordic countries to compare how the national memberships of the ESRF function and have been utilised, and to learn from each other's different sets of experiences and solutions. A second purpose is to evaluate the NORDSYNC collaboration with a view to potentially improving Nordic cooperation on international/European research infrastructures in the context of the evolving ESFRI Roadmap.

The evaluation provides insight into a working example of the membership of an international research infrastructure through a Nordic consortium. Research infrastructures are high on the science agenda in all of the Nordic countries and the ESFRI process has initiated discussions about a number of new European RIs. The evaluation is intended to help national decision-makers to establish national, or possibly Nordic, platforms for new memberships which can maximise the overall scientific impact and cost-effectiveness of new RI involvement.

1.3 Objectives of the evaluation

The evaluation is also intended to establish a common platform for learning and improvement in relation to international research infrastructure involvement, with NORDSYNC and the ESRF as a test case. This will allow each of the participating countries to assess and possibly adjust their practice in relation to international research infrastructure involvement. Also, the evaluation will form the basis for discussing further Nordic cooperation. A further objective is to provide best-practice tools not only for existing RI memberships but also for new memberships. Each country is expected to become involved in a growing number of international research infrastructures. Thus, there is an increased need for solutions for how to best organise such memberships at the national level. It is important to note that the present evaluation focuses on utilisation, organisational and administrative aspects of NORDSYNC and ESRF involvement. It has not been an objective to carry out a scientific evaluation of the Nordic activities at the ESRF.

1.4 Summary of the evaluation methodology

The evaluation is based on: (1) a desk study of NORDSYNC and ESRF documents that were made available by the NRIN committee or are publicly accessible, generally via the Internet; and (2) in-depth interviews with 26 key stakeholders in the Nordic countries and at the ESRF (18 interviews were carried out in person and eight by telephone; see the list in Annex II). The people to be interviewed were selected in consultation with the NRIN committee members, who nominated a range of candidates from their respective countries that included scientific and industrial users, research agency representatives, members of the ESRF Council and Administrative and Finance Committee, university deans and heads of departments as well as staff at the ESRF. The evaluator has striven to obtain quantifiable data using available, tangible data and indicators in the documentation. The evaluation report also includes qualitative feedback and assessments from the interviews. Important input has been obtained from the ESFRI Roadmap and other ESFRI reports as well as national roadmaps and strategy reports.

1.5 Principal findings and conclusions

The ESRF has been a success both as a European research infrastructure and as an asset for the Nordic science community. The ESRF source, beamlines and instruments are world leading and have in several cases been developed in close cooperation with Nordic groups (e.g. the SNBL, Troika beamline, ID 16 beamline and 3DXRD microscope). The ESRF is now a mature research infrastructure and has established a trend-setting user programme and user support system that is second to none. The ESRF is also the leading centre for instrument development to the benefit of the national centres in Europe.

The NORDSYNC membership has formed the core of the strong involvement of leading research groups in the Nordic countries from the very early phases. This has led to a consistently high Nordic use of the facility with an over-proportional share of beam time relative to the financial share. The engagement has been characterised by effective formal and informal contacts at many levels and a suitable mix of bottom-up (e.g. Long Term Projects) and top-down initiatives (e.g. the Swiss-Norwegian Beam Lines) coupled with responsiveness on the part of the ESRF to Nordic user demands.

The ESRF has proven to be very relevant to strong research communities in different disciplines among the various Nordic countries. This has resulted in distinct differences in user profiles across the scientific disciplines. Swedish groups are very strong in macromolecular biology, Danish groups have particular strength in material research, Norwegian groups are strong in chemistry and Finnish groups excel in condensed matter physics and medical imaging. It has been possible to accommodate these differences in scientific focus under the NORDSYNC consortium model. There has been some involvement of industrial partners and limited direct industrial use of the ESRF, but the volume of activity falls short of the perceived potential.

The user communities are thriving in all of the Nordic countries, with new groups and institutions getting involved and new areas of science taking advantage of the access to synchrotron radiation. This trend is further bolstered by the ability of the user groups to successfully compete for funding within each of the Nordic countries. This has in turn meant that more university positions have become available for junior staff and Ph.D. students.

NORDSYNC has proven to be an efficient administrative arrangement vis-à-vis the ESRF, which has given additional weight to the Nordic voices in the ESRF Council and in the advisory committees. NORDSYNC is seen as a constructive owner/partner by the ESRF management and the other partners. Trust and respect have been earned by the manner in which delicate issues such as budgets, “juste retour” and fees for overuse have been handled.

There are clear differences in how the NORDSYNC and ESRF memberships are administered in the different Nordic countries. This reflects the differences in the organisation of and traditions for research funding in general and research infrastructure in particular. Research infrastructure is viewed as a strategic issue in all four countries. All are active in the ESFRI process and have developed national roadmaps of their own for the planning of national facilities and participation in international projects.

NORDSYNC matters have been handled in a flexible manner with an appropriate mixture of formal and informal efficiency. This is illustrated by the manner in which the NORDSYNC delegation interacts (with an annual meeting and consultations prior to the ESRF Council meetings) and achieves consensus, and by the new NORDSYNC agreement from 2007 that introduced a new, dynamic scheme for cost-sharing on the basis of scientific use.

The NORDSYNC user communities see a continued strong need and world-leading role for the ESRF in the coming 15-20 years. The advent of new national SR sources and X-ray free electron lasers will create new scientific opportunities and change the landscape, but these new sources will not be able to replace the ESRF in the medium term. They will be complementary, and there are many potential synergies with respect to the ESRF. The ESRF Upgrade Programme illustrates how the ESRF can stay competitive as a source of creative SR technology while making the most of the potential for continued thematic and geographic expansion of its user base by further developing the user support system. Nevertheless, the time is right for a joint review of the NORDSYNC priorities and set-up in light of these new developments, including the opportunities offered by PETRA III in Hamburg in the short term and MAX IV in Lund in the medium to longer-term.

1.6 Recommendations

NORDSYNC should continue to support the ESRF’s strategic development and use with focus on:

- Scientific quality based on the unique source strength for hard X-rays and the world-leading beamline and instrument technology;
- Development of the synergies with neutron sources (e.g. the ILL) and the new SR sources and FELs;
- Development of the merit-based access scheme to ensure the highest scientific quality and to attract talent and encourage collaboration on a global scale;
- Development of the user support system with new remote access and handling features and further development of the e-Infrastructure for data acquisition, handling, analysis and modelling, and data curation;
- Efforts to involve industry more directly in the use of the ESRF.

The ESRF and NORDSYNC should be used as a testing ground for streamlining the operations of a Nordic consortium with further delegation of responsibility to a single partner or pair of partners (e.g. head of delegation plus a substitute), combined with more systematic interaction using teleconferences before ESRF Council and committee meetings. Such a high degree of delegation is considered more suitable for mature organisations such as the ESRF and NORDSYNC and less appropriate in the initial phases of a new RI project. Streamlining should be carried out with a view to increasing transparency and dialogue among all of the stakeholders and actors, such as members of the ESRF Council, AFC, SAC and selection committees and user representatives.

The organisations behind NORDSYNC and/or NordForsk should encourage further integration of the Nordic user communities both within and across the disciplines. This could be achieved by:

- Combining national meetings to form Nordic meetings;
- Joint programmes for students and post-doctoral students, exchange of staff and sabbaticals;
- Joint summer and winter schools;
- Joint hearings on strategic issues such as RI roadmaps.

1.7 Summary of lessons learned

NORDSYNC is an example of a well-functioning Nordic cooperation measure. It was conceived in response to the politically-determined threshold contribution of 4% set for becoming a full partner of the ESRF, alongside the desire among the Nordic countries to contribute less than the usual GDP-based share to an international research infrastructure such as, for example, CERN. The 4% NORDSYNC contribution was accepted after negotiations with the other partners in the very early phases of the project, and the NORDSYNC consortium has been followed by two other consortia in the ESRF: BENESYNC as a full partner with a 6% share and Centralsync as a scientific associate with a 1.05% contribution to the running costs.

NORDSYNC has been a success in that the scientific communities in the Nordic countries have enjoyed full and unrestricted access to the ESRF, which has been exploited by leading groups to obtain a relatively large share of the beam time and to become deeply involved in the development of the ESRF. NORDSYNC has become a respected partner due to the high quality of the use combined with the Nordic tradition for flexibility, consensus and pragmatism when approaching delicate matters such as budgets, fees for overuse and access.

The success has been secured by the high-quality engagement and commitments at many levels of the ESRF operations and activities from the very early phases of the project. These engagements have been encouraged and supported by the employment of key staff from the Nordic countries in both shorter and longer term positions.

The NORDSYNC consortium model could be used for new engagements in some of the research infrastructure projects on the ESFRI Roadmap, and joint management with a large degree of delegation and task-sharing between the Nordic partners could lead to significant savings in the administration of these engagements.

Industrial utilisation of science-driven research infrastructures such as the ESRF evolves slowly and requires close collaboration between users in academia and industry, e.g. joint projects for Master's and Ph.D. students. It also requires dedicated outreach from the facility in terms of ease of access and use.

1.8 Acknowledgements

As the author of the present evaluation I have received considerable help, thanks to the patience, openness and frankness of the participants in the interviews and the cordial assistance offered by the staff at the NORDSYNC member organisations and at the ESRF. Valuable input has also been obtained through discussions with colleagues at ESFRI and DG Research and Innovation of the European Commission. I would like to thank everyone for their help, with special thanks to the NRIN committee for giving me this interesting assignment and for our stimulating discussions.

Jørgen K. Kjems

1.9 List of acronyms

AFC	Administrative and Finance Committee, ESRF
ALBA	Spanish Synchrotron Facility, Barcelona
APS	Advanced Photon Source, Argonne, USA
ASTRID	Aarhus STorage Ring, Denmark
BAG	Block Allocation Group at the ESRF
BENESYNC	ESRF consortium of Belgium and the Netherlands
Centralsync	ESRF consortium of Czech Republic, Hungary and Slovakia
CERN	Centre Européenne pour la Recherche Nucléaire
CRG	Collaborating Research Group, ESRF
DANSCATT	Danish neutron and x-ray scattering consortium
DESY	Deutsches Electronen Synchrotron, Hamburg
DLS	Diamond Light Source, UK
DORIS III	4.5 GeV storage ring at DESY, Hamburg
DTU	Technical University of Denmark
ERIC	European Research Infrastructure Consortium
ERL	Energy Recovery Linac
ESF	European Science Foundation
ESFRI	European Strategic Forum for Research Infrastructure
ESRF	European Synchrotron Radiation Facility, Grenoble
ESRP	European Synchrotron Radiation Project
ESS	European Neutron Spallation Source
FEL	Free Electron Laser
FLASH	Free electron LASer in Hamburg at DESY
FSRUO	Finnish Synchrotron Radiation User Organisation
GDP	Gross Domestic Product
IFE	Institute for Energy Research, Kjeller, Norway
LCLS	Linac Coherent Light Source, Stanford University, USA
LTP	Long Term Project, ESRF
LURE	Laboratoire pour l'Utilisation Rayonnement Eletromagnetique, Orsay
MAX IV	Next generation synchrotron radiation facility at MAX-Lab, Sweden
MAX-lab	National Electron Accelerator Laboratory, Lund, Sweden
MoU	Memorandum of Understanding
MX	Macromolecular Crystallography
NMR	Nuclear Magnetic Resonance
NordForsk	Organisation that funds Nordic research cooperation
NORDSYNC	Nordic consortium for ESRF membership
NRIN	Nordic Research Infrastructure Network
NSLS-II	National Synchrotron Light Source, Brookhaven, USA
OECD	Organisation for Economic Co-operation and Development
OECD GSF	OECD Global Science Forum
PEP X	New Synchrotron X-Ray Source, Stanford University, USA
PETRA III	Positron Electron Accelerator at DESY, Hamburg
PI	Principal Investigator
PRL	Physical Review Letters
RANNIS	Icelandic Centre for Research
RI	Research Infrastructure
SAC	Science Advisory Committee, ESRF
SLS	Swiss Light Source, Villingen
SNBL	Swiss-Norwegian Beam Lines at the ESRF
SOLEIL	French National Synchrotron Radiation Facility
SR	Synchrotron Radiation
SSRLS	Stanford Synchrotron Radiation Light Source
USM	ESRF User Service Mode
VR	Swedish Research Council (Vetenskapsrådet)

Putting a sample on a beamline. (Credit: G. Duvernay, INSIGN STUDIO, ESRF)

2 Purpose of the evaluation

The purpose of the evaluation is to assess how the individual national memberships function and are utilised at an organisational level in relation to the European Synchrotron Radiation Facility (ESRF) through the NORDSYNC consortium formed by Denmark, Finland, Norway and Sweden.

The basic question is: *How have the Nordic countries exploited their individual memberships of the ESRF through NORDSYNC?*

The evaluation is set in a context of learning and sharing of best practices, and it has addressed five fundamental criteria: quality and relevance of the project, effectiveness, efficiency of implementation, impact and potential for sustainability of Nordic participation in the ESRF through the NORDSYNC consortium.

The evaluation has been conducted with a view to:

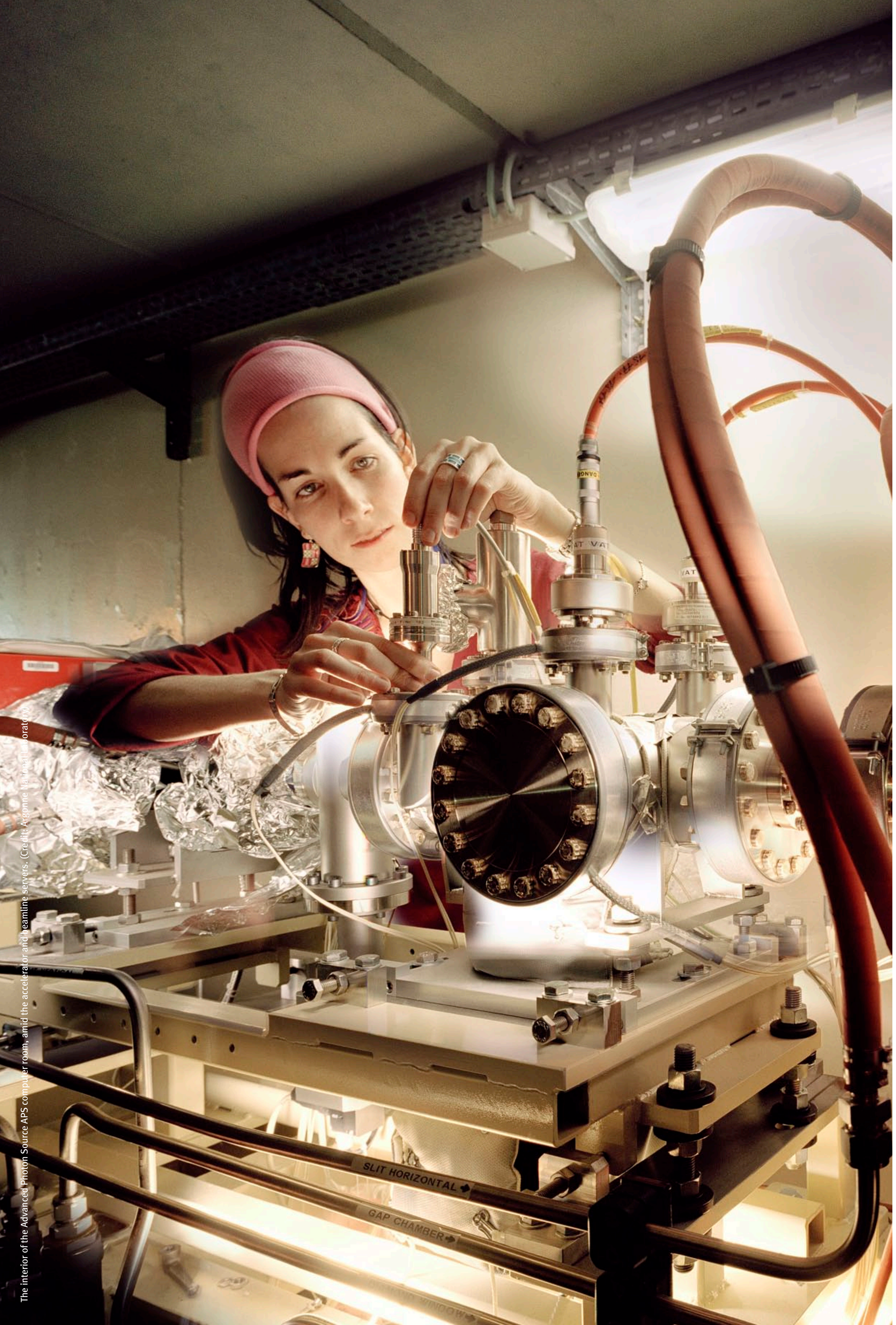
- Enhancing impact-effective utilisation of national memberships of NORDSYNC/ESRF;
- Developing recommendations for Nordic involvement and the guidance of similar projects in the future;
- Drawing key lessons learned to contribute to organisational learning;
- Enhancing credibility and transparency with respect to the use of public research funding.

A second purpose has been to use the evaluation of NORDSYNC and Nordic involvement in the ESRF to create a comparative reference point for each of the Nordic countries' involvement and to benchmark the utilisation of the ESRF memberships across the Nordic countries. An important rationale for a common evaluation is to enable each of the participating countries to compare themselves with other similar countries.

The evaluation is intended to establish a common platform for learning and improvement based on the different sets of experiences and solutions of each of the Nordic countries in relation to international research infrastructure involvement, with NORDSYNC and the ESRF as a test case. This will allow each of the participating countries to assess and possibly adjust their practices in relation to international research infrastructure involvement. Also, the evaluation may form the basis for discussing further Nordic cooperation in order to improve the overall scientific impact and cost-effectiveness of international engagements.

A further objective has been to provide best-practice tools not only for existing RI memberships but also for new memberships. Each country is expected to become involved in a growing number of international research infrastructures as a result of increased international collaboration under the ESFRI process. Thus, there is an increased need for solutions for how to best organise such memberships at the national level.

It is important to note that the present evaluation focuses on utilisation, organisational and administrative aspects of the NORDSYNC and ESRF involvement. It has not been an objective to carry out a scientific evaluation of the Nordic activities at the ESRF.



The interior of the Advanced Photon Source APS computer room, amid the accelerator and beamline servers. (Credit: Argonne National Laboratory)

3 Audience and use of the evaluation

The evaluation report is targeted towards the national agencies/research councils in each of the countries involved. These are also the actors represented in the NRIN committee, which commissioned the evaluation:

- The Danish Agency for Science, Technology and Innovation
- The Swedish Research Council
- The Research Council of Norway
- The Academy of Finland
- The Icelandic Centre for Research (RANNÍS)

The evaluation report is also intended to be of use to the other stakeholders in the ESRF and NORDSYNC activities that may be in a position to act on the results. These include:

- Persons involved in the NORDSYNC operation;
- Representatives of the scientific community using the ESRF (from academia and industry);
- Ministry/agency/academy officials (funding agencies);
- Science policymakers concerned with research infrastructure (NordForsk);
- Research council members (funding agencies);
- University deans and department heads (research institutions);
- The general public.

Spherical analyser crystal from the ID28 spectrometer. (Credit: Photoshop by S. Evans & G. Garner)

4 Evaluation methodology

The evaluation is based on: (1) a desk study of NORDSYNC and ESRF documents that were been made available by the NRIN committee or are publicly accessible, generally via the Internet; and (2) in-depth interviews with 26 key stakeholders in the Nordic countries and at the ESRF (18 interviews were carried out in person and eight by telephone).

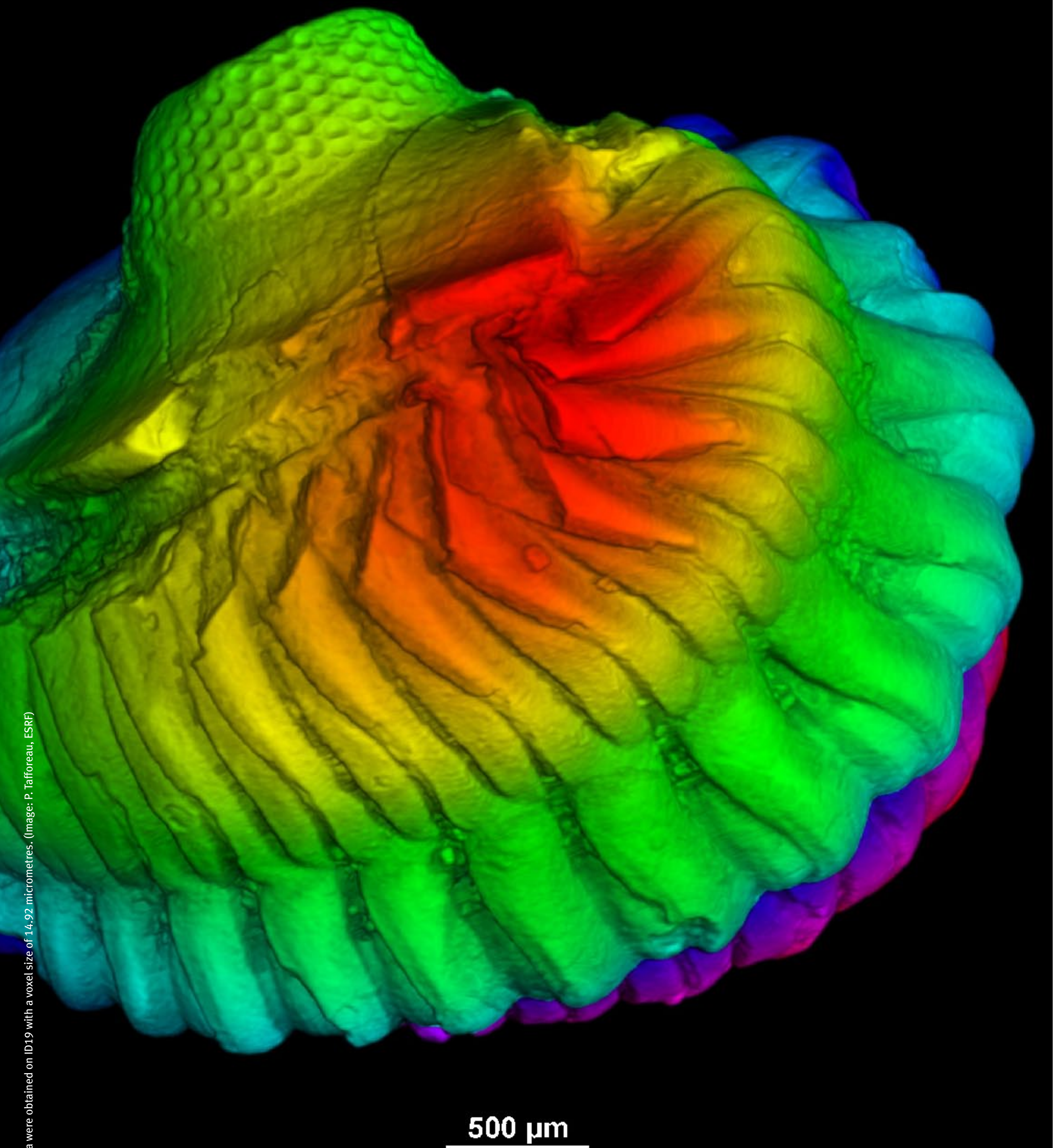
The documentation consisted of material related to the ESRF and NORDSYNC:

- Membership Statutes;
- Annual work plans;
- Technical reports;
- Regulations and policies;
- Research/surveys;
- NORDSYNC Annual Reports (2005-2009);
- Partnership arrangements, e.g. agreements of cooperation;
- Newsletters and publicity information;
- Output of any organisational learning initiatives;
- Other assessments, e.g. self-assessments, previous evaluations.

A list of references is included as Annex I to the report.

The people to be interviewed were selected in consultation with the NRIN committee members, who nominated candidates from their respective countries. The names of the persons interviewed are listed in Annex II. Interviewees include scientific and industrial users, research agency representatives, members of the ESRF Council and Administrative and Finance Committee, university deans and heads of departments as well as staff at the ESRF.

The interviews were conducted using a guide with topics and issues to be discussed (Annex III). The evaluator has striven to obtain quantifiable data using available, tangible data and indicators in the documentation. The evaluation report also includes qualitative feedback and assessments from the interviews. Important input was obtained from the ESFRI Roadmap and other ESFRI reports as well as national roadmaps and strategy reports.



3D rendering of a Devonian phacopsidae trilobite. Data were obtained on ID19 with a voxel size of 14.92 micrometres. (Image: P. Tafforeau, ESRF)

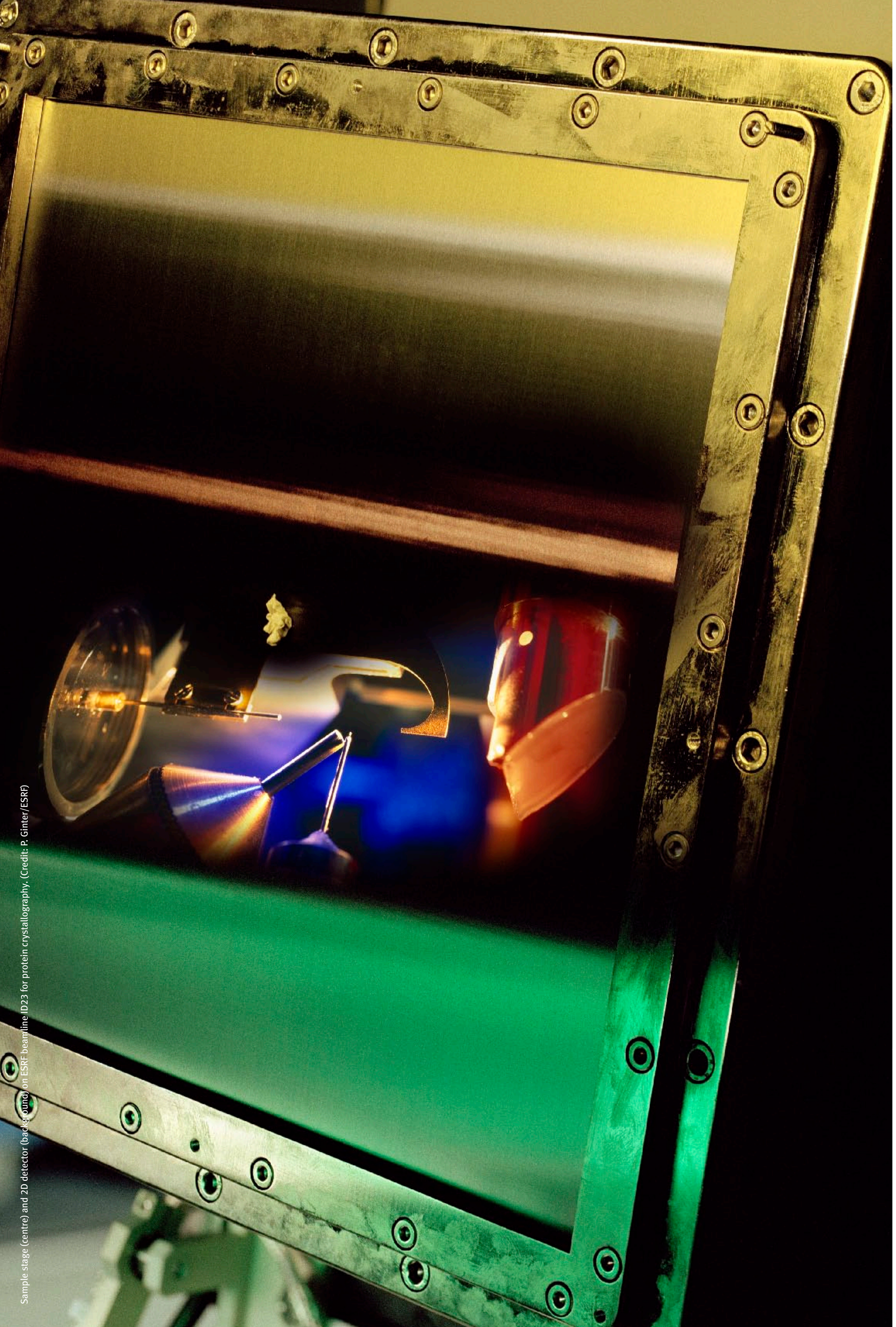
5 Limitations of the evaluation

The evaluation has been carried out over the course of four months and has been limited by the availability of NORDSYNC and ESRF-specific documentation. This has – with a few exceptions – restricted the quantitative analysis and benchmarking of the utilisation to the period 2005-2010.

The relatively small number of interviews in each Nordic country means there is only limited coverage of stakeholders and scientific communities in each country. This has resulted in only partial coverage of the scientific disciplines active at the ESRF. On the other hand, some of the surveyed documentation was prepared by broad user groups, e.g. in Finland, and thus represents broader community views.

Evaluations of this type are prone to difficulties relating to assessment and gauging of impact. The present evaluation is no exception. Publication and citation rates in high-impact journals are often used as proxy measures – and this approach was used in this evaluation as well.

The report does not include an evaluation of scientific quality of NORDSYNC activities at the ESRF, but instead relies on relevant national evaluation reports for individual disciplines, when such reports are available.



Sample stage (centre) and 2D detector (background) on ESRF beamline ID23 for protein crystallography. (Credit: P. Ginter/ESRF)

6 Evaluator

The evaluation has been conducted by civ. ing. lic. tech. Jørgen K. Kjems (evaluator), former director at Risø National Laboratory (now Risø DTU). Jørgen K. Kjems is the owner of the consulting firm Kjems R&D Consult. The evaluator has the following profile:

- Senior scientist no longer actively involved in research activities;
- Scientific experience within materials science and research at the ESRF;
- Familiar with other large-scale international synchrotron facilities;
- Broad range of specific knowledge of issues related to international RI facilities such as membership, governance, funding, research, collaboration within Europe and abroad from his career at Risø and from work for research councils and committees;
- Knowledge of RI policy at the European as well as the Nordic level through membership of ESFRI and OECD Global Science Forum, as well numerous advisory committees and evaluation panels.

The NRIN committee has served as the reference group for the evaluation.

7 Synchrotron radiation science and the ESRF

Movable detector on ESRF beamline ID02 for small-angle scattering studies. (Credit: P. Ginter/ESRF)

7 Synchrotron radiation science and the ESRF

Since their discovery by Röntgen just over 100 years ago, X-rays have been used as powerful tools in research, industry and medicine. All facets of X-ray research have been revolutionised in the past four decades by the use of synchrotron radiation and the high brightness beams that are now available (Figure 1). Synchrotron radiation, which is electromagnetic radiation emitted during the acceleration of charged high-energy particles (electrons and positrons), has very special properties because the radiation is concentrated in the forward direction of the accelerated particles due to relativistic effects. It was first generated in the bending magnets of accelerators built for high-energy particle physics research. Particle physics accelerators were soon inadequate for meeting the increasing demand for synchrotron radiation within the scientific community. These have been replaced by storage rings built for this purpose. The applications of synchrotrons cover virtually all scientific disciplines, from biology, life sciences and medicine to engineering, materials science, geophysics, chemistry and fundamental physics.

Current growth areas for synchrotron radiation-based research include:

- Advanced nano/biomaterials;
- Science of materials in extreme conditions;
- Ability to study processes and performance in situ, e.g. catalytic reactions;
- Archaeology and palaeontology;
- Cultural heritage;
- Interactions with industry (especially through imaging).

X-ray brilliance from available sources has grown faster than Moore’s Law, as scientists, engineers and technicians have developed custom-built synchrotron sources that first use bending magnetic radiation and then SR sources based on insertion devices.

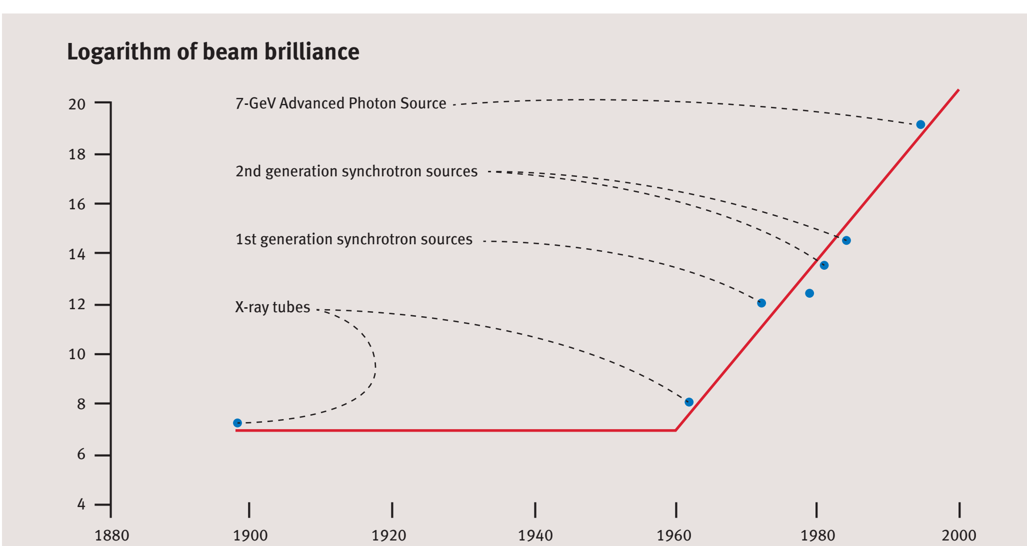


Figure 1: Brilliance of X-ray beams as a function of time (photons/s/mm2/mrad2/0.1%BW).[1]

1 Figure quoted from the ESFRI Working Group report on Analytic Facilities (2010).

7.1 Global development

Dedicated storage rings and associated instrumentation with enhanced performance characteristics have been constructed in Europe, Asia and the USA during the past four decades. It quickly became apparent that the brilliance of a source can be tremendously increased by introducing magnetic insertion devices in the storage ring (“undulators” and “wigglers”). The results were such that third-generation sources, based essentially on such insertion devices, were proposed in the 1980s in various locations. For the soft X-ray and ultraviolet range, an energy of less than 2 GeV is sufficient and such facilities are built on a national scale. Higher energy is required to achieve X-ray wavelengths of several hundredths of a nanometre, which is the radiation needed for certain areas of physics, chemical and biological research. Three such hard X-ray facilities are now in operation: SPring-8 (Nishi Harima, Japan, 8 GeV), APS (Argonne, USA, 7 GeV), the ESRF (Grenoble, France, 6 GeV).

The current provision of SR facilities includes 40-50 sources worldwide (see Figure 2) including major new facilities coming online in the emerging economies of Brazil, India, China and Taiwan. Recent years have seen major new European investments with the commissioning of SLS (CH), Soleil (F), DLS (UK), ALBA (E) and PETRA III (D), and the start of construction of MAX IV (S), as well as the planning of a Polish SR facility.

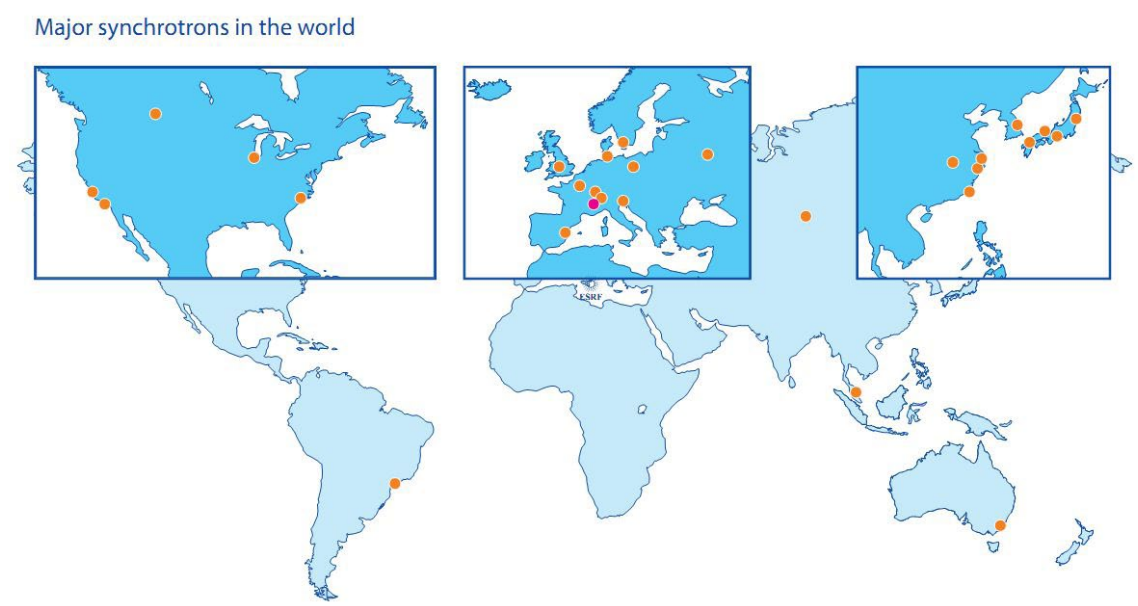


Figure 2: Synchrotron radiation sources worldwide (picture courtesy of APS, ANL).

7.2 Brief history of the ESRF[2]

In the mid-1970s the European Science Foundation (ESF) launched a study of the feasibility of a synchrotron radiation machine to span the entire X-ray region up to wavelengths to the order of 0.1 Å. This resulted in the report "Synchrotron Radiation – A perspective view for Europe" (Black Book 1, 1975), which pointed out the benefits of such a facility and provided information about the desired technical parameters, costs and schedule. The machine would require energies of 5 to 7 GeV. The concept was further refined with technical work and extensive inquiries within the European scientific community. These efforts resulted in the publication of "European Synchrotron Radiation Facility. The Feasibility Study" (a four-volume document called the Blue Book, 1979), which outlined the main features of the future European Synchrotron Radiation Facility (ESRF). Several scientists from the Nordic countries contributed to this work.

In 1980 an intergovernmental ESRF Progress Committee was formed with representatives from Austria, Belgium, Denmark, Finland, France, Germany, Italy, The Netherlands, Sweden, the United Kingdom and Yugoslavia. The work of the machine and instrumentation subgroups continued under the auspices of the ESF ad-hoc committee with the aim of incorporating new technological development and experience gained by synchrotron radiation users. An updated document "A case for a European Synchrotron Radiation Facility" (Yellow Book, ed. J. Als-Nielsen et al., 1982) was presented to the Progress Committee and provided specifications for the facility, taking into account the most recent technological advances (devices to be inserted in the straight sections).

A European Synchrotron Radiation Project group was created in 1982 under the leadership of B. Buras, a professor at Copenhagen University and Risø, and S. Tazzari, and was located at CERN. Its conclusions were published in "European Synchrotron Radiation Facility – Report of the ESRP" (Green Book, 1984), which described the project goals (including industrial applications), the source, experimental equipment, time scale, cost and general construction requirements. In parallel, the Progress Committee started exploring possible sites for the facility, including Dortmund, Roskilde (Risø), Strasbourg and Trieste. The siting process was interrupted in 1985 when France and the Federal Republic of Germany proposed to implement the project in France and agreed to contribute a major share of the financing. They invited other countries to join, with a minimum contribution of 4%. The Foundation Phase began on 10 December 1985 with the signing of a Memorandum of Understanding (MoU) by France, the Federal Republic of Germany, Italy, the United Kingdom and Spain. The provisional ESRF Council and several subcommittees were formed. The Council established a construction team in Grenoble, led by R. Haensel as Director General. The detailed scientific, technical and financial data were reported in the "Foundation Phase Report" (Red Book, 1987), adopted by the ESRF Council in 1987 as the central planning document for the ESRF. At the same time, preparation of the legal basis and negotiations with additional member countries were carried out. The Nordic countries were accepted as the first consortium, NORDSYNC, with a 4% share of the construction and operation cost. The establishment of the NORDSYNC consortium was motivated by the size of the required minimum threshold for full participation combined with a political wish to pay less than the normal GDP-based share, as was the case for CERN.

The location in Grenoble was confirmed on a site adjacent to the ILL high flux reactor made available by the local authorities, and the Foundation Phase ended with the signing of a protocol on 22 December 1987 by the five countries mentioned above, plus Switzerland and the four Nordic countries Denmark, Finland, Norway and Sweden. On 16 December 1988, the ESRF agreements on the Intergovernmental Convention and the Statutes of the ESRF were signed in Paris by the research ministers of 11 countries: Belgium, France, Germany, Italy, Spain, Switzerland, the United Kingdom and, acting jointly as a single contracting party – NORDSYNC– Denmark, Finland, Norway and Sweden. In 1990 Belgium and The Netherlands joined the convention and established a consortium, BENESYNC, with joint participation of both countries to be effective from the beginning of the construction period. Later, in the 1990s and early 2000s, several new countries joined as scientific associates, each contributing about 1% of the running costs: Portugal, Israel, Austria, Poland and the consortium Centralsync (Czech Republic, Hungary and Slovakia).

2 Based on the article on the ESRF website entitled "Making of the ESRF".

ESRF member contributions:
27.5% France, **25.5%** Germany, **15%** Italy, **14%** United Kingdom, **4%** Spain, **4%** Switzerland, **6%** BENESYNC (Belgium, The Netherlands), **4%** NORDSYNC (Denmark, Finland, Norway, Sweden)

Additional contributions:
1% Portugal, **1%** Israel, **1%** Austria, **1%** Poland, **1.05%** Centralsync (Czech Republic, Hungary, Slovakia)

The ESRF company (a French Société Civile Immobilière) was established on 12 January 1989. Construction work started on the site in late 1989, and on 12 November 1991 the ESRF injector reached its operational energy of 6 GeV for the first time. All of the technical buildings were completed by the end of that year. The initial construction programme described a facility with 30 beamlines, essentially based on insertion devices as radiation sources. However, the storage ring provides the potential for building additional beamlines on bending magnets. The Council agreed that groups from research institutes based in the contracting party countries could use this bending magnet radiation, and adopted "General conditions for beamlines established at the ESRF by Collaborating Research Groups". Shortly afterwards, contracts for the construction of four CRG beamlines and a special high-energy physics experiment were concluded.

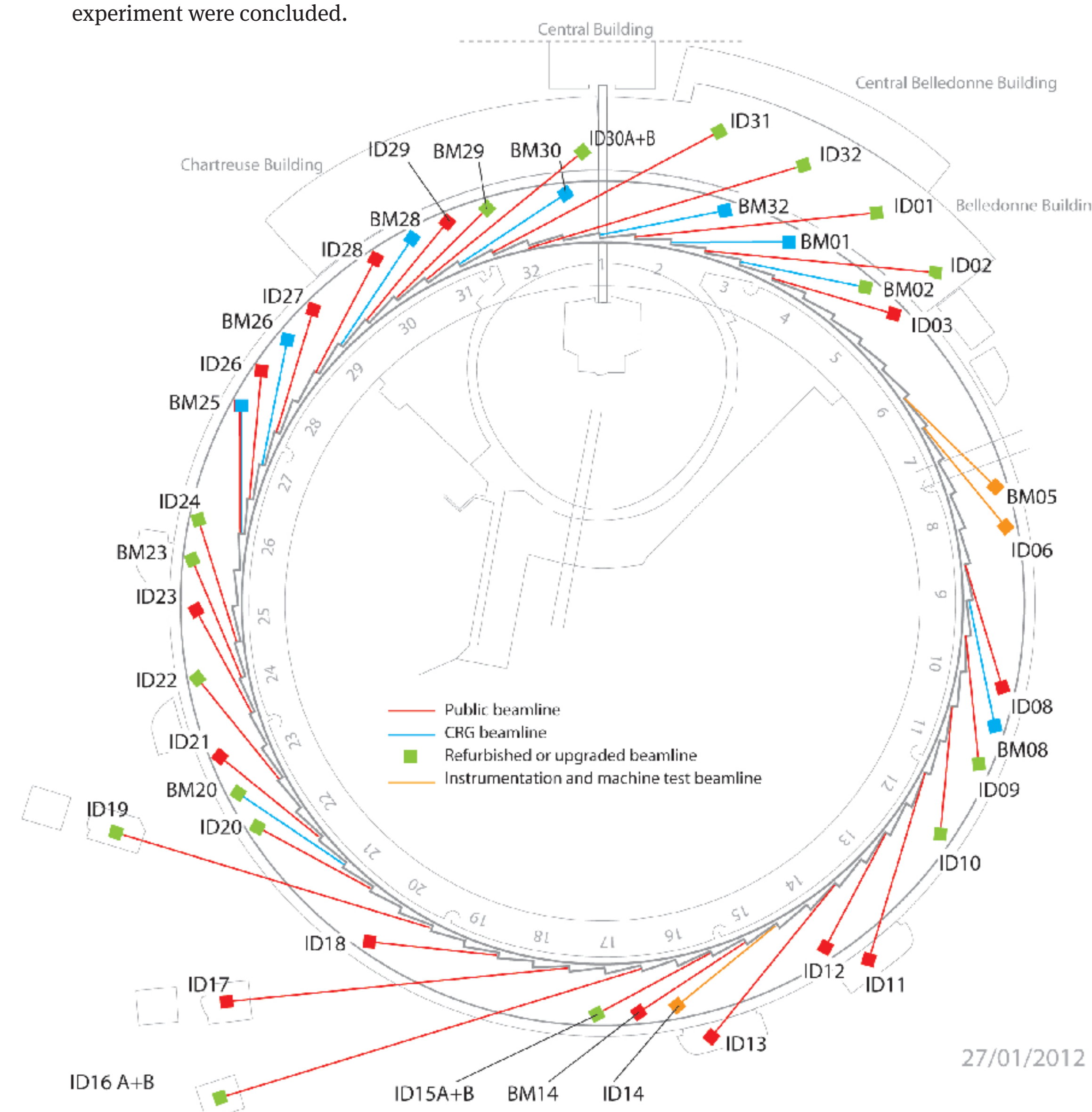


Figure 3: Current layout of beamlines at the ESRF.

Preliminary user service operations were conducted during 1993 and 1994, and the first set of beamlines was commissioned. The beam time allocation procedure was implemented for the first time for the period September-December 1994 (Annex IV). By June 1994 the scientific programme for the first 26 (of 30) ESRF beamlines had been determined, seven CRG beamlines (plus a special high-energy physics experiment) had been approved (one of these CRGs was the Swiss-Norwegian collaboration, SNBL) and applications for another two were under review. In September 1994 the ESRF inauguration ceremony took place in the presence of research ministers and representatives from the 12 countries of the contracting parties. Parallel to the construction of further beamlines, regular user operations took place on the already completed beamlines (see the current beamline diagram in Figure 3).

In 1995, 4 752 hours of User Service Mode (USM) were scheduled and delivered, with an average availability of 92.9%. These figures have been improving steadily. Figure 4 illustrates the excellent performance in terms of availability of the source in recent years, with an average of 98.3% in the 2004-2010 period and an average of 5 269 USM hours delivered by the facility per year.

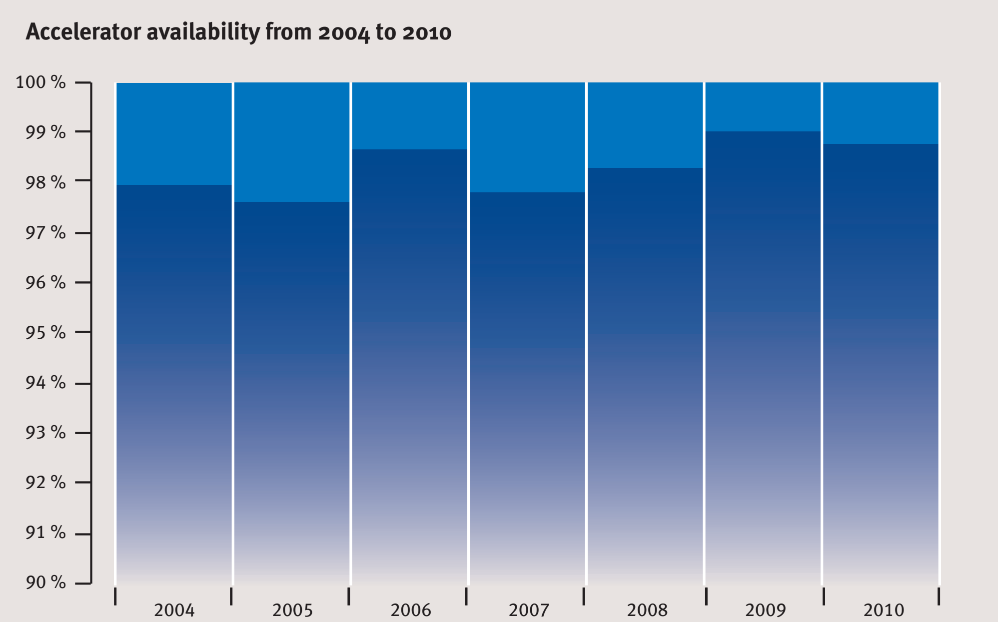


Figure 4: Availability of the beams at the ESRF in the 2004-2010 period.[3]

It is worth noting that the construction of the ESRF followed the overall budget and timelines defined for the project and that it soon surpassed the original performance specifications on almost all parameters.

3 www.esrf.eu/Accelerators/Operation/Statistics/AVAIL2010.pdf

The ESRF, key figures for 2010[4]

Budget: The 2010 operating budget was EUR 98 M (including funding earmarked for the ESRF Upgrade Programme).

Staff: About 600 people work at the ESRF.

Visiting researchers: About 7 000 researchers visit the ESRF each year to carry out experiments.

Applications for beam time: More than 2 000 applications are received each year for beam time at the ESRF.

Scientific papers: Users and staff publish about 1 700 papers annually on work carried out at the ESRF.

7.3 The ESRF Upgrade Programme 2009-2015

The use of the ESRF has grown steadily since its inauguration in 1994, and the user communities have expanded and the usage has spread to new fields. In order to maintain its leading role and respond to emerging scientific challenges, the ESRF is implementing an ambitious Upgrade Programme (2009-2015), comprising (i) the extension of the experimental hall to enable the construction of new and upgraded beamlines with largely improved performance and new scientific opportunities, as well as improved infrastructures for the preparation of experiments; (ii) a programme of improvements of the accelerator complex; (iii) a strong supporting programme of engineering and technology development; and (iv) the development of productive science and technology-driven partnerships. The possibility of establishing a joint high magnetic field laboratory with the ILL and other European high field laboratories is also foreseen. The planned upgrade will facilitate significant progress in fields such as nanoscience and nanotechnology, structural and functional biology, health, the environment, energy and transport, information technology and materials engineering. The science case and related technological challenges are laid out in the Purple Book, available on the ESRF website. The scope of the Upgrade Programme encompasses:

- Eight new beamlines with unique capabilities;
- Refurbishment of many existing beamlines to maintain their world-class standard;
- Continued world-leading X-ray beam availability, stability and brilliance;
- Major new development in synchrotron radiation instrumentation.

The project is included on the ESFRI Roadmap and has received EUR 6.8 M in support from the European Commission (under FP7) for the preparatory phase. The total construction cost for the upgrade is EUR 238 M, of which EUR 77 M will come from the regular operating budget. The implementation has been delayed and the scope has been adjusted as a consequence of the budget reduction for the 2011-2013 period.

7.4 The ESRF organisation and operation, representation of partners

The governing bodies of the ESRF are the Council, assisted by two advisory committees (Scientific Advisory Committee and Machine Advisory Committee, the latter up to mid-1994) and the Director General. Each contracting party may appoint maximum three delegates to the Council (plus two observers). The NORDSYNC delegation consists of three delegates and an observer. The head of the NORDSYNC delegation rotates annually, and the head of delegation of the prior year assumes the observer role in the following year. The Council takes all decisions concerning possible changes in shareholdings in the company, operating rules, scientific programme, budget, timeshare policy, choice of director, etc. Each contracting party has one vote.

4 The ESRF company report 2011.

The ESRF has instituted weighted voting procedures, which take into account both the contracting parties and their financial contribution in terms of their shareholding:

- Simple majority: one-half of the capital, the number of unfavourable votes not exceeding one-half of the contracting parties;
- Qualified majority: two-thirds of the capital, the number of unfavourable votes not exceeding one-half of the contracting parties;
- Unanimity: at least two-thirds of the capital and no counter-vote by any contracting party, all the contracting parties having been given the opportunity to take part in the vote.

Unanimous approval in the Council is required for any change in the number of contracting parties and any amendment to the bylaws or the operating regulations. A qualified majority is required for budget decisions, establishment of the scientific programme, director appointment, beamline timeshare policy and the institution of advisory committees. A simple majority decides all other matters.

As the ESRF's facility is intended for use in both basic and applied research, the possibility of discoveries leading to a patent application is high. Consequently, intellectual property rights are covered in great detail in Article 14 of the bylaws.

Economic considerations and industrial return and the notion of fair return are contained in Article 13.4 of the bylaws: "*(...) The Director General shall report to the Purchasing Committee and the Council regularly on the distribution of contracts. In the case of a significant imbalance in the value of contracts among the countries of the Contracting Parties in comparison with their contributions the Council shall upon request of any Contracting Party consider appropriate measures to be implemented by the Purchasing Committee and the Director General, having regard to [fair return].*"

In practice, at the beginning, return coefficients for the award of contracts (excluding civil engineering) were between 1.1 and 1.3 for Switzerland, the United Kingdom and France, around 0.9 for Germany and NORDSYNC, between 0.6 and 0.7 for Italy and BENESYNC, and 0.3 for Spain. In recent years the NORDSYNC return coefficient has been between 0.5 and 0.6 (see Table 5, p. 35).

7.5 Scientific "juste retour"

The allocation of beam time based on merit and peer review does not automatically imply that science communities in each member country receive beam allotments that correspond to the share of running costs for the ESRF. Since the inauguration of the ESRF, Germany and Italy have tended to receive consistently less beam time in relation to their financial share, and NORDSYNC, the United Kingdom and Spain have received more than their financial share. In 2004 this resulted in the ESRF Council adopting corrective measures to the beam time allocation process. According to these measures, 80% of the beam time is to be allocated based on scientific merit alone, whereas the allocation of the remaining 20% is to be based on scientific merit (score given by the Review Committees) combined with an algorithm that gives bias and preference to proposals from countries with "underuse". The ESRF deems that these measures have been implemented without significant loss of scientific quality due to the uncertainties inherent in the peer review system as such. At the same time, agreement on the interpretation of "substantial overuse" was reached, which meant additional payments for overuse exceeding 0.125% of the financial share (i.e. 4.5 % for NORDSYNC). NORDSYNC has therefore paid for overuse since 2005.

In 2010 the allocation system was further modified as a consequence of the reduced annual contributions and expenditure budgets for the period 2011-2013. As part of an 11-pointplan, the ESRF Council adopted temporal but fixed limits for the allocation of beam time to contracting parties and scientific associates that had been forced to reduce their financial contribution in relation to the agreed share in the ESFR Convention. Specifically, this means that the scientific use by the United Kingdom and Italy will be limited to 10.32% and 13.41%, respectively, for the next three years. The corrective measures still apply to the other countries. However, the NORDSYNC delegation has reserved its position and will not automatically pay for overuse if the new allocation procedure results in beam time allocation above

6% for NORDSYNC. Spain has chosen not to pay for overuse over the past few years, and the ESRF has thus restricted Spain's usage to the value defined by the 4% share.

7.6 Observations and findings concerning the ESRF

All of the interviews showed a very high degree of satisfaction with the ESRF operation. ***The ESRF is viewed both as a scientific lighthouse with world-class, pioneering synchrotron beamlines and as a very well-functioning user facility.*** This is corroborated by the informal benchmarking between SPring-8, the APS and the ESRF, where the ESRF is leading in terms of the number of users, publications, availability and diversity of beamlines.[5] The institution is now in full bloom, with steadily growing user communities and impacts, as can be seen from the publication data (see Figure 5). The ESRF has been very responsive to the needs and wishes of the Nordic user communities. This is illustrated by the development of beamlines for biology research, which started with a single dedicated facility and now involves 10 beamlines. ***The ESRF is viewed as the major competence centre for synchrotron radiation technology, from the accelerator to the detectors and data handling systems***. The institution willingly shares its know-how with the growing number of national facilities. Several users saw unused potential for synergies between the ILL and the ESRF. ***The ESRF Upgrade Programme is a key driver for new instrument development, which will create new scientific opportunities especially in the hard X-ray area*** and will allow for new frontier applications in established fields and a broadening of use to encompass new fields of research. The user support system is under continual development, with a strong user-oriented culture among the staff and continued development of the sample handling automation and remote access facilities. ***The user operations are second to none.*** At the same time this is seen as the raison d'être for the ESRF***. The access system is perceived as fair***, with appropriate involvement of user representatives. The flexibility in different modes of access is highly appreciated and the Nordic communities have made good use of all of the options: CRGs, Long Term Projects, BAGs and rolling access for exploratory measurements.

The temporary measures implemented to better align the financial contribution of the contracting parties with their scientific use[6] have caused concern among the users. ***The merit-based access scheme is generally viewed as the best way to promote scientific quality, and it has given rise to cross-national cooperation in teams competing to develop the best scientific proposals for beam time***. What may happen now is that teams from the countries that will experience access limitations due to financial constraints will be seen as less attractive partners despite their scientific standing. Many see this as an unfortunate juxtaposition of scientific and administrative matters, and it is hoped that the ESRF can soon return to normal practice. The corrective measures that promote the use of the ESRF by member countries with less-than-average use are seen as fair.

There is a overall agreement that ***the ESRF has delivered a very satisfactory return on investment and that the institution has exceeded expectations on all fronts*** (machine, source, beamlines, user services and impact). The Nordic communities are currently very dependent on the ESRF for their scientific work and will remain so in the foreseeable future.

The interviewees also noted that many new sources are coming on line and that ***the ESRF will face scientific competition from new high-brilliance facilities*** that will make it possible to conduct frontier and in situ experiments with dedicated sample environments, fast chemistry experiments using multiple experimental techniques, and capability for 3D imaging such as submicron bioimaging using contrast variation methods and fast reconstruction.

5 Unpublished, internal report of the ESRF.
6 ESRF Council resolution on 29 November 2010.

Viewport on an experiment in a beamline. (Credit: Photoshop by S. Evans & G. Garner)

8 NORDSYNC

8.1 Organisation and commitments

Four Nordic countries – Denmark, Finland, Norway and Sweden – are members of the ESRF through the NORDSYNC consortium, as set out in the contract dated 26 October 1987. The NORDSYNC membership and contribution to the ESRF is 4%. Until 2007, the national shares within NORDSYNC were distributed as follows: Denmark 28.5%, Finland 16%, Norway 14% and Sweden 41.5%. According to the contract, the shares are negotiable and new members may be included. The consortium is headed by a steering committee with one member from each country. Three of these committee members are also delegates to the ESRF Council, while the fourth member has advisor status at the meetings of the Council. The upper limit for the delegation to the ESRF Council is five persons. There is an annual rotation system for the delegates to the ESRF Council between the NORDSYNC members.

The NORDSYNC contract was renewed in 2007, and it was decided to make the individual national contributions dynamic, so that they reflected the average executed shifts for the preceding three years. Thus, the national shares for 2008-2010 were based on actual usage in the period 2004-2006, and the 2011-2013 shares were determined according to usage in the period 2007-2009. This decision has resulted in certain changes in the distribution compared to the former more static distribution valid during the period of the original NORDSYNC contract:

Table 1: Individual share of the NORDSYNC contribution to the ESRF.

Period	Denmark	Finland	Norway	Sweden
2008-2010	19.9%	15.9%	25.6%	38.6%
2011-2013	21.9%	13.7%	18.6%	45.9%

The algorithm for calculating the national shares (taken from Appendix 1 of the renewed NORDSYNC contract) is:

1. The calculations are based on data delivered by the ESRF containing information for each proposal on the number of executed shifts, participating institutions, the institutions' nationality, and whether the proposal is a CRG proposal, standard proposal or industrial proposal.

2. The National Fraction for each proposal is calculated as the number of participating institutions from a particular country divided by the total number of participating institutions. "Institutions" are considered identical if they have the same postal address, unless they belong to different research institutions or organisations. Only institutions from ESRF member countries or ESRF scientific associate countries are counted. The ESRF itself is considered a member institution.

3. A weight of 0.25 is assigned to the CRG proposals and a weight of 1.0 to the standard proposals. Industrial proposals are assigned a weight of 0.0.

4. For each proposal the weighted number of shifts is calculated as (number of executed shifts) x (National Fraction) x (weight).

5. The national share is calculated as (sum of weighted number of shifts for each country)/(sum of all weighted number of shifts for all NORDSYNC countries).

It was also decided that in the event of a request from the ESRF for an additional contribution due to overuse in the preceding three years, the contribution from each NORDSYNC country will be calculated using the national share valid for the year in which the additional contribution is to be confirmed at a meeting of the ESRF Council. For example, the overuse fee to be paid in 2008 was confirmed at the November 2007 Council meeting and was therefore distributed among the NORDSYNC countries according to the old shares, while the new shares were used for the regular 2008 contribution. The NORDSYNC contribution to the ESRF budget for 2011 amounts to EUR 4 013.9 K. This contribution consists of two components. The first corresponds to the regular 4% NORDSYNC share of the ESRF budget, amounting to EUR 3 472.8 K. The second component is an additional contribution for overuse of beam time in accordance with the ESRF rules for corrective measures, amounting to EUR 541.1 K for overuse in 2009.

8.2 NORDSYNC's scientific use of the ESRF

Since the beginning, the scientific communities in the Nordic countries have been very active users of the ESRF under the various forms of access schemes. The scientific use measured in terms of eight-hour beamline shifts delivered in the period 2005-2010 is shown in the table below:[7]

Table 2: Number of eight-hour beamline shifts delivered to NORDSYNC groups, and share of total.

Year	2005	2006	2007	2008	2009	2010
Shifts	836	767	855	795	950	936
Share of total	**6.3%**	**5.2%**	**5.9%**	**5.3%**	**5.9%**	**6.4%**

The distribution of the scientific use of the ESRF by the different scientific communities in the Nordic countries can be illustrated by the distribution of the number of delivered eight-hour beamline shifts at the ESRF during 2009. This is shown in the table below as the percentage of the total number of shifts obtained by scientists from the four countries. Shifts are assigned in fractions to a given country corresponding to affiliation of the individual proposers named in the proposals. This indicates that there are significant differences in the profiles of the Nordic ESRF user communities; for example, in this context Denmark is particularly strong in applied materials science and engineering, followed by chemistry and surface science.

7 Data from the ESRF user office.

Table 3: Distribution of the delivered shifts according to fields of science for the different NORDSYNC countries.

Distribution (%) of shifts in science fields, 2009	DK	FI	N	S
1. Chemistry	27	0	61	12
2. Electronic and magnetic properties	0	32	1	13
3. Crystals and ordered systems	0	8	6	3
4. Disordered systems	0	0	0	4
5. Applied materials and engineering	38	16	2	18
6. Environmental and cultural heritage	8	0	7	7
7. Macromolecular crystallography	8	19	11	24
8. Medicine	7	13	0	0
9. Methods and instrumentation	0	0	0	0
10. Soft condensed matter	0	0	5	2
11. Surfaces and interfaces	12	12	7	17

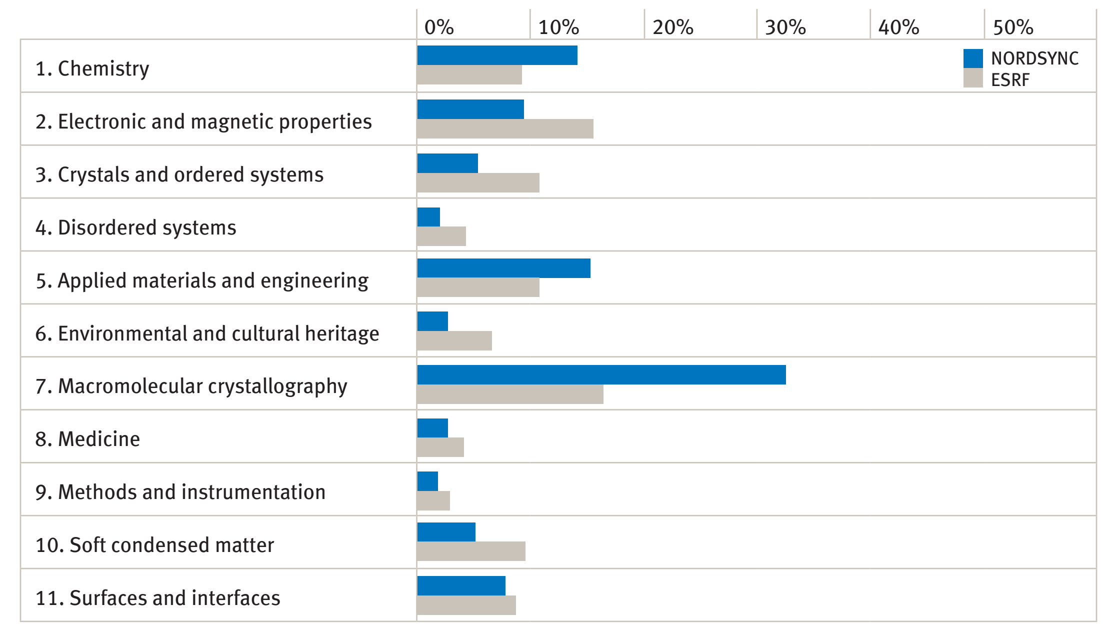


Figure 5: Graphic representation of the profile of use across the disciplines (listed in Table 3) in the 2004-2009 period for NORDSYNC and for the ESRF as a whole.

One can see a consistent trend of over-proportional use of the ESRF by about a factor of two in the fields highlighted in red in the table, compared to the average use in these fields by all of the ESRF partners in 2009. A similar trend is evident when comparing the profile of use for NORDSYNC as a whole with the profile of the total use of the ESRF in the 2005-2010 period (Figure 5). This illustrates that the Nordic scientific communities are particularly strong in these areas and are able to compete for a relatively large share of the beam time.

The impact of the ESRF in the Nordic communities can be gauged by the rate of publication. This has been growing steadily over the years since the ESRF was established, with the first signs of saturation at a level of about 300 publications per year in refereed journals and conference proceedings for the Nordic user communities as a whole.

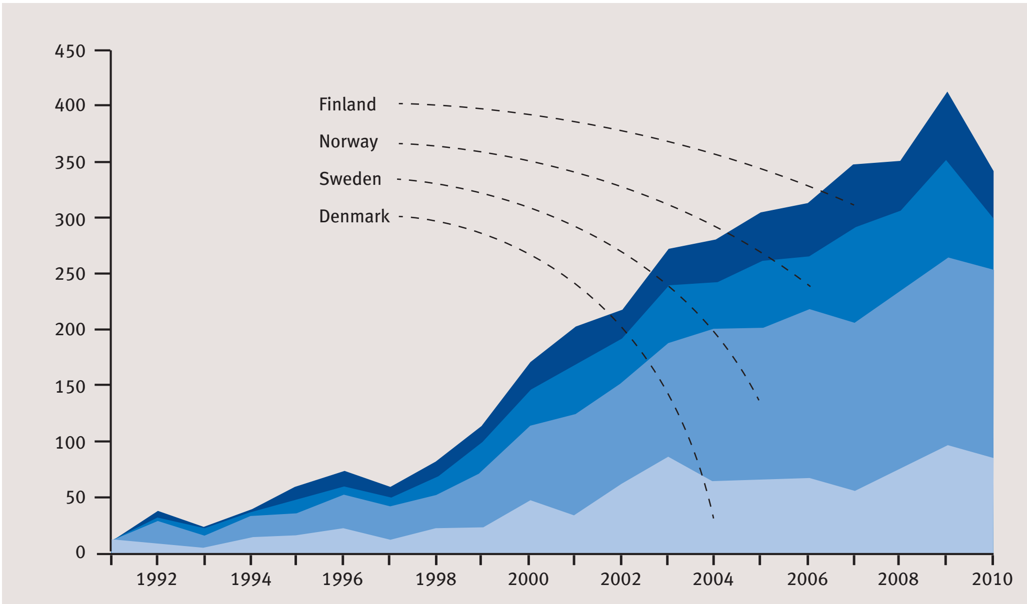


Figure 6: Number of publications by the Nordic ESRF user communities.

Figure 6 shows the number of scientific publications per year, where the ESRF and the name of one of the NORDSYNC countries appear in the affiliations in the 20-year period 1991-2010. The national numbers comprise an average amount of bilateral (11%), trilateral (1.5%) and multilateral (1.5%) collaborative works within the Nordic communities. Thus, the total numbers in the graph should be corrected for double count (Google Scholar).[8]

The number of articles in high-profile journals supplements the picture of the impact of the Nordic use of the ESRF. Using this metric, the Nordic communities also perform better than the average of ESRF users as a whole.

Table 4: Examples of the number of publications in high-profile journals during the ESRF lifetime.

Publications in the period 1992-2010	Nature	PRL	Science
Denmark	19	12	83
Sweden	39	23	116
Norway	4	1	57
Finland	7	7	29
Sum	69	43	285

One of NORDSYNC's objectives is to coordinate and enhance the use of synchrotron radiation for scientific and industrial research in the Nordic countries and to promote purchases at the ESRF from Nordic companies. The industrial liaison officer from the Academy of Finland based at CERN currently has the main responsibility for promoting this.

8 Results from a Google Scholar search with "ESRF" and "synchrotron" and "Nation1" and "Nation2".

Table 5: The latest data for the industrial return for companies in the Nordic countries:[9]

Period	Return coefficient
1/96-12/98	0.26
1/97-12/99	0.17
1/98-12/00	0.25
1/99-12/01	0.28
1/00-12/02	0.33
1/01-12/03	0.31
1/02-12/04	0.34
1/03-12/05	0.54
1/04-12/06	0.50
1/05-12/07	0.63
1/05-03/08	0.59

8.3 Observations and findings concerning NORDSYNC

NORDSYNC is seen as ***well functioning and is perceived mainly as an administrative measure*** by the scientific users; however, in most cases there is an adequate coupling to the user communities in the individual Nordic member countries. The NORDSYNC operation takes advantage of and has built trust between the Nordic partners at many levels. This has paved the way for flexibility in the preparation of ESRF and NORDSYNC matters, with a suitable mix of formal and informal contacts.

The NORDSYNC organisation has been ***able to handle and find consensus in delicate matters*** such as the corrective measures for beam time allocation, the payments for overuse and the dynamic redistribution of the NORDSYNC contributions.

NORDSYNC is seen as ***a respected and influential partner in the ESRF***, and the Nordic countries have been well represented on the staff of the ESRF, also at the top levels and in the advisory bodies. This is a result of the countries' consistently high-quality contributions to the development and use of the ESRF. The Nordic scientific ***user communities are highly respected***, and from the very start they have been able to compete for an over-proportional share of beam time (about 6%),despite the recent corrective measures that have made the access conditions even more competitive for the Nordic communities. The ***quality of the use is also reflected in the rate of publication***, including the number of articles in high-profile journals, to which the Nordic communities have contributed about 10% of the total. The Nordic use of the ESRF has been concentrated in areas where the corresponding communities have a ***strong standing, such as in the areas of structural biology, chemistry, condensed matter physics and materials research.*** In many cases, the use of ESRF beamlines has been an essential component of the work of the leading groups in these fields in each of the Nordic countries.

NORDSYNC as such has not generated scientific cooperation, although there are many examples of bilateral and multilateral projects in the publications originating from work at the ESRF. There are also many examples of joint summer schools for graduate students and post-doctoral students in the Nordic countries and at the ESRF in Grenoble. ***Nordic contacts are growing within the different fields***; for example, the annual KULUA meeting in structural biology has an attendance of about 100 scientists.

9 Data from NORDSYNC report 2009.

There is ***some industrial use of the ESRF***, mainly in the form of collaborative projects with university groups by research-oriented firms such as AstraZeneca, Haldor Topsøe, Hydro and Novo Nordisk. There are also ad hoc examples of direct industrial use of the ESRF by these companies, but the volume of work is quite limited (such use accounts for about 1% for the ESRF as a whole, of which 60% comes from pharmaceutical companies). The ESRF offers access for proprietary research for commercial exploitation. Such access is priced according to the market value, with a 20% additional charge for non-ESRF member states. Samples can be handled by the ESRF staff with remote access experiments and data, either in full remote mode or in a mix. Several of the interviewees expressed the opinion that ***industrial use could and should be promoted further***, and that this would require more active engagement on the part of the academic users, e.g. joint student projects, and further streamlining of the access conditions and services.

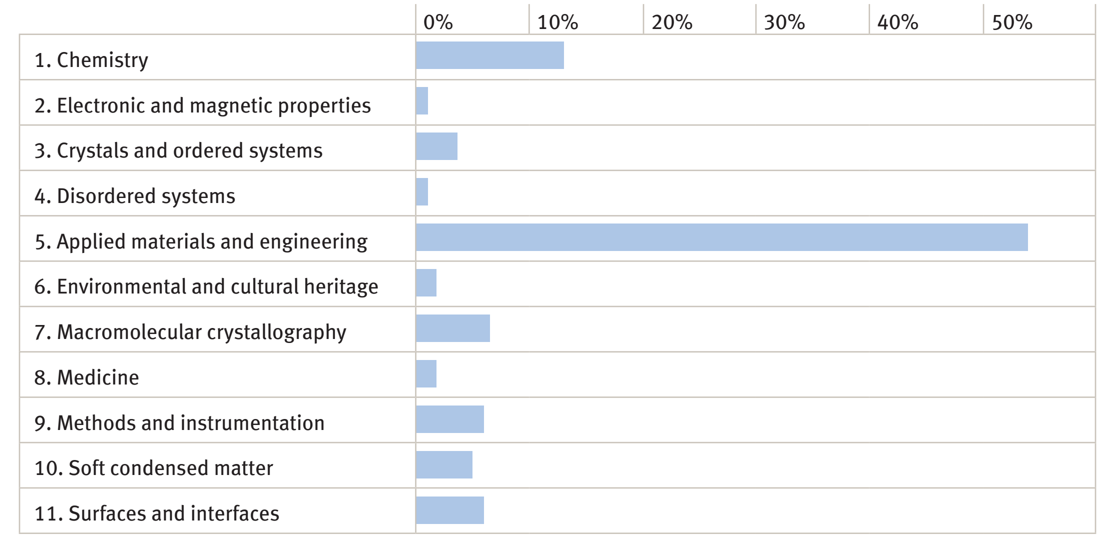
Industrial deliveries to the ESRF from Nordic firms are sub-proportional to the NORDSYNC share, as can be seen in the return coefficients in Table 5. Orders are generally obtained by very specialised firms that deliver high-tech components for accelerators and beamlines; Nordic firms have had less success as suppliers of more mundane deliveries where proximity and labour costs are decisive factors in the competition. NORDSYNC has organised regular interaction with the ESRF and dissemination of information concerning purchasing announcements, but increasing the return coefficient is viewed as an uphill battle.

The interviewees ***expressed satisfaction with the mode of work of the Council and the NORDSYNC delegation.*** The annual rotation of the task as head of delegation is considered optimal, and the limit of a three-member delegation plus one observer is seen as a formality. There are regular contacts prior to the Council meetings, with ad hoc telephone consultations as needed in cases where there are important or delicate matters on the agenda. There is a mindset tuned towards consensus and scientific excellence, and NORDSYNC is perceived as a very loyal and effective owner/partner, both by the ESRF management and the other ESRF partners.

NORDSYNC has chosen a three-year term for the head of delegation to the Administrative and Finance Committee (AFC). This has provided more continuity in the interactions with the ESRF concerning administrative matters such as payments, preparation of meetings, announcements and data exchange. It is often the case that not all NORDSYNC partners are represented at the AFC meetings. Absent partners rely on written material, telephone contacts and e-mail exchanges before and after the meetings.

8.4 The Danish user community

Profile of use (% beam time)
2004-2009 average:



Characteristics of the Danish community:

- Growing community represented at all three major universities: KU, AU and DTU;
- Supporting accompanying grants are essential (Dansync, DanScatt) and serve to organise the user community;
- NORDSYNC representatives have close ties to users, but weaker ties to research agency members;
- Has attracted large competitive grants (Grundforskning, UNIK) and received institutional support via allocation of positions;
- BAG allocations increase efficiency of use through flexibility;
- Examples of valuable synergies with the ILL in biophysics;
- Industrial engagement in science projects and instrument development.

Danish scientists have been involved in the development and use of synchrotron radiation sources since the 1970s. Historically the Danish science community has been and still is very strong in materials analysis using a range of probes and scattering techniques. Experiments are carried out on a suite of instruments such as scanning probe and electron microscopes, spectrometers (NMR), laboratory scale laser and X-ray equipment as well as the large national and international neutron and synchrotron radiation sources. The involvement of Danish scientists in the ESRF started very early on, with leading roles in the preparatory studies. In 1985 this led to the proposal of a site for the construction of the ESRF near Risø National Laboratory. In the mid-1990s there were many Danish contributions, as well as contributions from the other NORDSYNC communities, to the technical design of both the beamline facilities and instrumentation during the construction period and first rounds of experiments. The practical experience came from the use of the HASY lab facilities in Hamburg where scientists from Risø and Copenhagen University had been engaged with in-kind contribution to the instrumentation since 1980. Today Danish researchers rely on access to the leading synchrotron and neutron scattering international facilities. In the area of synchrotron radiation the Danish community uses access to MAX-lab in Lund, the ESRF in Grenoble, the SLS near Zurich, the ALS in Berkeley, the APS in Chicago, SPring-8 near Osaka in addition to the specialised soft X-ray and VUV facility, ASTRID, at Aarhus University. In the area of neutron scattering, Danish researchers are engaged at PSI SINQ near Zurich and at the ILL in Grenoble, and Denmark is strongly committed to the coming European neutron spallation source, ESS, in Lund, with involvement in the design of the user facilities and the building of the ESS Data Management Centre to be located in Copenhagen. The Danish community covers all of these activities with many groups using both synchrotron radiation and neutron scattering in their research. There appears to be less segregation between the different disciplines than is the case in the other Nordic countries.

The initial scientific drivers for the engagement in X-ray and synchrotron science in general, and the ESRF in particular, came from basic condensed matter science with pioneering studies of surfaces and interfaces that were made possible by advances in brilliance and resolution. From this basis efforts developed in more applied materials research such as studies of in situ grain growth in metals and in structural biology. It is difficult to estimate the size of the Danish community that uses and benefits from the ESRF both directly and indirectly. Workshops in macromolecular crystallography now typically attract audiences of between 50 and 100 scientists and similar numbers are reported from regular meetings in the other fields. The Danish community obtains on average (2005-2010) access to about 200 eight-hour shifts at the ESRF per year, and uses all of the access routes: Standard Proposals every six months, BAG Proposals for all of the Danish structural biology communities (about one day of use at the ESRF per month), and proposals for Long Term Projects. One group has been selected as a beta tester of a new allocation system for small angle X-ray experiments.

About 40 Danish senior scientists are listed as proposers on successful Standard Proposals for beam time at the ESRF, for which there are submission deadlines every six months. The experiments involve about 100 scientists directly (including students) and a similar number of scientists are indirectly involved as collaborators on other facets of the projects such as synthesis of samples and theoretical analysis of the experimental results.

From the beginning, the Danish use of the ESRF has been encouraged through accompanying research grants (“følgeforskning”). These grants started out as earmarked grants connected to each of the facilities of which Denmark was a member, but they are now administered as a common pool of competitive grants (instrument centre) for the purpose of maximising the scientific return from these memberships. Currently the use of the ESRF is supported via the annual grant of about DKK 7 M to the DanScatt consortium, which also supports use of internationally available neutron sources. Furthermore, the engagement in and use of the ESRF have been supported by five larger grants – Centres of Excellence – from the Danish National Research Foundation since 1993 (a total of about DKK 250 M), and the UNIK elite institutional grant from the Ministry of Science, Innovation and Higher Education (DKK120 M in total). The latter was granted in 2009 to a cross-disciplinary group in synthetic biology at Copenhagen University with extensive trans-disciplinary expertise ranging from chemistry, nanoscience, molecular plant biology and molecular neurobiology to biophysics. The grants have enabled several universities to create groups with critical mass in fields where SR is a preferred research tool. This has resulted in a vigorous Danish ESRF user community, with a good mix of senior and younger staff including talented students. The traditional strength in materials science and structural chemistry has been complemented by a rapidly growing strength in structural biology. The users come from all of the Danish universities, with particularly dynamic groups at Copenhagen University, Aarhus University and DTU (including Risø National Laboratory). The Danish user community also includes staff from industrial companies such as Haldor Topsøe, NOVO and NOVOZYMES, and there are one-year Master’s thesis projects in collaboration with industry laboratories such as the Danish Meat Research Institute and Maersk Oil and Gas.

The Danish community has established very good working relationships with the ESRF staff and management. This has been helped by the fact that several Danish scientists have been selected for senior positions both on the staff and in the governing and advisory bodies of the ESRF. There has also been a continual flow of students, post-doctoral students and other temporary staff from Denmark.

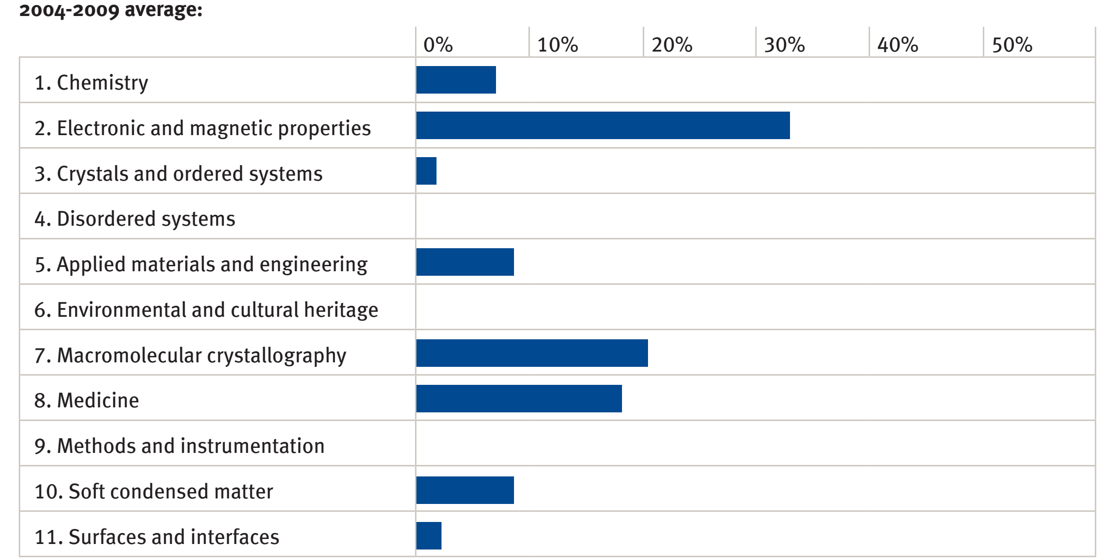
The Danish interviewees find that the common grant to the DanScatt consortium helps to organise the Danish ESRF scientific community. The consortium members meet twice a year and serve as an advisory forum for the Danish Agency for Science, Technology and Innovation in NORDSYNC and ESRF matters, including the nomination of members to the NORDSYNC delegation and ESRF advisory bodies.

The NORDSYNC organisation is viewed mainly as an efficient administrative vehicle that has provided a basis for very efficient scientific exploitation of the ESRF memberships. The NORDSYNC tradition of consensus has provided the Nordic governments and scientific communities with a powerful, unified voice in ESRF matters. There are several examples of joint Nordic activities within the different disciplines, e.g. summer schools and workshops, but NORDSYNC as such is not seen as the appropriate forum for scientific collaboration. Nevertheless, most of the interviews indicated an openness towards more Nordic collaboration, including potential partnerships with the Baltic countries within the NORDSYNC framework.

The scientific community has been consulted in connection with the Danish research infrastructure roadmap process, particularly in connection with the ESFRI projects in materials analysis (ESS, ESRF upgrade, XFEL and EuroFEL) and the new national facilities with opportunities also for Danish researchers (PETRA III and MAX IV). Similar consultations have taken place in the other Nordic countries, and there is latitude for organising a portion of these consultations at the Nordic level, based on the positive experience from the NORDSYNC collaboration.

8.5 The Finnish user community

Profile of use (% beam time)
2004-2009 average:



Characteristics of the Finnish community:

- Two distinct communities associated with the ESRF and Max-lab, with limited overlap;
- Comprehensive, new user organisation, FSRUO, established in 2009 may change this picture;
- No earmarked research grants for international RIs, but the user communities get regular grants;
- Well-organised and rapidly developing national BAG community in structural biology;
- Strong user groups in hard X-ray, scattering, spectroscopy and imaging involved in beamline developments and Long Term Projects at the ESRF;
- Limited industrial use and industrial deliveries despite focused efforts by industrial liaison officer;
- General satisfaction with NORDSYNC operations, but concern about the contacts and dialogue among stakeholders in Finland.

Synchrotron radiation-based research in Finland ranges from fundamental science to applied and industrial research and covers a wide, interdisciplinary array of topics. The community is largely dependent on two facilities – the ESRF and MAX-lab –which both have a Finnish user base and scientific output of similar size. There is little overlap between the two facilities: different user groups and university departments use different facilities. This is due to the differences in the foci and properties of these facilities: the high-energy facility ESRF has been the centre of hard X-ray scattering, imaging and protein crystallography studies, whereas the lower-energy facility MAX-lab has offered unique opportunities for soft X-ray and VUV spectroscopy. Although the future MAX IV will offer many more research opportunities in the hard X-ray regime as well, there was a widespread opinion among the interviewees that these two facilities will remain largely complementary. They foresee the continuation of two strong, growing and viable branches of SR-based research in Finland – one using the ESRF and the other using MAX IV. However, several interviewees noted that there are weak relationships between the different fields, and atomic physics, materials research and biological science user communities do not have regular contact. This situation may change in the future due to the establishment of the Finnish Synchrotron Radiation Users Organisation (FSRUO), a non-profit association formed in 2009. The founding members come from the Universities of Helsinki, Oulu and Turku and the Tampere University of Technology. FSRUO provides a forum for information exchange and collaboration between researchers affiliated with Finnish institutions and companies whose work is related to the use of synchrotron radiation. The Finnish synchrotron radiation community consists of over 200 scientists.[10]

The main purpose of FSRUO is to promote and represent interdisciplinary basic and applied scientific research using synchrotron radiation and free electron lasers. The synchrotron community has grown over the past decade and the use of SR has been extended to new fields. The aim of the new user organisation is: (1) to enable the communities to become aware of each other and support each other; (2) to contribute to the debate on new larger projects, and (3) to serve in an advisory capacity vis-à-vis the Academy of Finland, the Ministry of Education and Culture and other ministries. The organisation arranges meetings, workshops and courses, encourages visits by lecturers and experts, and facilitates synchrotron-related infrastructure development and data collection. One of its first tasks was the review of SR-based research in Finland and the formulation of a position on potential Finnish participation in MAX IV in Sweden. The review showed that the community published 145 peer-reviewed papers in the 2004-2008 period and produced 26 doctoral theses in the same period using the access to the ESRF via NORDSYNC. There were similar results from the Finnish activities at MAX-lab. The Finnish users have been awarded about 120 beamline shifts per year at the ESRF in recent years.

The Academy of Finland administers the Finnish membership of the ESRF and NORDSYNC. The Academy does not directly promote the use of the ESRF nor does it award earmarked grants for this purpose. However, the scientists using SR are quite successful in obtaining project grants to be used for any source and generally receive four-year grants. The Academy of Finland produced a roadmap for research infrastructure in 2009, which included the ESRF upgrade and the potential partnership in MAX IV. This has been followed by calls for proposals for research infrastructures such as improved interfaces for data collection and processing.

Several Finnish universities have established positions with the strategic aim of strengthening involvement in research infrastructures in general and in synchrotron radiation infrastructures in particular. This is particularly evident in the field of structural biology, where a national consortium with 11 principal investigators (PI) manages the Finnish BAG at the ESRF allocated for protein crystallography. The PIs come from the universities in Helsinki, Turku, Jyväskylä and Oulu. These groups have also obtained support from the EU and private foundations.

Another strong user community is found in materials science and condensed matter physics, with the University of Helsinki as the centre of gravity for hard X-ray research. Finnish groups have been involved in the development of the ID 16 beamline at the ESRF, which was partly delivered by Finnish companies as one of the few industrial orders obtained by Finland. An earlier grant award for a Long Term Project supported this development, and the Finnish groups have also been involved in the planning of the latest upgrade. This has led to frequent extended visits to the ESRF by Ph.D. students and post-doctoral students, and the Finnish members of the ESRF staff come from these groups.

Medical imaging comprises another strong niche in the Finnish use of the ESRF. Groups at Helsinki University Central Hospital have been involved in a pioneering effort with collaborators from several European countries and the USA.

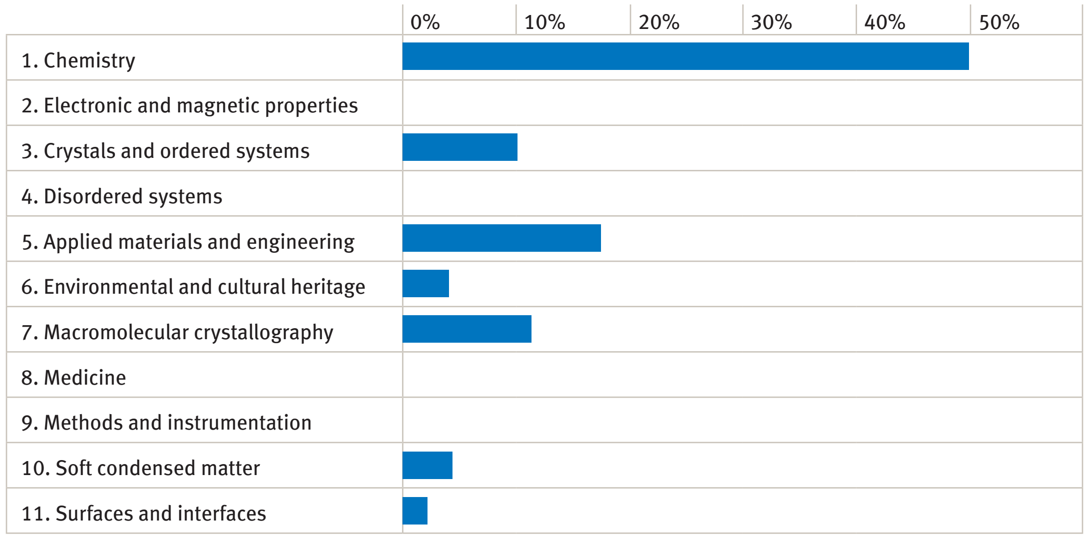
The direct involvement of Finnish industries in research at the ESRF has been quite limited, and industrial deliveries from Finland have also been few and far between. The Academy of Finland supports an industrial liaison officer at CERN, who follows the tender announcements for industry issued by the ESRF and provides input and advice to NORDSYNC members.

The Finnish engagement in the ESRF and NORDSYNC is administered by the Academy of Finland. The Academy appoints NORDSYNC delegates to the ESRF Council and the AFC. The Finnish delegate to the AFC is currently head of the AFC delegation for the three-year period from 2011 to 2013. The interviewees were generally satisfied with the ESRF and NORDSYNC operations, but ESRF users noted that contact with the ESRF user community in Finland was weaker in periods when the Council delegate appointed by the Academy had no or little scientific contact with the community. Regular meetings and/or consultations between the NORDSYNC delegations and the Nordic members of the SAC and the ESRF Review Committees could promote better dialogue.

10 FSRUO publication, May 2010.

8.6 The Norwegian user community

Profile of use (% beam time)
2004-2009 average:



Characteristics of the Norwegian community:

– The Swiss-Norwegian Beam Lines (SNBL) has been an important driving force since 1995;

– Strong groups in chemistry and condensed matter research;

– The SNBL is organised as a company, with universities and IFE as shareholders and with staff at the ESRF;

– The SNBL and other use of the ESRF are supported by accompanying research grants with an international steering group;

– National strategic programme in biotechnology and functional genomics has been essential for building up the use of the ESRF for structural biology research;

– Support for streamlining of the NORDSYNC operations with fewer members of the delegations and better use of teleconferences.

The Norwegian scientific engagement in the ESRF began in 1989 with the diffraction physics group at the Norwegian University of Science and Technology (NTNU), which had a good working relationship with a group at Ècole Polytechnique Fédérale de Lausanne (EPFL) in Switzerland. Both groups were involved in the preparations for the ESRF, and their contact, combined with broader dialogue in Norway involving NAVF (the former research council for science and technology) and the University of Oslo (UiO), led to a proposal for the Swiss-Norwegian Beam Lines (SNBL) when this became an option at one of the ESRF bending magnets. The SNBL became operational in 1995 with two independent experimental facilities: one aimed at powder diffraction, spectroscopy and topography, and another aimed at single crystal diffraction including protein crystallography. In the beginning, the SNBL was organised as a Swiss company with a 28% Norwegian share and 72% Swiss share based on five-year agreements. A consortium (formally a Norwegian limited company) formed by the Research Council of Norway and several universities held the Norwegian shares. Following the opening of the Swiss Synchrotron Radiation Facility (SLS) in 2001, the Swiss-Norwegian partnership was changed to equal shares in 2003. The Norwegian partners are a consortium comprising the Research Council, IFE and the universities in Oslo, Stavanger, Tromsø and Trondheim, and had a budget of about NOK 8 M in 2009. A committee manages the SNBL, with three representatives from Switzerland and three from Norway. The SNBL employs a scientific and administrative staff at the ESRF (both permanent and short-term positions and two post-doctoral positions). The SNBL staff assists the users of the beamlines. One-third of the beam time is allocated via the normal ESRF procedures. The SNBL is equipped with multipurpose user instrumentation, and the equipment has recently been upgraded to match ESRF standards for single crystal and powder diffraction and absorption spectroscopy. The SR community in Norway has strong groups in chemistry and materials research with good relations with industrial research groups in metallurgy, microporous materials, hydrides and catalysis.

From the beginning, the SNBL has also been used for structural biology, in particular by Swiss academic and industrial users. The Norwegian use of SR for biology research has been supported by the National Programme for Research in Functional Genomics (FUGE) (2002-2011) and the Norwegian Structural Biology Centre (NorStruct), a national research and service centre in functional genomics, systems biology, metabolomics and applied research areas such as protein engineering and drug discovery. The use of the ESRF for biological and medical research is growing. It began in 1995 with the use of the SNBL, but now predominantly takes place at the dedicated structural facilities at the insertion device beamlines at the ESRF. The Norwegian community started to use the BAG allocation scheme in 2011. Some 40 researchers are directly involved in experiments at the ESRF each year, and they are awarded about 100 shifts per year in addition to the beam time reserved for the SNBL. The total community is estimated to be roughly the same size as the communities in Finland and Denmark.

The Research Council has supported the use of the ESRF and the SNBL via dedicated funding for research associated with the facilities ("følgeforskning") of about NOK 5.5 M per year (2009). As a new feature, the Programme on Synchrotron and Neutron Research (SYNKNOYT)[11] has established a programme board with Nordic members (two Norwegians, two Danes and one Swede) that will take final decisions on allocation of funding to research projects, support for travel expenses related to the use of the SNBL and the ESRF, and support for extended stays at the ESRF (minimum six months). The Norwegian SR community is currently preparing input to the Research Council on the Norwegian position on MAX IV.

A recent evaluation[12] of basic physics research in Norway finds that both the SNBL and the dedicated grants have been very important to the development of research based on synchrotron radiation in Norway, and that the SNBL effectively acts as a home laboratory for the SR users within physics, chemistry, biology and medicine. It is recommended that the dedicated funding scheme for research associated with the use of the ESRF and other SR, e.g. MAX-lab, is strengthened and expanded to encompass activities in connection with ESS in Lund.

The Research Council administers the ESRF and NORDSYNC memberships on behalf of the Ministry of Education and Research. The Ministry appoints the Norwegian delegates to the ESRF Council and the AFC. The Norwegian delegate is currently the vice-chair of the AFC (2009-2012). There is no formalised organisation of the user community; however, there has always been close cooperation between the Norwegian partner institutions in the SNBL cooperation. The programme on synchrotron research has also had a key role in the development of national strategies for synchrotron research. Biannual user meetings are organised in addition. Beyond this, the SNBL and the activities supported by the research grants (meetings, summer schools, etc.) create additional opportunities for dialogue with and within the community.

The interviewees generally expressed the view that the ESRF and the SNBL have been important enablers of Norwegian frontier science, with a very good return on investment. The ESRF is seen as an important user facility and source of SR technology. The ESRF and the SNBL demonstrate the value of strategic investment in international research infrastructure.

NORDSYNC is considered to be well functioning although there is room for further streamlining of administrative activities. The ESRF is now a mature organisation, and one interviewee pointed out the

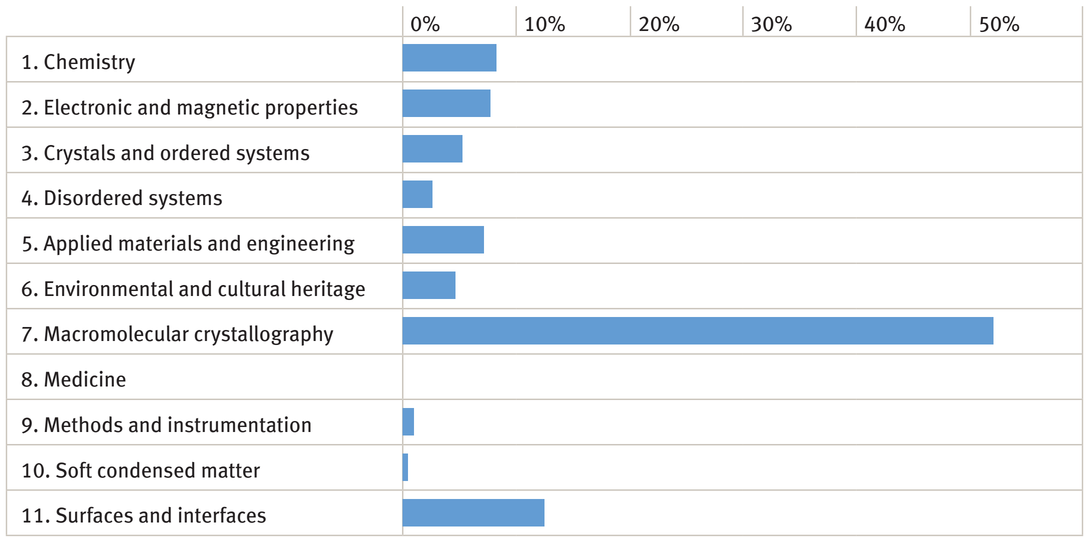
11 Work programme for the SYNKNOYT programme.

12 Follow-up plan for the Evaluation of Basic Physics Research in Norway (2010) (Norwegian only).

potential for further rationalisation, for example of the AFC, with more frequent use of teleconferencing and fewer delegates to meetings in Grenoble. NORDSYNC could limit its representation to two delegates, for example, (head of delegation appointed for three years plus another delegate rotating among the other three countries), and preparatory teleconferences could be held.

8.7 The Swedish user community

Profile of use (% beam time)
2004-2009 average:



Characteristics of the Swedish community:

- Early efforts at MAX-lab in synchrotron radiation, with pioneering efforts in physics and biology;
- Structural biology community is a major user at the ESRF, with five BAGs involving all major players in Sweden;
- Swedish pharmaceutical companies are prominent industrial users at the ESRF;
- Special council for research infrastructures but no earmarked accompanying research grants for RIs;
- MAX IV and ESS are significant investments on a global scale offering enhanced scientific capabilities;
- MAX-lab has 55% international users (25% Nordic), including Baltic user groups;
- MAX-lab annual meeting normally has representatives from all of the SR user groups among the 400 attendees.

Important drivers for synchrotron radiation research in Sweden have come both from the field of physics and from the field of biology. Traditionally, Sweden has also played a leading role in materials research, and areas of strength include steel and metal research, semiconductor research with silicon chips and optical semiconductors, research on fibres and polymer materials, research on biomaterials and biocompatible materials, thin film syntheses, and classification of materials, e.g. surface analysis and microscopy. This research in materials science has taken advantage of the access to advanced instrumentation, including electron and scanning tunnel microscopes, synchrotron-radiation-based diffraction, spectroscopy and short pulse lasers. The high-intensity X-rays from synchrotron radiation facilities have provided new opportunities for detailed analysis. These advancements were first introduced in materials science, and subsequently in biology, where protein crystallographers now

represent one of the largest user groups of X-ray instrumentation involving synchrotrons. The first electron accelerators were built in Lund, and in 1986 the MAX I storage ring began providing VUV and soft X-ray for experiments in physics and chemistry. The field of protein crystallography was developing rapidly during the same period. Leading Swedish scientists in Uppsala and Stockholm soon appreciated the power of synchrotron radiation for this field, and projects were granted funding by the Swedish Research Council. In 1992 Carl-Ivar Brändén became the first scientific director for life sciences at the ESRF and was instrumental in the development of dedicated beamlines for macromolecular biology in the insertion devices and the BAG allocation scheme. The Swedish structural biology community was among the first to use the BAG allocation scheme starting in 1998, and there are now five active Swedish BAGs led by Uppsala University (1998), Karolinska Institutet (two BAGs, 2000 and 2005), Swedish University of Agricultural Sciences (2000), and Gothenburg and Lund Universities (2002). This has given the Swedish biology community a leading role in structural studies of biomolecules to clarify molecular mechanisms in detail using high-resolution synchrotron radiation facilities.

Swedish researchers have access to synchrotron radiation experiments both at the national MAX-lab facility in Lund and at the ESRF in Grenoble. The MAX-lab user organisation arranges yearly multidisciplinary meetings with more than 400 attendees to discuss strategy for the facility in the European context. The members come from the different scientific communities using synchrotron radiation and are also representative of the ESRF user community. The current use of MAX-lab is 45% Swedish and 55% international, of which Nordic use represents 25%.

There are no earmarked grants for use of the ESRF or other international research infrastructures, but the Swedish Research Council has established a special council for research infrastructure with a secretary general that works to:

- Increase focus on international collaboration concerning infrastructure, especially European infrastructure;
- Enhance national coordination of infrastructure;
- Develop national nodes or centres for coordination with international infrastructures;
- Promote Sweden as a host for international infrastructures;
- Increase openness in researchers' use of infrastructural resources and data;
- Enhance coordination between research funding agencies regarding infrastructure;
- Open up new e-Science opportunities in order to develop infrastructure, especially in new fields.

The Council for Research Infrastructures funds planning, investment and operation of research infrastructures as well as memberships of international infrastructure organisations.

The secretariat of the Swedish Research Council administers the ESRF and NORDSYNC memberships. The Council for Research Infrastructure nominates the delegates to the ESRF Council. They are generally members of one of the research councils and are appointed by the Director General of the Swedish Research Council along with the members of the AFC. The Swedish AFC delegate served as the head of delegation during the previous period (2008-2010).

The interviewees expressed satisfaction with the NORDSYNC operations, which have taken advantage of the mutual trust and confidence among the Nordic partners that has been built up over the years. NORDSYNC is perceived as a mainly administrative arrangement, and in many cases it would be possible for one Nordic delegate to represent the NORDSYNC consortium vis-à-vis the ESRF, especially at the present stage where the ESRF organisation is mature and operations are running relatively smoothly. This would require systematic internal consultations prior to the meetings. Interviewees also stated that delegation to a single partner would have been less advisable in the early stages of the ESRF project when national priorities and interests were still being formed.

There was a positive attitude towards increased collaboration with the Baltic countries, which is of interest because of the emerging scientific groups such as the XAFS group in Riga and the growing use of EU Structural Funds for research infrastructure.[13]

The MAX IV facility is being constructed as a national facility and is co-owned by Lund University. It will provide unique research capabilities for the Swedish (and Nordic) synchrotron user communities. The technology is developing rapidly, and the MAX IV design represents a major step forward in accelerator and storage ring technology with the potential for nanometre focus with very high brilliance of the X-ray beam and better coherence properties than has be achieved so far (see Figure 6). About 20 beamlines are expected to be constructed by 2020 and international participation is also expected. The legal and organisational framework is being developed to accommodate new partners.

8.8 Observations and findings from comparison of the national approaches to NORDSYNC

The user communities in all of the Nordic countries have benefited from membership of the ESRF, and ***there are vibrant scientific activities with a growing number of researchers, projects and publications in all four countries***. The countries have different profiles in terms of the scientific disciplines involved. This is due in part to the national history of engagement in synchrotron radiation research – which is often driven by strong scientific personalities in the initial phases – and in part to the national areas of scientific strength, which also differ from country to country. This is reflected in the ***areas of science where the allocation of beam time to Nordic groups significantly exceeds the average*** (applied materials research (DK), chemistry (N), electronic and magnetic properties (FI), and macromolecular crystallography (S); see Table 3).

There are also ***important differences in the approach to the strategic and practical administration of the involvement in NORDSYNC and the ESRF in the different countries***. This reflects the differences in roles and relationships between ministries, agencies, research councils, institutions and scientific communities as well as traditions for and balance between bottom-up and top-down initiatives.

When the ESRF and NORDSYNC were established in 1987, the approach to international research infrastructures was very much ad hoc in all of the Nordic countries and the number of international projects was quite limited. Since 2001, when the European Strategic Forum for Research Infrastructure (ESFRI) was formed, the approach has become more strategic. ***The ESFRI Roadmap and the accompanying process have led most European countries, including the Nordic countries, to draw up national roadmaps as a basis for decision-making concerning national and international RI projects.*** In Denmark the roadmap process is administered by the Danish Agency for Science, Technology and Innovation, in Finland by the Academy of Finland and in Norway by the Research Council of Norway. Sweden has established a dedicated council for research infrastructure with advisory functions, with the Swedish roadmap as one of its main responsibilities and tools for communication. All of the Nordic roadmaps include the ESRF and the ESRF Upgrade Programme as a priority.

Norway is the only country that has used the opportunity to create a CRG at one of the ESRF bending magnet beamlines. This was a combined bottom-up initiative and strategic decision which involved both a research council and several universities and resulted in the collaboration with Switzerland on the SNBL. This has clearly had a positive impact on the Norwegian access to and use of the ESRF. After the opening of the Swiss Light Source (SLS), the Norwegian share in (and use of) the SNBL has increased, and the national strategic partnership has been expanded to encompass more institutions.

13 ESFRI WG report on Regional Issues (2010).

Norway is the exception in that universities provide direct support for the use of the ESRF through their share of the SNBL. In all of the countries, universities have provided indirect support by establishing academic positions in relevant areas, and the members of ESRF user communities have been quite successful in the competition for such positions.

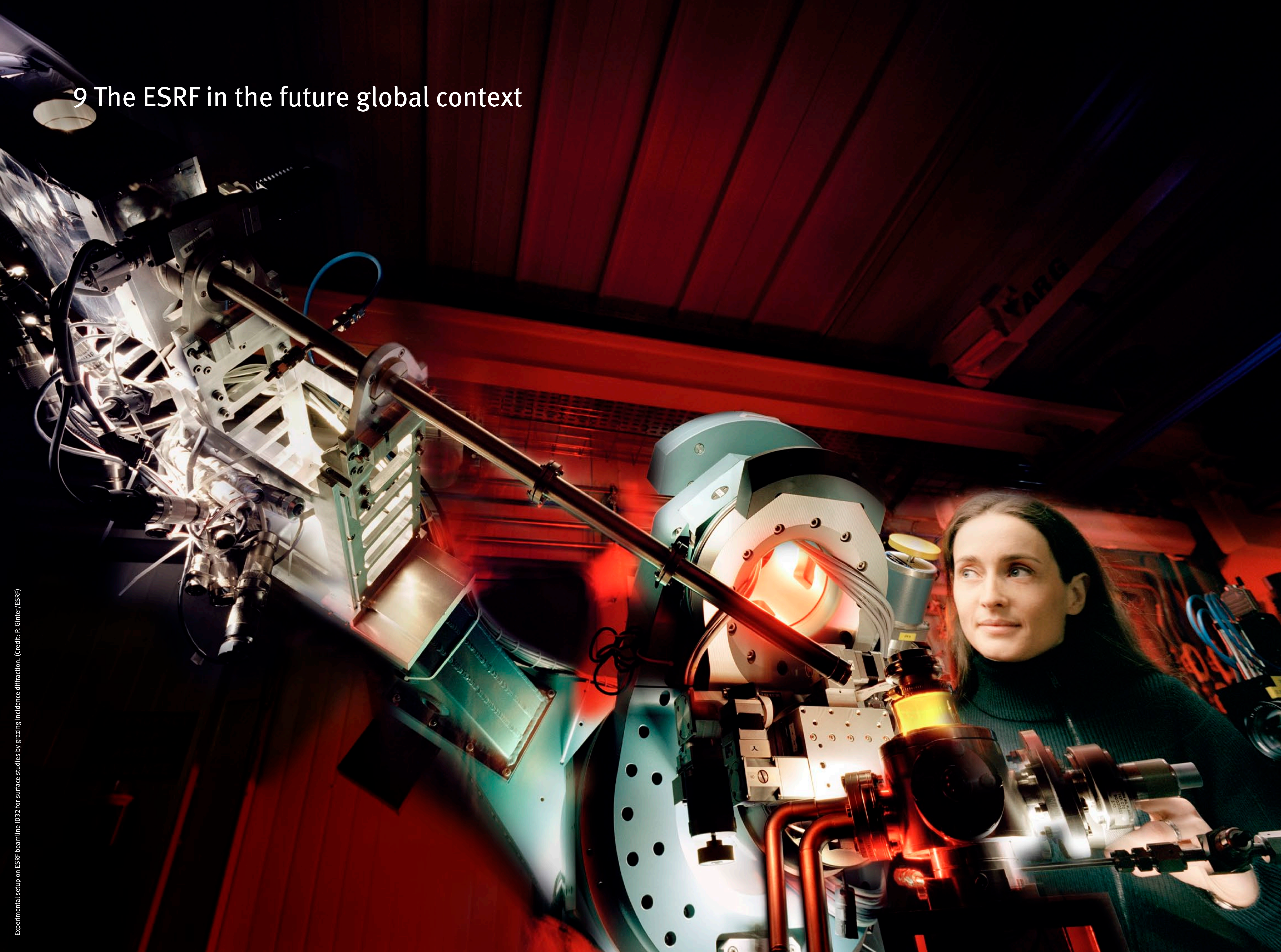
Denmark and Norway have a tradition of earmarking funding for research to support the exploitation of the membership of international research infrastructures ("følgeforskning"), whereas ***the Academy of Finland and the Swedish Research Council employ standard, competitive project funding schemes*** for such support. The earmarked funding in Denmark and Norway is becoming more competitive and less restricted to a given facility. The DanScatt grant in Denmark covers activities at both synchrotron radiation facilities and neutron facilities, and a similar development is foreseen in Norway.

NORDSYNC as such has not led to scientific collaboration across the Nordic countries. However, there are many examples of joint projects, summer schools and meetings within the different disciplines. The scientific user communities in the individual countries are more or less fragmented. ***In Sweden, there are strong user groups in biology at the leading universities, all of which have BAG allocations, whereas the Danish and Finnish biology users have a common national BAG.*** The user community associated with MAX-lab serves as a national forum for information and debate concerning SR research in Sweden. The new ***FSRUO in Finland has established a common forum for all SR users***, independent of discipline. In Denmark the ***users of the DanScatt grant form the core of the Danish community.*** In Norway, ***the SNBL, in combination with the dedicated programme for SR and neutron beam research, provides the common forum***.

There is openness in all of the sampled communities towards new initiatives that could strengthen Nordic collaboration, also including dialogue with the SR communities in the Baltic states.

NORDSYNC is viewed as an efficient administrative solution for membership of the ESRF. Its mode of work has allowed for a suitable mix of formal and informal interactions, both within and between the individual countries, which has led to broad consensus on ESRF matters. The collaboration relies on mutual knowledge and trust, and ***there is latitude for developing the degree of delegation so that fewer delegates would be needed at the Council and AFC meetings in Grenoble.*** This would involve telephone contact and teleconferences for meeting preparations and follow-up. Such a system of delegation was considered most attractive for the administration of memberships of mature institutions such as the ESRF, and could become even more attractive if the NORDSYNC model was applied in relation to new institutions on the ESFRI Roadmap

9 The ESRF in the future global context



Experimental setup on ESRF beamline ID32 for surface studies by grazing incidence diffraction. (Credit: P. Ginter/ESRF)

9 The ESRF in the future global context

A survey of the SR light sources landscape was carried out by an ESFRI Working Group in 2010.[14] The survey covered both synchrotron radiation (SR) sources and X-ray free electron lasers (FELs). It was noted that optical laser facilities can address the same (femtosecond) timescales and some of the same science areas as SR facilities, and future technological development in laser-accelerator interactions may bring the fields even closer. SR facilities can be divided into those with very large rings (884m-2,300m) producing hard X-rays from electron beams in the 6-8 GeV range: SSRTC in Novosibirsk (1970); the ESRF (1992), the APS (1996), SPring-8 (1997) and PETRA III (2009); and those with smaller rings producing softer X-rays from electron beams in the region of 2-3 GeV. In contrast to the situation with neutron sources, a significant number of new SR light sources have recently been commissioned or are under consideration. Upgrade programmes, driven by emerging science opportunities, are also currently being undertaken, for example at the ESRF and the APS.

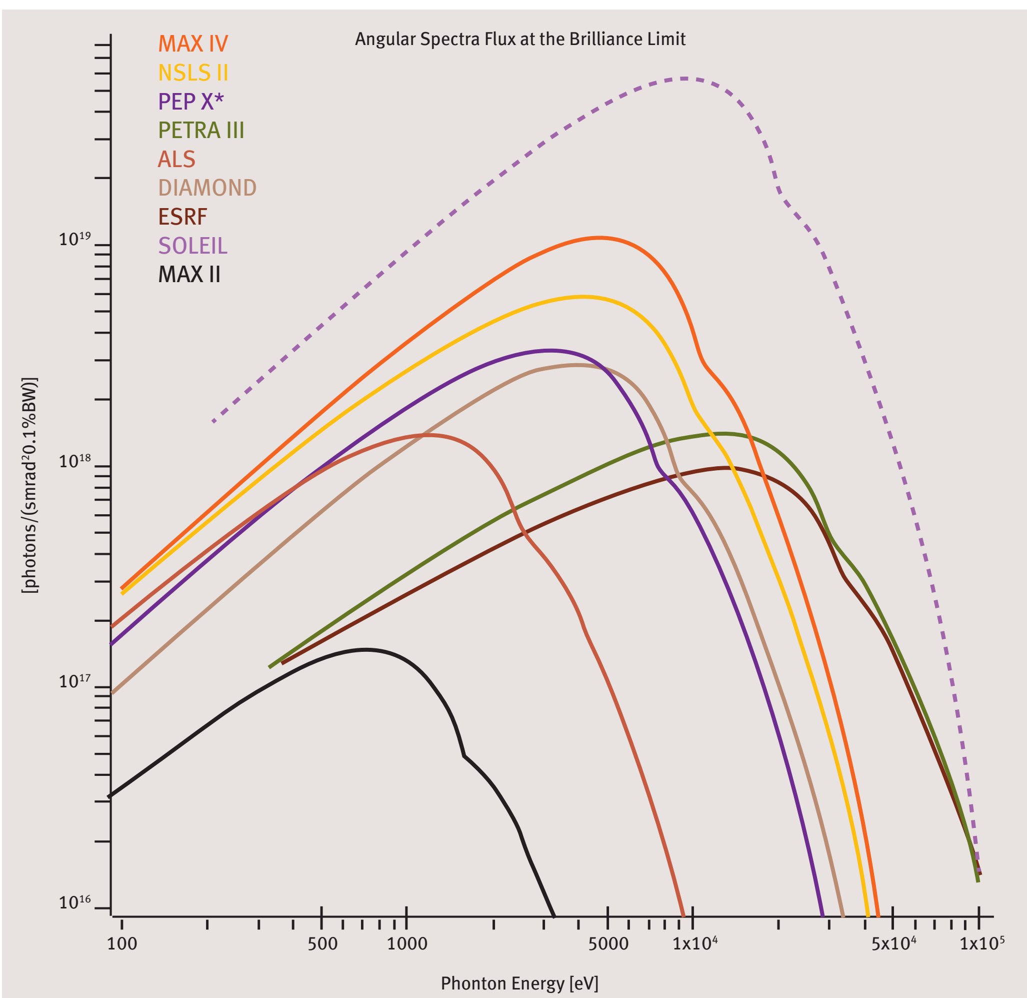


Figure 6: Calculated brilliances for different existing and planned synchrotron radiation sources.[15]

14 ESFRI Analytic Facilities Working Group report (2010).

15 From MAX IV presentation by Lars Börjesson

Future high energy rings, such as the NSLS-II (now under construction at Brookhaven National Laboratory (BNL)) and MAX IV (under construction in Lund) as well as concepts such as PEPX at SLAC, KEK at the Photon Factory, and BERLinPro at Helmholtz Zentrum Berlin (based on an ERL) will continue to push the boundaries of science in terms of brilliance and flux.

Older SR sources have been decommissioned as new sources have come online, for example LURE (2003, F), SRS at Daresbury (2008, UK) and DORIS III (due to close at the end of 2012, D). However, overall, there has been a substantial increase in SR capacity as new communities have adopted these techniques. The interviews gave the impression that the ESRF has a very strong global position and the potential to stay competitive for the next 15-20 years due to the high energy, the leading beamline technology and an unsurpassed record as a user facility. The timelines for the major SR facilities (existing and planned) are shown in Figure 7 below.

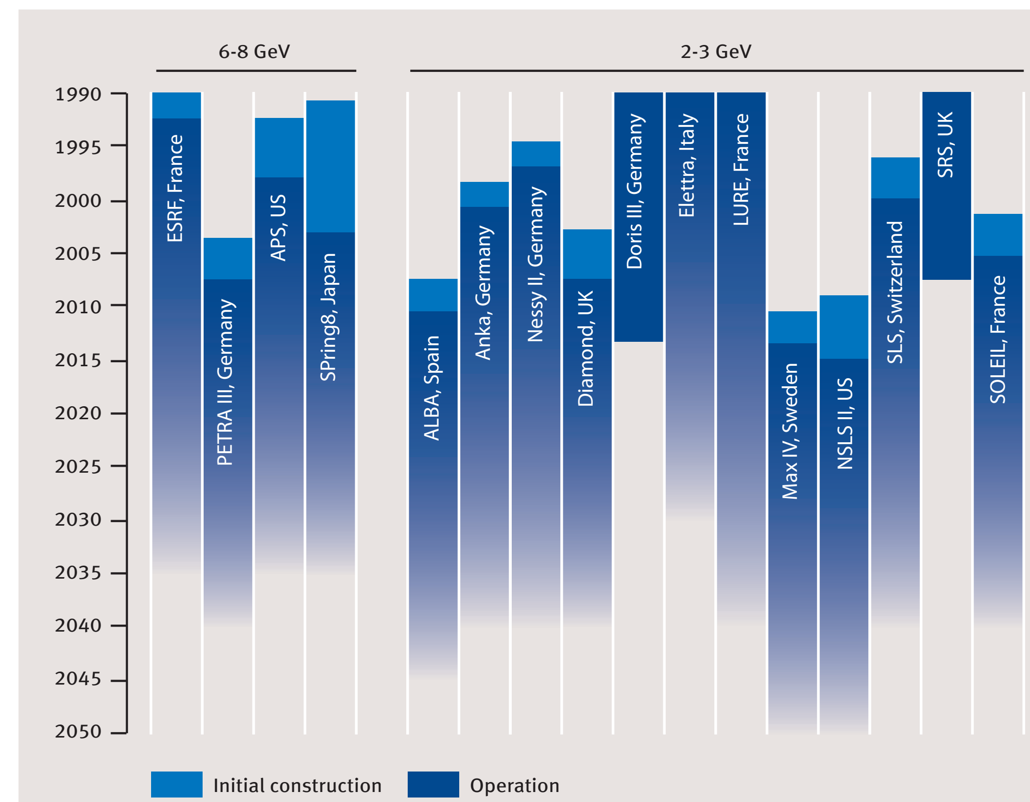


Figure 7: Illustrative timelines of the major national and international SR facilities worldwide.

Free electron laser facilities that produce X-rays with extreme intensities and peak brilliance are currently being developed and may revolutionise some of the areas of science that so far have benefited from the access to synchrotron radiation from storage rings with insertion devices. The FELs are expected to push peak brilliance levels 10^{12}-10^{13} times higher than synchrotron sources, with very short femtosecond pulse lengths. This huge increase in brilliance will open up new areas of science, such as fast chemistry, biology, physics, materials (pump-probe), nanoscale imaging and extreme conditions (plasma) science. Lower energy FEL sources have existed for several years and have produced good science. Currently, there are more than 20 FELs in existence worldwide and more than one dozen are on the verge of being implemented or are under construction. Further improvement of the extreme brilliance of FELs as well as their ability to produce extremely short pulses will create the technological background for spectral, spatial and time resolutions in spectroscopic and structural investigations which were unattainable up to now. Current development in FEL sources focuses on high energy, high brilliance sources. The two main FEL sources currently operating and producing scientific output are FLASH (soft X-rays) in Germany and LCLS (hard X-rays) in the US. The main project currently under construction in Europe is the European XFEL (hard X-rays), which is aiming to come into user operation in 2015. Indicative timelines for the development of FELs around the world are shown in Figure 8 below.

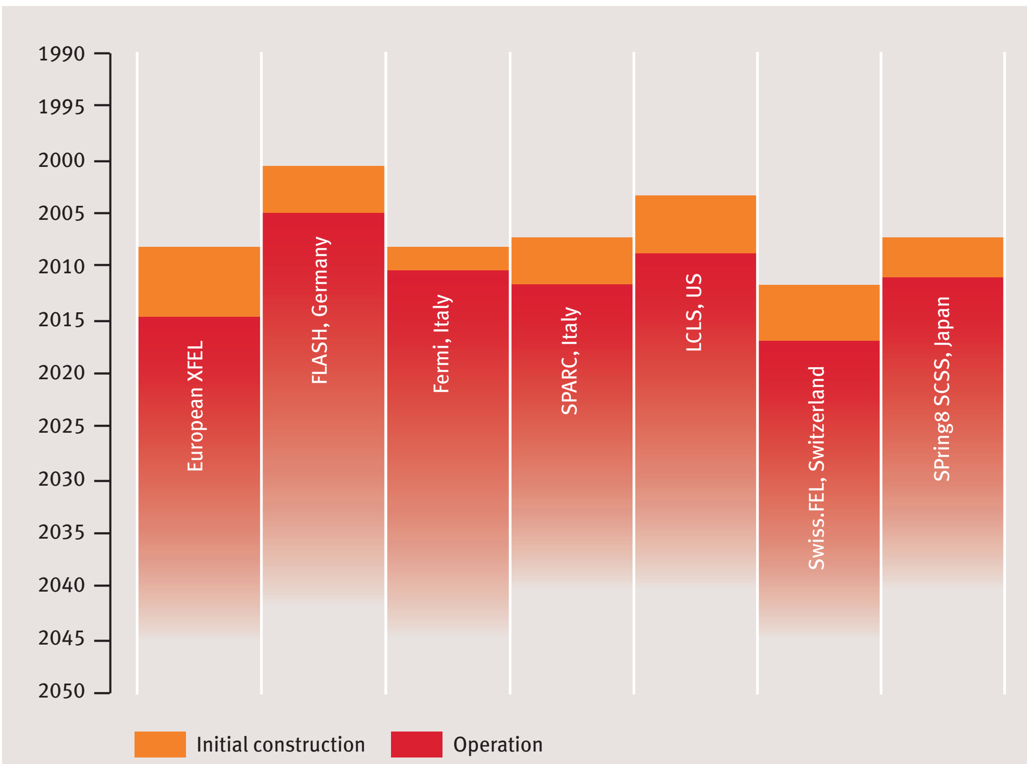


Figure 8: Timelines for current and proposed large FEL facilities worldwide.[16]

It is the opinion of the ESFRI Working Group that although FEL sources may change the landscape, they will not replace SR sources. They will expand science into new areas, but a relatively small number of experiments (in comparison to SR or neutron sources) can be accommodated at these facilities. This limitation will probably result in a change in how the user community will use such facilities, e.g. scientists will work together in larger collaborations to carry out experiments, and FELs will probably be used, certainly initially, only when the science demands capabilities clearly beyond those of synchrotrons or laboratory lasers.

The move towards larger-scale collaborations may require some changes to the way that proposals are assessed, as it will become increasingly difficult to attribute specific experiments to individuals. The costs of operating FEL facilities also tend to be higher – so the "entrance fee" for a nation proposing to build one is larger. Furthermore, it is highly unlikely that the FEL user communities will cover as broad an area of science as users of the SR sources during the initial years of operation; the sample handling and detection techniques required will first need to be developed to a level that is accessible for non-laser experts. In addition to storage rings and FELs, the technology for Energy Recovery Linacs (ERLs) is now emerging. ERLs have the potential to combine the advantages of both types of light sources, as they

16 From ESFRI WG Report, 2010; the fate the SPARC project has become more uncertain since then.

can serve a large number of users simultaneously with a beam that can be adjusted in a straightforward manner to specific parameters such as pulse length, brilliance, time structure and coherence. Work on a design of ERL sources in the X-ray range is currently being done at Cornell University (USA) and KEK (Japan). However, further R&D work is required before a high-brilliance multiuser facility supplying broadband radiation can be built based on this technology.

Looking further into the future, the ESFRI Working Group expects that optical lasers will start to be used in this area of science. Laser facilities address the same (femtosecond) timescales and some of the same science areas as SR sources. The group pointed to a need to think more about how to integrate accelerator-driven and laser-driven photon probes. Smaller and/or cheaper sources may become possible in the very long term (several decades from now), e.g. by the application of laser/plasma-driven accelerators, although the number of experiments that can be carried out at each facility will always be limited compared to SR sources.

9.1 Observations and findings concerning the future of the ESRF

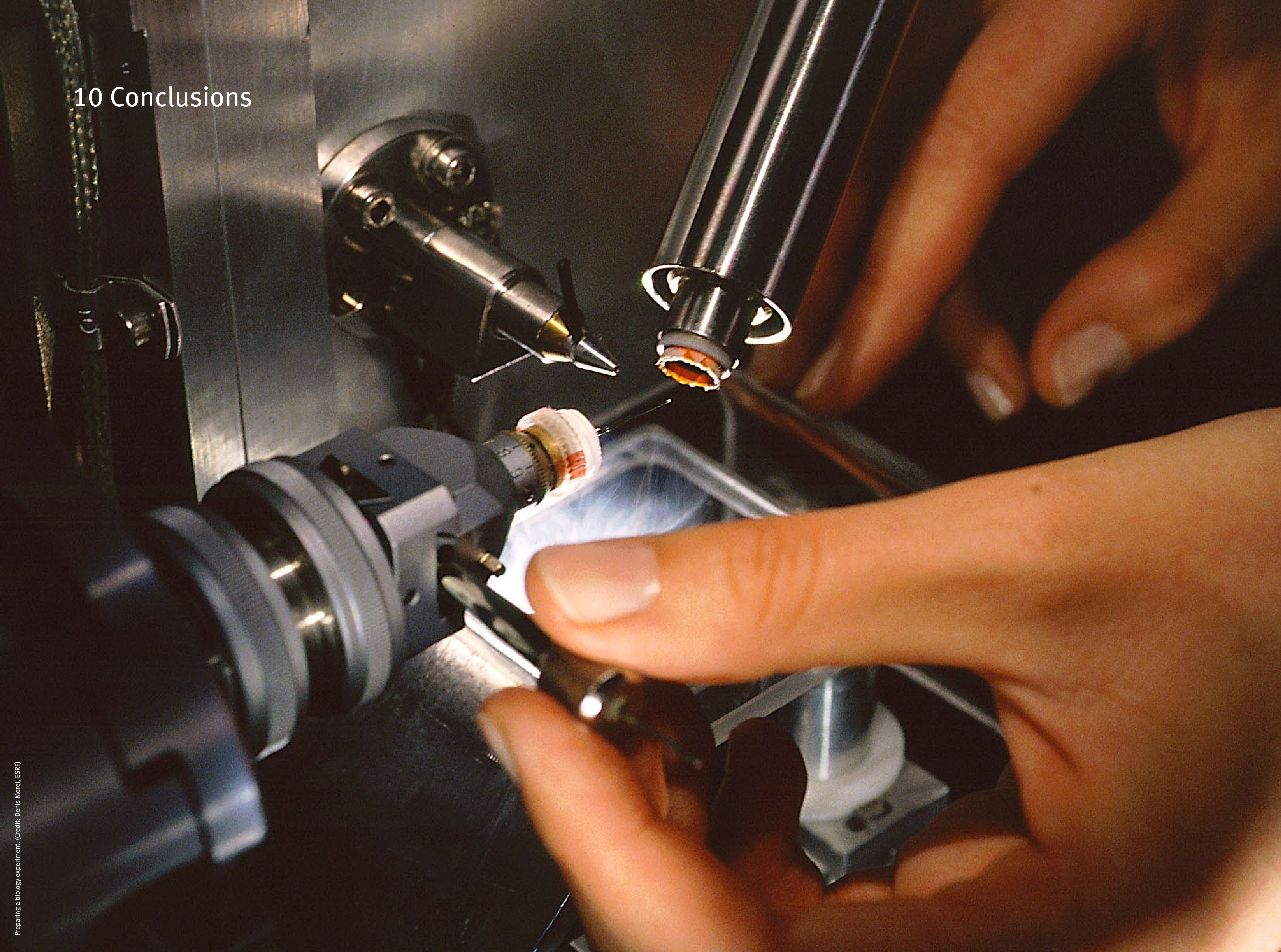
The ESRF has established itself as ***one of the world's leading synchrotron radiation research infrastructures***, and the present evaluation indicates that it will be able to maintain a leading role in the coming 15-20 years due to the combination of high intensity and brilliance in the hard X-ray region, the strong emphasis on development of the accelerator, beamline and instrumentation technologies, and the user-oriented culture and performance of the ESRF organisation, which delivers a high degree of user satisfaction. The ESRF will experience ***increased competition from the many new national synchrotron facilities*** that have been built recently or are under construction. The coming MAX IV facility is of particular interest for the ESRF and NORDSYNC. MAX IV will cater to sections of the Nordic community that are presently using the ESRF. The PETRA III source in Hamburg will also be an attractive source for Nordic users of hard X-rays, partly because more German and Nordic institutions are establishing permanent activities on the DESY campus. However, ***it is very likely that the ESRF will remain an attractive partner for the national facilities as the common source of technology,*** and that the national sources and the ESRF will develop synergies and complementarities in response to user needs. The ***scientific use of SR is expected to grow*** in both existing and new fields. The ESRF is already overbooked and cannot respond to growing demand, especially in areas that require dedicated sample environments over longer time periods. ***The ESRF has a competitive edge with a very well-functioning user mode,*** which could be further refined with new remote handling and control features.

The ESRF and other SR sources will experience severe competition concerning scientific capability from the emerging free electron laser sources (FELs). However, the opinions sampled in this evaluation indicate that the ***FELs will be complementary both with regard to the scope of the experiments and the mode of operation,*** with larger teams behind each project. The FELs will open up new areas of science, but will not be able to replace the storage ring sources and satisfy the needs of the very broad SR user base.

The ESRF has recently signed an MoU with Russian institutions and is developing its global network. Enhancing its global role is an attractive scenario for the ESRF. Access to talent from the emerging economy countries could boost scientific creativity and strengthen collaborative ties. ***Bringing in the Baltic countries as partners in NORDSYNC*** could be a step in the same direction. It is vital that any expansion of the user base retains the merit-based access system.

Industrial use of the ESRF has so far been limited despite a clear perception of its potential among the interviewees. Significant changes to this picture would require ***further development of the services offered to industrial customers*** in terms of sample and data handling, combined with automation and streamlining of the procedures in order to bring down costs and turnaround times.

10 Conclusions



Preparing a biology experiment. (Credit: Denis Morel, ESRF)

10 Conclusions

The ESRF has so far been a success both as a European research infrastructure and as an asset for the Nordic science community. The ESRF source, beamlines and instruments are world leading and have in several cases been developed in close cooperation with Nordic groups (e.g. the Troika beamline and 3DXRD microscope). The ESRF is now mature, and has established a trend-setting user programme and user support system that are second to none. The ESRF is also the leading centre for instrument development to the benefit of the national centres in Europe.

The NORDSYNC membership has formed the core of the strong involvement of leading research groups in the Nordic countries from the very early phases of the ESRF. This has led to a consistently high Nordic use of the facility with an over-proportional share of beam time relative to the financial share. The engagement has been characterised by effective formal and informal contacts at many levels and a suitable mix of bottom-up (e.g. Long Term Projects) and top-down initiatives (e.g. the Swiss-Norwegian Beam Lines) coupled with responsiveness on the part of the ESRF to Nordic user demands.

The ESRF has proven to be very relevant to strong research communities in different disciplines among the various Nordic countries. This has resulted in distinct differences in the user profile across the scientific disciplines. Swedish groups are very strong in macromolecular biology, Danish groups have particular strength in materials research, while Norwegian groups are strong in chemistry and Finnish groups in condensed matter physics and medical imaging. It has been possible to accommodate these differences in scientific focus under the NORDSYNC consortium model. There has been some involvement of industrial partners and limited direct industrial use of the ESRF but the volume of activity falls short of the perceived potential.

The user communities are thriving in all of the Nordic countries, with new groups and institutions getting involved and new areas of science taking advantage of the access to synchrotron radiation. This trend is further bolstered by the ability of the user groups to successfully compete for funding within each of the Nordic countries. This has in turn meant that more university positions have become available for junior staff and Ph.D. students.

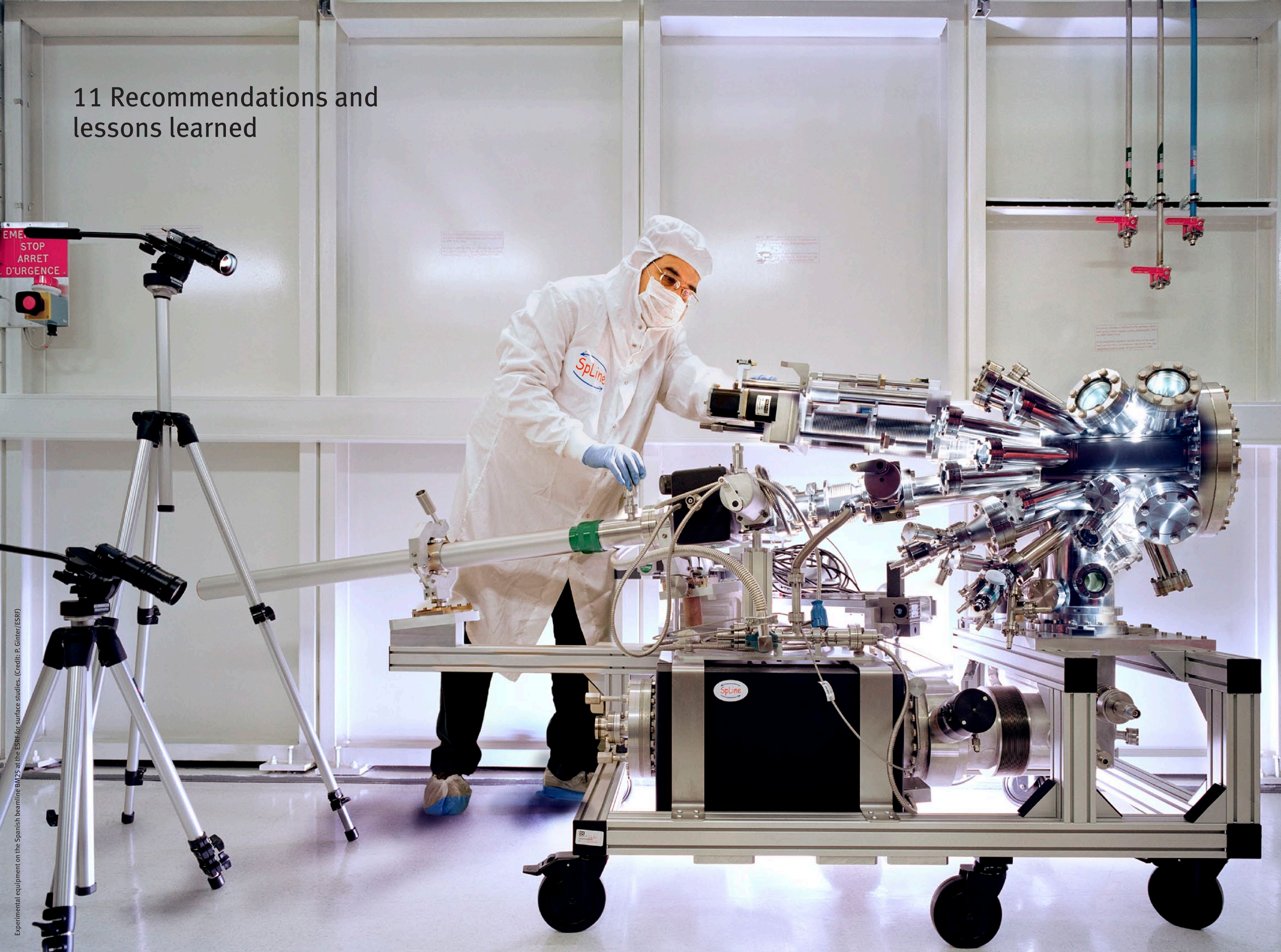
NORDSYNC has proven to be an efficient administrative arrangement vis-à-vis the ESRF that has given additional weight to the Nordic voices in the ESRF Council and in the advisory committees. NORDSYNC is seen as a constructive owner/partner by the ESRF management and the other partners. Trust and respect have been earned by the manner in which delicate issues such as budgets, "juste retour" and payment for overuse have been handled.

There are clear differences between how the NORDSYNC and the ESRF memberships are administered in the different Nordic countries. This reflects the differences in the organisation of and traditions for research funding in general and research infrastructure in particular. Research infrastructure is seen as a strategic issue in all four countries. All are active in the ESFRI process and have developed national roadmaps of their own for the planning of national facilities and participation in international projects.

NORDSYNC matters have been handled in a flexible manner with an appropriate mixture of formal and informal efficiency. This is illustrated by the manner in which the NORDSYNC delegation interacts and achieves consensus, and by the new NORDSYNC agreement from 2007 that introduced a new, dynamic scheme for cost-sharing on the basis of scientific use.

The NORDSYNC user communities see a continued strong need and world-leading role for the ESRF in the coming 15-20 years. The advent of new national SR sources and X-ray free electron lasers will create new scientific opportunities and change the landscape, but the new sources will not be able to replace the ESRF in the medium term. They will be complementary, and there are many potential synergies with respect to the ESRF. The ESRF Upgrade Programme illustrates how the ESRF can stay competitive as a source of creative SR technology while making the most of the potential for continued thematic and geographic expansion of its user base by further developing the user support system. Nevertheless, the time is right for a joint review of the NORDSYNC priorities and set-up in light of these new developments, including the opportunities offered by PETRA III in Hamburg in the short term and MAX IV in Lund in the medium to longer term.

11 Recommendations and lessons learned



Experimental equipment on the Spanish beamline BM25 at the ESRF for surface studies. (Credit: P. Ginter/ESRF)

11 Recommendations and lessons learned

Recommendation 1:
NORDSYNC should continue to support the strategic development and use of the ESRF, with focus on:

- *Scientific quality based on the unique source strength for hard X-rays and the world-leading beamline and instrument technology;*
- *Development of the synergies with neutron sources (e.g. the ILL) and the new SR sources and FELs;*
- *Development of the merit-based access scheme to ensure the highest scientific quality and to attract talent and encourage cross-border collaboration on a global scale;*
- *Development of the user support system with new remote access and handling features and further development of the e-Infrastructure for data acquisition, handling, analysis and modelling, and data curation;*
- *Efforts to involve industry more directly in the use of the ESRF.*

Recommendation 2:
The ESRF and NORDSYNC should be used as a testing ground for streamlining operations of a Nordic consortium with further delegation of responsibility to a single partner or pair of partners (e.g. head of delegation plus a substitute) combined with more systematic interaction using teleconferences prior to ESRF Council and committee meetings. Such a high degree of delegation is seen as more suitable for mature organisations such as ESRF and NORDSYNC and less appropriate in the initial phases of a new RI project. Streamlining should be carried out with a view to increasing transparency and dialogue among all of the stakeholders and actors, such as members of the ESRF Council, AFC, SAC and selection committees, and user representatives.

Recommendation 3:
The organisations behind NORDSYNC and/or NordForsk should encourage further integration of the Nordic user community (possibly including the communities in the Baltic states) both within and across the disciplines. This could be achieved by

- *Combining national meetings to form Nordic meetings;*
- *Joint programmes for students and post-doctoral students, exchange of staff and sabbaticals;*
- *Joint summer and winter schools;*
- *Joint hearings on strategic issues such as RI roadmaps.*

Lesson 1:
NORDSYNC is an example of a well-functioning Nordic cooperation measure. It was conceived in response to the politically-determined threshold contribution of 4% set for becoming a full partner of the ESRF, alongside the desire among the Nordic countries to contribute less than the usual GDP-based share to an international research infrastructure, such as, for example, CERN. The 4% NORDSYNC contribution was accepted after negotiations with the other partners in the very early phases of the project, and the NORDSYNC consortium has been followed by two other consortia in the ESRF: BENESYNC as a full partner with a 6% share and Centralsync as a scientific associate with a 1.05% contribution to the running costs.

Lesson 2:
NORDSYNC has been a success in that the scientific communities in the Nordic countries have enjoyed full and unrestricted access to the ESRF, which has been exploited by leading groups to obtain a relatively large share of the beam time and to become deeply involved in the development of the ESRF. NORDSYNC has become a respected partner due to the high quality of the use combined with the Nordic tradition for flexibility, consensus and pragmatism when approaching delicate matters such as budgets, fees for overuse and access.

Lesson 3:
The success has been secured by the high quality engagement and commitments at many levels of the ESRF operations and activities from the very early phases of the project. This is illustrated by the roles persons from the Nordic countries have played in the Council, the management, the advisory committees and the user community in general. These engagements have been encouraged and supported by the employment of key staff from the Nordic countries in both shorter and longer term positions.

Lesson 4:
The NORDSYNC consortium model could be used for new engagements in some of the research infrastructure projects on the ESFRI Roadmap, and joint management with a large degree of delegation and task-sharing between the Nordic partners could lead to significant savings in the administration of these engagements.

Lesson 5:
Industrial utilisation of science-driven research infrastructure such as the ESRF evolves slowly and requires close collaboration between users in academia and industry, e.g. joint projects for Master's and Ph.D. students. It also requires dedicated outreach from the facility in terms of ease of access and use.

Annex I: References

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Annex II: List of persons interviewed

Name	Country	Institution	Interview type
Lise Arleth	DK	KU Life	person
Robert Feidenhansl	DK	KU	person
Henning Friis Poulsen	DK	Risø DTU	telephone
Pernille Harris	DK	DTU	person
Sine Larsen	DK	KU	person
Inger Andersson	SE	SLU	telephone
Winnie Birberg	SE	VR	person
Lars Börjesson	SE	Chalmers	person
Johan Holmberg	SE	VR	person
Ulf Karlsson	SE	KTH	telephone
Helena Aksela	FI	Oulu U	telephone
Adrian Goldman	FI	Helsinki U	person
Keijo Hämäläinen	FI	Helsinki U	person
Pietari Kauttu	FI	CERN	telephone
Edwin Kukk	FI	Oulu U	telephone
Tuukka Lehtiniemi	FI	Academy of Finland	person
Helmer Fjellvåg	NO	Oslo U	person
Bjørn Hauback	NO	IFE	person
Aase Hundere	NO	Forskningsrådet	person
Arne Smalås	NO	Tromsø U	telephone
Manuel R. Castellano	ES	ESRF	person
Veijo Honkimäki	FI	ESRF	person
Joan McCarthy	UK	ESRF	person
Jean Moulin	BE	ESRF Council	telephone
Fransesco Sette	I	ESRF	person
Michael Wulff	DK	ESRF	person

Annex III: Guide for interviews for the evaluation of NORDSYNC and the engagement in the ESRF

1. Brief profile of the person being interviewed
2. Types of relations and experiences with NORDSYNC and ESRF

Specific experiences and opinions:
1. User perspectives:

- Research projects (area, number, year, collaboration)
- Beam time allocation system
- Fellowships and other employments
- Scientific collaborations and support from ESRF
- Publications and other results
- National NORDSYNC relations
- Research Council grants and other relations
- Institutional strategies and involvement
- Industrial use and collaborations
- Industrial orders

2. Administrative perspectives

NORDSYNC:

- Local organisation, involvement and experiences
- Functioning of NORDSYNC
- National dialogue and strategies
- Nordic collaborations
- Best practice examples of the organisational set-up

ESRF:

- Involvement in ESRF organs
- Functioning of NORDSYNC in relations to ESRF organs
- Decisions making procedures incl. budget issues
- Responsiveness to NORDSYNC interests
- Strength and weaknesses in the ESRF/NORDSYNC relations
- Opportunities and threats in the ESRF/NORDSYNC relations
- Opinion on the return on investment

3. Quality, impact assessments and outlook

- Organisational arrangements for NORDSYNC and the ESRF relations
- Efficiency and effectiveness of the implementation (name a few indicators)
- Impact and over all return on investment (name a few indicators)
- Potential for improvement

4. Other issues and remarks

Annex IV: Procedure for allocation of beam time[17]

Two proposal review rounds are held each year, with deadlines for electronic submission of applications on 1 March and 1 September for the scheduling periods August to February, and March to July, respectively. Requests for beam time are based on shifts of eight hours. Allocation of beam time is usually made in multiples of three shifts. The person nominated as the “main proposer” receives all correspondence relating to the project and is expected to act as the experimental team coordinator if the project is allocated beam time. Each application is assigned to a broad scientific domain and is submitted to a Review Committee. Members of these committees are specialists in relevant areas of science and are appointed by the ESRF management. Four categories of proposals may be submitted and reviewed: 1: Standard Research Proposals; 2: Long Term Project Proposals (LTP); 3: BAG Proposals; and 4: MX BAG Proposals (rolling access procedure).

Beam time is allocated on the basis of scientific merit, following the recommendations of the Review Committees, and provided the proposed experiment meets technical feasibility and safety requirements. The Review Committees, assisted by external referees when appropriate, assess the proposals: they first assign each proposal a grade between 0 and 5.5 on the basis of scientific merit, 5.5 being the top score. The committees also rank the proposals in order of priority for each beamline.

Beam time for non-proprietary industrial research is available on the same conditions as university-based research; however, users from industrial firms do not receive a contribution to their expenses.
The 11 review committees are organised according to the fields of science pursued at the ESRF. These categories are also used in the reporting and statistical description of the activities:

- Chemistry-related Studies (CH)
- Environmental and Cultural Heritage Matters (EC)
- Disordered systems and Liquids (HD)
- Electronic and Magnetic Properties (HE)
- Crystals and Ordered Systems, Structures (HS)
- Applied Materials and Engineering (MA)
- Medicine (MD)
- Methods and Instrumentation (MI)
- Macromolecular Crystallography (MX)
- Soft Condensed Matter and Biological Materials (SC)
- Surfaces and Interfaces (SI)

When beam time is allocated, invitations to conduct experiments, together with detailed instructions, are then sent to the proposers by the ESRF User Office several weeks ahead of the scheduled experiment. In 2009,11 members of the Review Committees came from the NORDSYNC countries and two of them served as committee chairs.

A Long Term Project requires:

(a) Commitment from the proposing user group concerning the contribution of financial, technical and/or human resources during the implementation of the LTP;

(b) Identifiable benefit to the ESRF user community (such as a new technique, a new instrument or new possibilities for the beamline) expected to result from the successful accomplishment of the objectives of the LTP.

BAG proposals: As a step to enable groups to become familiar with beamline instrumentation and to make maximum use of their beam time, a Block Allocation scheme was introduced during the second scheduling period in 1998 for macromolecular crystallography requests. A number of groups (Block Allocation Groups, or BAGs) have been identified by the Life Sciences Beam Time Review Committee and are awarded a block

17 Based on the ESRF users guide on the ESRF website.

of beam time per allocation period, spread over all of the MX beamlines as needed. The identification of these groups is based mainly on previous usage and performance, and accounts for approximately 80% of the beam time currently awarded by the Committee. The scheduling of the beam time is also grouped, allowing greater flexibility in the choice of projects and samples. At the same time, the BAGs are requested to nominate one to two persons who will be trained to provide additional help when these teams are using beam time.

The Beam Time Review Committee may add or remove groups, or change the size of the Block Allocations according to performance.

MX BAG Proposals: This method of applying for beam time is used by scientists who are not part of a BAG and proposals may be submitted at any time. These applications will normally be reviewed electronically by the Beam Time Review Committee within two to three weeks after they are received by the ESRF, and if beam time is awarded it will be scheduled within six to eight weeks from the time of application. This method of application and review is designed to improve access to ESRF MX beamlines and encourage the use of ESRF facilities by smaller groups working in the macromolecular crystallography field.