Swedish National Facilities

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Cover photos

Top: PhD student Katarina Removic, Hahn-Meitner Institute in Berlin, performing XCMD-studies at beamline D1011, MAX-lab. (Gunnar Menander)

Right: Mathias Fredrixon at the multichamber high-vacuum sputter machine, in Chalmers MC2 clean room, used for processing and research of Nb-based superconducting tunnel junctions employed as a key component in mm and submm wavelength radio astronomy receivers. (Victor Belitsky)

Left: Mikael Björkhage prepares the electron collector in the CRYSIS ion source (at MSL) for efficient production of highly charged ions. (Anders Källberg)

Bottom: The TSL engineer Elin Hellbeck, sitting behind the upper part of the WASA pellet system, is involved in developing and operating this system. (Teddy Thörnlund)

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Preface

The Swedish research council is a governmental agency which has the mission of supporting basic research within a broad range of scientific fields ranging from the humanities and social sciences, through medicine to natural and engineering sciences. The main part of the Swedish research council´s budget funds high quality research projects on an individual basis. The Swedish research council also has several other tasks and among these is the support of the operation of Swedish National Facilities.

The operational support for these facilities is provided as a result of periodic reviews and the current review of the four National Facilities, the Manne Siegbahn laboratory, Stockholm, the Onsala space observatory, Göteborg, the MAX laboratory, Lund, and the The Svedberg laboratory, Uppsala, addressed scientific, technical and strategic issues.

The members of the Review Panel were Prof. Sam Aronson, Brookhaven national laboratory, USA, Prof. Robert L. Jaffe, MIT, USA, Prof. Malcolm Longair, Cavendish laboratory, United Kingdom, Prof. Irène Nenner, CEA/Saclay, France and Prof. Dr. Jochen R. Schneider, DESY, Germany. Professor Gunnar Öquist, Umeå university, was appointed chairman of the evaluation committee. During the evaluation Dr. Leif Eriksson (Swedish research council) assisted Prof. Öquist and Dipl. Phys. Jan Conrad, Uppsala university acted as secretary.

The Swedish research council would like to express its sincere gratitude to the Review Panel for devoting their time and expertise to this difficult task and for their engagement during the site visits. We would also like to thank Prof. Öquist for his skilful and firm guidance of the work of the Review Panel in accordance with its terms-of-reference. Dr. Eriksson and Dipl. Phys. Conrad are also thanked for assisting the Review Panel and for providing background material. Finally, the Swedish research council would like to thank representatives of the four National Facilities for delivering reports and for giving informative presentations to the Review Panel.

Director General
Professor Pär Omling
The Swedish research council

Secretary General
Professor Kåre Bremer
The Scientific council for
natural and engineering sciences

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Background

The four existing facilities were established as National Facilities in 1994–1995 by the decision of parliament. In the first round, these were the MAX laboratory at Lund university, the The Svedberg laboratory at Uppsala university, and the Onsala space observatory at Chalmers technical university. In the second round, the Manne Siegbahn laboratory at Stockholm university was designated a National Facility. These transformations involved the transfer of funds from the host universities to the Swedish research council (up to 2001-12-31 the Swedish natural science research council, but after 2002-01-01 the Swedish research council), which had the responsibility of undertaking periodic evaluations of the activities and submitting requests to the government for appropriations on behalf of the facilities. The Swedish research council was created in order to concentrate the governmental funding structure into fewer agencies. Four research councils – Medicine, Natural sciences, Engineering sciences and Humanities with Social sciences – and the Swedish council for planning and coordination of research were merged to form the Swedish research council and the responsibilities of the old councils were taken over by the Swedish research council.

Bilateral agreements were reached between the Swedish research council and the host universities for the National Facilities in order to regulate the division of financial support and other responsibilities. The basic division of financial support is that the host university pays the rent including electricity and the Swedish research council pays for the operations. The host university acts as employer of the staff of the facility, while the Council supplies the overall scientific guidelines, monitors and periodically evaluates the ongoing activities. The host university is responsible for setting up a board for the facility, two of the members being proposed by the Swedish research council.

Short description of the facilities

The Manne Siegbahn laboratory (MSL) operates the cooled storage ring CRYRING with an electron cooler and several ion sources, such as the electron beam ion source (CRYSIS), that provides highly charged ion beams for laser spectroscopy and slow ion-atom collision experiments outside the ring, and for recombination experiments in the cooled ring.

The Onsala space observatory (OSO) operates the two radio telescopes at

Onsala in the mm and cm wavelength regions, and the sub-mm radio telescope SEST at La Silla, Chile. The main scientific focus is on the origin of stars and galaxies using high frequency spectroscopy and high resolution observations in radio astronomy, and the application of these techniques in Earth environmental science. These activities are supported by research and development in millimetre/submillimetre receiver technology.

The MAX Laboratory (MAX-lab) operates the storage rings MAX I and MAX II. These rings provide synchrotron radiation to a number of beamlines, which are used in a large number of research fields in biology, chemistry, physics and engineering. The electron energy is 550 MeV in MAX I and 1.5 GeV in Max II. At MAX I, a 95 MeV stretched electron beam is also produced for nuclear physics. Development work includes several new beam lines, the superconducting MAX wiggler, the 700 MeV storage ring MAX III and a new 500 MeV injector, a Linac/recirculating system.

The The Svedberg laboratory (TSL) operates the Gustaf Werner cyclotron and the CELSIUS storage and cooler ring. The cyclotron can accelerate a wide range of ions of various energies, for example, up to 180 MeV for protons and 45 MeV/nucleon for light ions. One beam line contains a source of monoenergetic neutrons with energies between 20 and 180 MeV. In CELSIUS the ions can be further accelerated up to 1.36 GeV for protons and 470 MeV/nucleon for light ions. The scientific program ranges from fundamental research in nuclear and low energy particle physics to interdisciplinary research in application-oriented projects.

The Swedish research council and the National Facilities

The Swedish research council has established a committee for National Facilities (NF), the "Kommittén för nationella resurser" (KNR), which is responsible for overseeing the work of the facilities and for preparing the material needed for council decisions. The first evaluation was carried out in 1997 and resulted in the continued operation of all four facilities. A written report was produced which included separate evaluations for each of the facilities.

In the tables below, the Swedish research council's funding for the operation costs and upgrades of the facilities are shown for the period 1998–2002. 2002 is the last year of a three-year contract period.

In addition, the facilities themselves, user groups and individual scientists

Operating costs per year (MSEK)

Lab	1998	1999	2000	2001	2002
MSL	14.55	14.9	14.7	15.068	15.068
OSO	14.65	15.0	14.8	15.17	15.17
MAX	16.22	16.5	16.7	17.117	17.117
TSL	20.4	20.8	20.249	20.755	20.755

Upgrades per year (MSEK)

Lab	1998	1999	2000	2001	2002
MSL	1.2	1.0	1.1	1.0	1.1
OSO	1.2	1.0	1.0	1.0	1.1
MAX	1.5	1.9	1.9	1.6	1.9
TSL	1.5	1.5	1.7	1.4	1.1

can apply for funding of scientific equipment. The third table shows aggregated funding for investments in equipment at the facilities for the period 1998–2002. Funding from the Swedish research council, as well as funding from private foundations and companies, are all included. Most funding relates to the construction of equipment which can take a long time, sometimes several years, but in the table the total funding for such instrumentation projects is listed under the year at which the funding decision was taken. The figure for OSO includes receiver development for satellites and antennas. The figure for MAX includes grants to user-groups at other universities that build equipment to be used at the beam-lines at MAX. The figure for TSL includes grants to user-groups that build their own detectors for TSL.

Lab	Funding of scientific equipment (MSEK 1998-2002)
MSL	6.5
OSO	36.3
MAX	171.6
TSL	25.8

Review procedure

KNR has been instrumental in planning the 2002 review and in defining its terms-of-reference. The terms-of-reference were agreed by the board of the Swedish research council and the director general invited the persons to serve on the Review Panel.

A written report from each of the facilities was sent to the members of the Review Panel prior to their arrival in Sweden in June 2002. Each site visit took approximately six hours followed by closed discussions within the Review Panel during which an outline draft was prepared. The KNR committee met with the Review Panel both on the day of their arrival and on the last day of their visit.

Executive summary

General observations

Sweden has evolved a rather unique and very positive model for university/national facility collaboration. The Review Panel noticed in particular the shared responsibility between the Swedish research council and the host university not only for funding and operating a particular facility, but also for its long term strategic planning. Both the university and the facility can strongly benefit from such a collaboration. The Review Panel noticed the positive effects of a strong university/facility connection for the MAX laboratory, but the absence of such a working relationship for the Manne Siegbahn laboratory was equally noticeable.

All the four National Facilities scrutinised in this review provide remarkable scientific output in proportion to their operating budgets. The nominal budgets are about 2 to 3 times lower than for comparable facilities abroad. This puts the swedish facilities in a difficult, perhaps untenable, situation which will lead inevitably to a loss of international competitiveness over time.

The Review Panel notices that the mismatch between program aspirations and operating budgets stems to a large extent from the fact that the agencies provide capital equipment grants without providing the operating costs. This has led to "shadow economies" in which students and researchers from external institutions and universities now routinely carry out tasks of general user support, which ought to be assigned to technicians and support scientists for the facilities.

It is the view of the Review Panel that the National facility program of the Swedish research council has now reached a point where either the budget must be increased substantially, or the number of operating facilities must be reduced to match the present total budget of roughly 75 MSEK, taking account of the scientific priorities of the swedish user community.

The four facilities

We visited the four laboratories, each with its own distinct character, and each at a different stage in its evolution. Two of the National Facilities, the MAX laboratory and the Onsala space observatory, are thriving, healthy, but underfunded. They have well-defined missions which are broadly supported by strong user groups. One, the The Svedberg laboratory, is reaching the end of its traditional research program and needs to be reoriented. The Manne Siegbahn laboratory is focused on its in-house research agenda, with a limited role as a facility on the national scene. The laboratories are arranged in the order in which they were visited by the Review Panel.

The Manne Siegbahn laboratory (MSL)

The Manne Siegbahn laboratory pursues in collaboration with visitors its own long-standing research agenda in the physics of atomic and molecular ions. The facility, an ion storage ring with several ion sources, is technically performing very well. MSL has demonstrated a widely recognized competence and experience in accelerator physics and EBIS ion sources. The scientific output is characterized by several highlighted results in electron-atom and electron-molecule recombination, but quantitatively limited. The facility lacks a strong national character with its limited number of operating hours and number of users. MSL lacks a common strategic plan with its parent university. Future plans regarding a double electrostatic storage ring have not yet matured to a state to be convincing. The future of MSL needs to be discussed in the context of the proposed National accelerator physics programme (see Recommendations, page 13).

The Onsala space laboratory (OSO)

The Onsala space observatory has an excellent world-wide reputation in radio, millimetre and submillimetre astronomy and provides effective support to astrophysics in these areas for all swedish astronomers. The SEST telescope in Chile is the largest submillimetre telescope in the Southern hemisphere and is operated jointly with ESO. The telescopes at Onsala are used for lower frequency studies and the 20-metre telescope provides an important link in international VLBI. The technology developed by the Observatory is world-leading and used in space as well as ground-based telescopes. The next major ground-based facility will be the ALMA array and the Onsala scientists are already playing a major role in its development. As a precursor to that program, the APEX prototype telescope for the ALMA array will soon be located at the Chajnantor site in Chile and will provide important science for swedish astronomers. It is of concern that the operation of the SEST telescope has been jeopardised by ESO's decision to close that telescope to fund the operating costs of APEX.

The MAX laboratory (MAX-lab)

The MAX laboratory has a clear mission as the swedish national synchrotron radiation light source, serving a large, dynamic, and growing community in the fields of physics, materials science, chemistry, and biology. It stands out among the four national laboratories as a source of basic infrastructure support for swedish science and technology broadly defined. MAX-lab has gained a very high reputation worldwide for its foresight in carefully planning the radiation sources, the beamlines and the instrumentation together with highly competent user groups, so that the laboratory could offer novel instrumentation for cutting edge research in emerging fields of science in due time. The laboratory is blessed with truly imaginative accelerator physicists who should be planning strategically to stay at the forefront of synchrotron radiation research.

The The Svedberg laboratory (TSL)

TSL is endowed with significant expertise in the physics and technology of accelerators, targets and detectors. The current science program in nuclear and particle physics has some strong components (for example, the CELSIUS/WASA study of rare decays of the η meson, and the CHICSi program in low energy heavy ion physics), but some parts have limited scientific impact. There is also a broad program in support of applied science, for example, in materials and biomedical research. More proactive program management by TSL would ensure that the present program has clear goals and that resources are directed to the strongest elements of this broad program of basic and applied research. There is a lack of long-range planning by TSL management. It is important that TSL together with its user community develop, through critical self-assessment, a vision for TSL's future role in swedish science. The future of TSL should be planned in the context of the proposed National accelerator physics program (see Recommendations below).

Recommendations

A need for national strategic planning

The most striking observation by the Review Panel is the need for forward looking, national strategic plans in the fields of accelerator physics and astronomy. This is not only motivated by the limited national resources, but also by the need to make national priorities within these areas if Sweden wishes to remain competitive and continue to be an active and important player on the international scene.

National accelerator physics program

At three of the four facilities visited (MSL, MAX-lab and TSL), we recognized a high degree of competence in accelerator physics as well as in the science carried out with accelerators. These include expertise in ion sources, in storing and accelerating beams from electrons to heavy ions and in the interaction of stored beams with advanced targets. The future of accelerator physics and technology includes new generations of X-ray sources such as free electron lasers (FELs) and energy recovery linacs (ERL), new commercial applications of accelerators for materials science and biomedical research and treatment and new international efforts in ultrahigh energy electron position colliders for basic research in particle physics. We believe the swedish accelerator physics community can play a major role in this future. We therefore suggest the establishment of a National accelerator physics program.

A National accelerator physics program could serve as the platform for swedish scientists to participate in all forms of accelerator based research, both competitively at the national level and internationally by facilitating the optimal use and participation in the development of international facilities, such as CERN.

In view of budget constraints, coupled with the somewhat uncertain future of the research programs at MSL and TSL, we believe this requires a concerted inter-laboratory effort. Therefore, the Review Panel recommends the building of a National program for accelerator physics based on the competence at MAX-lab, TSL, MSL, and their host universities. The establishment of such a program could be an essential component in the future reorientation of activities at MSL and TSL.

One way of approaching this type of program building would be to form an Accelerator physics steering committee under the auspices of the Swedish research council. This Steering committee would be charged with formulating a national program and developing a plan and schedule for its implementation. Such a program should include the training of young accelerator physicists. The Steering committee should involve representatives of the three National Facilities, their host universities, and their user communities, as well as the international accelerator physics community and the Swedish research council. In all probability, workshops and inter-laboratory working groups would be formed to provide input to the Steering committee. A reasonable goal would be to present a plan and schedule to the Swedish research council for review within a year.

The Review Panel believes that there would be an advantage if there were a National accelerator science advisory panel within the Swedish research council to enable a coherent discussion of national priorities within the context of the strategic plan for accelerator based research as a whole to take place. This panel could be the successor to the Steering committee mentioned above.

National strategy for astronomy

As already noted in the Review of swedish astronomy (2000) Sweden lacks a national strategy for astronomy. The Review Panel recommends that steps now need to be taken to develop a more strategic approach to swedish astronomy, in which the Onsala space observatory should play a central support role for swedish and nordic astronomy. The future program in radio, millimetre and submillimetre astronomy is rather clear, but it needs to be placed in the context of swedish astronomy as a whole. Such a strategic plan should encompass all aspects of astronomy and astrophysics, such as future scientific priorities and long term plans for large facilities and the role of astronomy for school and public education. In particular, the role of swedish astronomy in provision of advanced instrumentation technology should be considered. The Onsala space observatories program could be extended within this plan to include instrumentation for optical and infrared wavebands.

The Review Panel believes that there would be an advantage if there were a National astronomy advisory panel within the Swedish research council to enable a coherent discussion of national priorities within the context of the strategic plan for astronomy as a whole to take place.

Funding

It became obvious to the Review Panel that the funding of the National Facilities is insufficient. Thus, it is impossible to keep four National Facilities, which are supposed to operate at the forefront of research, with the present budget. Without a forward looking, national strategic plan along the lines proposed above, the shut-down of one or two of the facilities over the next few years is inevitable.

In part the financial problems originate from a serious structural problem in the swedish funding policy. The funding of investments in instrumentation and other infrastructure is usually decoupled from the support for operational costs. Scientists at the facilities cannot resist the lure of research opportunities presented by new investments, despite the obvious absence of operational support. To compensate, the National Facilities have developed a “shadow economy”, in which students and users provide technical and user support over and above their research activities. The panel thus recommends a funding model where there is a better match between operational and investment funds.

First we recommend that an attempt be made to assess carefully the extent of the operating budget shortfall which has been hidden by the evolution of a “shadow economy“. Second we recommend that an attempt be made to link operating costs more closely with the distribution of new program funds.

If the budget were to be increased by 15 MSEK per year, the following allocation is proposed:

Both the MAX-lab and the OSO should receive substantial additional funding, with a significantly larger fraction being allocated to the MAX-lab than to the OSO. The remaining fraction should be dedicated to the formation of the proposed National accelerator physics program. Additional resources should be reallocated from MSL and TSL, strongly coupled to a reorientation of their scientific programs to match the proposed National accelerator physics program.

If the budget were to be decreased by 15 MSEK per year, the following allocation is proposed:

A decrease of the budget by 15 MSEK would require the dismantling of two of the National Facilities. To ensure future swedish competitiveness, it is considered very important to develop the proposed National accelerator physics program and hence a dismantling of two facilities will be needed. Considering the high quality of research and strong positions of both the MAX-lab and the OSO as well as their pressing needs for increased funding, the dismantling of TSL and MSL would be the natural consequences over the next few years.

User involvement

Capital investment projects should be science driven and the users should be involved at an early stage of planning. Every National Facility has to play a central role in the national community of prospective users and stimulate first class science with a strong impact upon the international community.

University/National facility connections

The Review Panel emphasizes the need for a strong connection between the host university and the National Facility. For their mutual benefit, strategic future plans for the host university and the facility should build explicitly on the strength of both institutions. The Review Panel recommends the Swedish research council and the host universities to revise their contractual agreements to achieve this crucial goal.

Education

The National Facilities should play a strong role in education at undergraduate as well as graduate levels. The Review Panel therefore urges the faculties of the host universities and the National Facilities to exploit more effectively the educational resources at the facility. Obviously, such an effort has to be accompanied by an increase of the scientific staff of the facility.

General observations

National Facility – university relations

Sweden has evolved a rather unique and very positive model for university/national facility collaboration throughout its national facilities program. Each facility is linked to a host university. The Swedish research council funds and evaluates the facilities, but the university appoints the board and the director, and operates the facility. The operating budget of the facility is separated in such a way that space and infrastructure support, such as electricity and water are provided through the university budget, while other operating funds are provided directly to the facilities through the Swedish research council.

Through its close relation to a university, the facility can gain access to a strong local academic community, to local resources on the university campus, and to excellent students. The university can become a partner in relationships of the facility with industry and governmental agencies, and offers an attractive route for recruiting first rate young researchers. The host university profits strongly from a first class National Facility on campus, thus strengthening the profile of the university and attracting high quality young as well as outstanding senior scientists and professors.

Particularly at the MAX laboratory, and also at the Onsala space observatory, the Review Panel noticed during the site visits very strong and healthy interactions between the facilities and the host universities, with the facilities playing strong and significant roles in the development of university/faculty programs and vice versa. We also noticed that Uppsala university recognizes the value of the The Svedberg laboratory and has taken active steps to give it a central role in the future national planning for accelerator based research. However, in the case of the Manne Siegbahn laboratory the absence of an active interaction between the university/faculty and the facility was quite noticeable.

In considering the future of its National Facilities, the Swedish research council should maintain this generally very successful linkage between the facilities and their host universities and use it as an ingredient in planning new programs.

The overall level of funding

All four National Facilities covered by this review provide remarkable output in proportion to their operating budgets. It seems almost impossible that these facilities manage to carry out their programs on yearly operating budgets of roughly 20 MSEK. Even though rent, electricity, and some other infrastructure costs are covered by their host universities, the Review Panel estimates that laboratories' operations at the scale we saw would cost about a factor of 2 to 3 more than the figures presented in the budgets of the facilities. Unquestionably, the facilities are underfunded. For example, a comparison between BESSY II in Berlin and MAX-lab shows that the nominal budget of the MAX-lab needs to be doubled in order to match that of BESSY II.

It is the view of the Review Panel that the National Facility program of the Swedish research council now has reached a point at which either the budget must be increased substantially, or a restructuring phase must begin to reduce the number of operating facilities to match the present budget of roughly 75 MSEK, taking account of scientific priorities.

The mismatch between program aspirations and operating budgets appears to stem in part from the way that projects are funded in the Swedish system. Facilities and researchers apply to foundations and government agencies for capital program funds to develop and build new devices and facilities. The agencies provide grants for capital equipment, but not for operating costs. The scientists, eager to move forward, seem willing to ignore the obvious absence of sustaining operating funds. The result is a chronic shortfall in operating funds evident at every laboratory, roughly in proportion to the laboratories success in generating new program support. An increase in operating budgets can provide a short-term fix, but if this systemic problem is not resolved, then operating shortfalls will inevitably arise again in a few years.

In the course of our review, the panel also became aware that the laboratories have, to a greater or lesser extent, evolved "shadow economies", in which important infrastructure tasks have been shouldered by research scientists or students in order to sustain core programs in the absence of adequate operations budgets of the facility. As a result, the true cost of doing business cannot be accurately gauged from formal budget information. This makes it very difficult for us to judge the real need for additional operating funds, except to be certain that it exceeds the amount evident on paper. The extent of the "shadow economy" differs from facility to facility. It appears to be very extensive at MAX-lab, where researchers from outside institutions and universities now routinely carry out tasks, which should be assigned to facility staff, assistant staff and technicians.

We recommend the following steps to be taken by the Swedish research council:

First we recommend that an attempt be made to assess carefully the extent of the operating budget shortfall which has been hidden by the evolution of a "shadow economy" at each of the national laboratories. We feel that the situation is particularly critical at MAX-lab where it is necessary also to address the more recent structural problem posed by the rapidly expanding participation by technically unsophisticated users.

Second we recommend that an attempt be made to link operating costs more closely with the distribution of new program funds. We realize that this is easier said than done. It may well require a broad strategic review of the planning process for determining research priorities and a close integration of the roles of the Swedish research council and the private foundations, which have played such a vital role in providing capital resources.

The Manne Siegbahn laboratory (MSL)

The facility

The facility comprises a set of ion sources with their associated beam lines, and a synchrotron and storage ring (CRYRING) equipped with an electron cooler. The latter is very effective since it allows unprecedented energy resolution in recombination experiments. This ensemble is one of the few facilities in Europe comparable to the storage rings in Denmark (ASTRID) and Germany (TSR). In addition to the electron beam ion source CRYSIS, the facility has offered since 1997 an ECR source for highly charged ions, a plasma ion source as an isotope separator, and several other sources for positive or negative ions for singly charged atomic and molecular ions. The vacuum of the ring is excellent – less than $5x10^{-12}$ torr average pressure – providing a very low background. The lifetime of the cooled ion beam can reach days or weeks under the best conditions. The variety of ions which can be accelerated, especially for molecular and cluster positive ions as well as atomic and molecular negative ions, has increased significantly since the last review. The flexibility of the machine is demonstrated by the capacity of storing at total energies between 20 keV for single charged Xenon ions and 1.4 GeV for Pb^{55+}. The present record of the charged state has been obtained for U^{70+}, with the EBIS type of source CRYSIS. The ECR source is now in operation and delivers ions with energies up to 330 keV. Injection into the ring is planned later this year.

An R&D program on the performances of ion sources has been developed steadily by a group of dedicated and very active research and technical staff members. An accelerator physics research program is also pursued by the in-house staff. The observation of a reduction of the Schottky noise in a cold heavy ion beam, interpreted as an ordering of ions in the beam, is very interesting. This activity shows that MSL in-house science and instrumentation development work well in parallel.

The facility offers some 1500 hours/year of beam-time at the ring. This number is basically limited by the number of accelerator operators. Weekends are not scheduled regularly for the same reason. This amount of beam-time is much lower than that offered in other low energy ion facilities (2500 to 3500 hours/year). Most users are trained to use the available equipment and benefit from collaboration with the technical staff.

The goals set out for the facility in 1999 have largely been met according to plan. It has however been decided not to build a second electron cooler. Instead plans are under way to design and build a double electrostatic storage ring, DESIREE (see below).

The science

The science performed at MSL is largely conducted by external groups, one half from foreign universities and one half from swedish universities, mainly Stockholm university, and is dominated by the physics of atomic and molecular ions with a marked orientation towards problems of astrophysical interest and more recently of atmospheric relevance. Metrology of atomic weights is an additional activity. MSL also pursues, as an in-house research activity, some accelerator physics research and development related to ion sources.

A well established area of atomic physics at CRYRING is the study of *electron-atomic recombinations*. Apart from their general interest for plasmas, especially for modelling astrophysical processes, absolute values of recombination rate coefficients, accurate resonance energies and hyperfine splittings, offer stringent opportunities for testing the most advanced many-body aspects of the theory of the electronic structure of atoms, including relativistic and QED effects. *Spectroscopy of metastable states* due to forbidden transitions in heavy atomic ions, using laser techniques for probing, is interesting because modern space telescopes such as the Hubble space telescope provide an increasing wealth of data awaiting interpretation.

Studies of *dissociative recombination reactions* of molecular ions with free electrons represent one of the highlights of the science done with CRYRING. Similar experiments are carried out in a few other places in Europe, at ASTRID in Denmark and TSR in Germany. The appeal of this program originates not only in the fundamental questions addressed at the forefront of molecular physics, but also in their recognized importance in the physical chemistry of the interstellar medium and in certain regions of the earth atmosphere. The extension of this program from diatomic to polyatomic ions and cluster ions represents a real challenge. Nevertheless this group has produced the first interesting results in triatomic molecules, including the important H_3^+ case, which is not yet understood. However, although the new investigations of dissociative recombination of *hydrated molecular ionic clusters* is of potential interest, the identification and selection of a specific isomer out of cluster ions of the same mass is intrinsically very difficult. For these activities, the interactions with ongoing research in atmospheric chemistry and modeling appear insufficient.

The newly installed gas-target in CRYRING opens up opportunities for *electron transfer experiments* enabling several types of collision studies with slow and fast ions in atoms (low and high charge states), molecules and free clusters to be undertaken. Interesting results have been obtained recently with C_{60} and helium using the Recoil-ion-momentum spectroscopy technique. Other collision experiments based on the interaction of highly charged ions with surfaces, aim to study the X-ray relaxation of the impinging ion after electron capture from the surface, rather than investigating the surface as such. The subject was initiated elsewhere some 10 years ago with the discovery of hollow atoms. However, the progress is rather slow and the future perspective is not particularly exciting.

Studies *of negative ions* represent a new subject but in a largely well-visited domain. The search for doubly charged molecular anions by electron impact, or for excited states of singly charged anions by laser photodetachement, may bring some new insights, but breakthroughs are not expected.

Atomic weight determination is a metrology program continuing a long swedish tradition. The goal to reach 10^{-10} accuracy is worth the effort, since it addresses fundamental questions in physics. For example, in the future double beta-decay measurements, with more statistics and resolution, would benefit from better mass measurements.

The scientific productivity of MSL amounts to about 25 articles per year on average and has been more or less constant over the last 7 years, despite an increase of the number of users.

The organization

The management of MSL seems to be functioning well. However, although the scientific program is largely undertaken by external users, it appears to the Review Panel that MSL is more technology- than science-driven. This may explain why it has a rather limited number of users, and why most of the swedish users come from the local environment in Stockholm. The impression that the scientific user community plays a rather marginal role in setting the priorities at MSL was enhanced during the site visit, where references frequently were made to astrophysics and atmospheric chemistry without referring to strong user groups in these areas.

A troubling aspect of MSL´s present situation is its relationship with Stockholm university. Most serious is the fact that the university does not seem to have a long term strategic plan for science and technology in which the MSL has a key role to play. The university's host role appears limited to paying for the rent, electricity and water for a laboratory historically located on its campus. This is in sharp contrast to the situation at the other National Facilities which are locally viewed as important elements for the future strategic planning of the university/faculty. It appears symptomatic that when Stockholm consolidated its physics activities in a new center, MSL was left isolated in a corner of the campus. Despite the fact that some 25% of the researchers in the physics department have some research connections with MSL, the Review Panel was not presented with evidence of any attempt to initiate new links with other departments related to, for example, biophysics or atmospheric chemistry, other than a 1999 workshop at MSL.

The budget is extremely cost effective. However, the Panel had no detailed information about the financial support coming from the project grants of external user groups and this limits the present analysis. Furthermore, the technical staff appears barely sufficient to support the present operation of the CRYRING, some 1500 hours a year. Increase of the available beam-time by establishing steady weekend operation, as well as the construction of the double electrostatic ring DESIREE, appear to be out of reach within the present operating budget.

It is clear that MSL as an organization has strengths in various areas of accelerator physics including, magnet and beam optics design, electron cooling, EBIS and ECR ion sources. There is no doubt that the technical staff could contribute to a variety of accelerator-based projects at MSL or elsewhere.

The users´ perspective

The MSL serves the needs of a relatively small user community, about 150 users over 2 years, half of them coming from foreign laboratories. In 2001, 38 proposals were considered, including 25 from Stockholm university and 8 from foreign countries. The maximum oversubscription of beamtime amounts to a factor of 2 and concerns the ions in CRYRING. Concerning other experiments using ion sources, almost all applications are accommodated. This rather limited request for beam-time could be due to the fact that the users know that only a small number of experiments can be performed at the facility.

The CRYRING Program Advisory Committee, CPAC, gives advice to the MSL board on scientific matters. Its main task is annual evaluation of proposals for experiments following the MSL's published request for proposals. The proposals are examined by CPAC members and classified into three categories: first choice projects which get their allotted time as requested, high priority and medium priority, for which the allotted time is scaled down. Detailed reports from CPAC are available.

Importance of MSL for swedish R&D, industry and society

The reputation of MSL is based on its competence and experience in accelerator physics, and ion beam sources. This can be considered as a generic expertise of national importance. MSL has established a very good reputation as a result of several technical developments in the area of accelerator physics and related topics, which are of scientific and technical, rather than of industrial, relevance.

The electron cooler is a success and has been implemented in several other rings. This electron cooler, which is equipped with a superconducting magnet, has produced a reduced energy spread, down to about 1 meV. This has considerably increased the energy resolution achieved in dissociative recombination measurements.

The competence of the MSL staff on EBIS ion sources for production of ions with very high charged states originated from collaboration with the russian inventor in Dubna. The resulting expertise has developed strongly and is internationally highly appreciated today. A group from Brookhaven national laboratory (BNL) has been involved and several technicians and engineers from BNL (Relativistic heavy ion collider project) have been trained in MSL on the EBIS physics, practical design questions, special electronics, controls etc. – this collaboration is still extremely fruitful. MSL has been involved in the design and construction of an EBIS source at ISOLDE in CERN. MSL is considered one of the top EBIS laboratories in the world.

Concerning the activities in the field of the physical chemistry of the interstellar medium, the lack of a national coordination scheme such as that existing in France, that brings together astronomers and laboratory-based activities, has been recognized.

The preparation of a proposal for a light ion source for medical therapy in Sweden is underway with the initiative of the Karolinska Institute (KI) and the collaboration of MSL. The competence of MSL in accelerator design is of great importance here. The collaboration has already started in the form of student diploma in the area of magnet design and beam optics. A small symposium on Accelerators and instrumentation in medical physics was arranged in 1999 at MSL. The Review Panel considers this a positive initiative that could fit in a National accelerator physics program which also includes accelerators for medical applications.

MSL is part of the european network of Low energy ion facilities (LEIF) and one of the nine platforms producing low energy ion beams. Regular meetings and working visits are organized on technical topics only.

Future plans and budget considerations

MSL is preparing a proposal for an extension of the facility by building a Double electrostatic ion ring experiment, DESIREE, for studying ion-ion interactions. The laboratory strategic plan and how DESIREE could fit into a long-term vision of the laboratory did not become clear to us. It was difficult to establish whether this project and its specifications were derived from a scientific case, or if it was an extension of the ELISA design published in 1997, and then offered as an opportunity for local users. The Review Panel did not see evidence of a strong science case and recommends that such a case be prepared for a special review panel, before proceeding further.

An increase of the budget of MSL would help to improve the efficiency of the facility by increasing the running costs and enabling at least one additional operator needed for an increase of user beamtime to be employed, a scenario suggested by the CPAC. On the other hand, at present, the Panel does not consider the proposal for building DESIREE scientifically strong enough to justify increased funding.

A decrease of the budget would seriously jeopardize the normal operation of the laboratory. In such an event, the Panel recommends closing down of the facility.

Concluding remark

In an international comparison, MSL has evolved into a small size facility in atomic and molecular ion physics, with ongoing research conducted by external groups. Science at MSL has produced several highlights in electron – ion recombination studies, which take full advantage of the excellent performances of the ion storage ring CRYRING and EBIS ion sources. The laboratory is well recognized internationally for its scientific and technical achievements and capabilities. However, the rather limited scientific productivity of the laboratory and its modest impact as a facility for the swedish scientific community is also quite noticeable. The apparent isolation of the laboratory from Stockholm university severely weakens the future perspectives of MSL as a National Facility.

Recommendations

Although one could recommend specific steps to be taken for the future development of MSL as a National Facility on its own, the Review Panel sees a more viable future of MSL in the context of the proposed National accelerator physics program. The Review Panel therefore recommends that the intellectual and economic resources of MSL being prioritized and used for the establishment of the proposed National accelerator physics program as suggested under General recommendations. It is important that the host university takes an active part in the proposed process. The integration of prioritized activities at MSL into a National accelerator physics program will involve a transition period that needs to be carefully planned by the proposed Steering committee under the auspices of the Swedish research council.

The Onsala space observatory (OSO)

The facility

The Onsala space observatory has a long and distinguished history of excellence in radio astronomy, beginning with the pioneering initiatives of Olof Rydbeck in the late 1940s. The construction of the 25-metre and 20 metre radio telescopes have enabled swedish astronomers to undertake world class science in the areas of single-dish astronomy, in particular in millimetre line astronomy, and in (Very large baseline interferometry) VLBI as part of the European and world VLBI networks. Investment in advanced receiver technology has enabled these telescopes to maintain an outstanding track record, which has enabled Swedish radio astronomers to play a full role in the next generation of major international projects.

The Review Panel was impressed by the strong commitment of the Chalmers university of technology to the support of the OSO program. A number of members of the observatory hold positions at the university and the radio telescopes at the OSO are used remotely in the undergraduate teaching program. The receiver group is located within the new high technology facilities at the university and makes use of the new large clean room facilities. The OSO is now part of the Centre for the astronomical sciences within Chalmers university which spans the full range of activities from theoretical astrophysics and cosmology to astronomical instrumentation.

Millimetre astronomy will change dramatically over the next decade and it is important that the swedish astronomical community as a whole exploits the unique opportunities offered by the ALMA project. Likewise, there are great opportunities for technical contributions to the project and the astronomers and technologists at the Onsala observatory are in a very strong position to make a very significant impact in these areas. It is expected that the role of the observatory will evolve over this period and it is very important that this evolution involves the whole swedish astronomical community.

The goals of the Onsala observatory are to provide world-class observing facilities for swedish astronomers in the radio and millimetre wavebands. Following the renewal of the contract in 1999, the Review Panel notices that the goals set then have largely been met in a satisfactory way.

Astronomers at the OSO have made outstanding contributions to the ALMA project. They have played a full role in the choice of the Chajnantor site at 5,000 m in Chile for the ALMA array. Through the expertise of OSO, the ALMA project has adopted an ingenious spiral configuration for the telescopes which will allow the telescopes to be moved most efficiently in reconfiguring the array and which will enable the angular resolving power to be identical at different observing wavelengths. The receiver development carried out at the OSO has been outstanding and will be of real significance for the project.

A *Sputter facility* has been installed in the magnificent new clean room facilities at the Chalmers university of technology. The delay in installation is attributable to the time it has taken to complete the new clean room facilities, but it is now being actively used by the technologists of the OSO.

The completion of the *focal plane array* for the 20 metre telescope has been slightly delayed because of the problems of cross-talk between the multiple feed horns of the array. A significantly improved horn design has been adopted and the array receiver is now being commissioned.

A *bolometer array* has been successfully commissioned and is enabling very much more effective use of the SEST telescope to be made for the mapping of astronomical sources. These have included, for example, the possible detection of protostellar cores in nearby regions of star-formation. It has proved to be unnecessary to develop a nutating sub-reflector since the bolometer array can be used in an equally effective mode using the existing modes of observation of the telescope. The successful commissioning of the array on the SEST has resulted in a very significant increase in demand for observations with the SEST.

The new *S/X band receiver* for geodesy and astronomy has been successfully implemented for VLBI geodetic observations.

The ALMA program has not progressed as rapidly as expected in the 1999 contract. Instead, the OSO has participated in the development of a prototype 12-metre submillimetre telescope, the APEX telescope. This telescope, developed in collaboration with the MPIfRA in Bonn and ESO, will be moved to the Chajnantor site in 2002. Because of financial constraints, ESO and the OSO have had to bring forward the date at which operations funding will be transferred from the SEST to APEX, with the result that the SEST is faced with closure in 2003. The staff of the SEST in Chile have been fully involved in the site testing and site evaluation in Chile. We note with concern the difficulties which have led to the proposed closure of the SEST facility and comment upon these problems below. It is particularly distressing that this closure should be anticipated at the very time when the bolometer array on the SEST is making it a particularly attractive facility for swedish astronomers.

The staff at the OSO are to be congratulated on achieving their stated goals and going well beyond them in many respects. The result is that the OSO is in a strong position scientifically and technically to capitalise upon the opportunities offered by ALMA and VLBI, as well as continuing to exploit the opportunities offered by the 20-m and 25-m telescopes.

The OSO has maintained a successful program of observations in radio and millimetre astronomy for the swedish community of astronomers. Traditionally, there has been a bias towards the facilities being used primarily by the in-house astronomers at the OSO, but strenuous efforts have been made to involve the wider national and international community. This has been effective in millimetre astronomy, but to a much lesser extent in the area of VLBI which has a small user community in Sweden. Nonetheless, there is no question about the quality of the VLBI science being produced. These facilities are entirely appropriate for swedish astronomers and they have been used as effectively as has been allowed within the limits of a severely constrained budget. Technically, the performance of the National Facility is very commendable in terms of the amount of observing time made available to the community and the quality of the instrumentation provided. It will be noted below, however, that the operation is manned with the absolute minimum of staff and that telescope assistants have to be hired on an *ad hoc* basis to enable the telescopes to be operated 16 hours per day during the observing season.

The science

The quality of the work of the astronomers at the OSO was reviewed as part of the review of Swedish astronomy and astrophysics in 2000 and all the projects were very highly rated. The excellent scientific quality has been maintained in the intervening period. In the 2000 review, the following were identified as highlights of the program in which contributions were made at the frontiers of astronomy on a world-wide basis:

The study of chemical processes at large redshifts, the detection of atomic and molecular tori about active galactic nuclei, the demonstration that compact symmetric objects are young radio sources, the first detection of deuterated molecules in the Magellanic clouds, the discovery of new molecules detected in spectral scans of the Galactic centre, the detection of methanol masers in regions of star formation leading to the the first detection of a protostellar disc, the observation of circumstellar rings of SiO masers in evolved stars, the discovery of spherical shells of molecular gas about U Cam and TT

Cyg, observations of very cold gas clouds in the Boomerang nebula seen in absorption against the Cosmic microwave background radiation, the detection of CO from comet Hale-Bopp at more than 10 AU from the Sun. Many of these programs have been carried out in collaboration with other swedish and foreign astronomers.

The organization

The OSO is operated in a lean and effective manner. The effectiveness of the operation depends upon the enthusiasm of the staff who work long hours in support of the astronomy program. There have been three staff positions which have not been refilled in recent years because of the very significant impact of underfunding for the overall facility. It is of concern that the operation is at the limits of viability for the current services which it provides. We agree with the director that the current programme is being operated as leanly as is reasonable. Any further reductions in operations funding would seriously impact the availability of the facilities to the community. We particularly commend the director's wholehearted and dynamic leadership of the programme which is proactive and enthusiastic.

The operation of the OSO has been jeopardised by the budget constraints imposed upon the program. It is encouraging that the observatory has been able to win capital funding for new projects through organisations such as the Knut and Alice Wallenberg Foundation, but the problem of ongoing operations costs presents a real difficulty. There are two aspects to this problem. The first is the fact that the operations budget has remained static in SEK since 1997. Thus, in real terms, the funding of the observatory's program has been gradually eroded. A particularly serious problem was caused by the change in charging policy by ESO for the operation of the SEST telescope on La Silla. The result was that the OSO had to pay an additional infrastructure cost of 2.5 MSEK per year to maintain the operations of SEST in Chile. The additional payments for SEST had to be found by the OSO, without any compensation from the Swedish research council, undoubtedly placing considerable strain upon the operating budget.

The organisation has shown admirable flexibility in coping with the problems of operations cost identified above. It has also been proactive in grasping opportunities as they arise to expand the scope of the program. The use of global VLBI for the detection of plate movements in geophysics is admirable, as is the use of the GPS standards to enable movements within the plate on which

Sweden is located to be measured in both position and height to a fraction of a millimetre per year. These scientific endeavours have been funded without a significant impact upon the main program of the OSO. The same remarks apply to the aeronomy measurements conducted from the Onsala observatory. These measurements are of scientific importance, but are self-financing activities and match the observatory's expertise in millimetre-wave instrumentation.

Another important aspect of the observatory's role is in public outreach and public education. The visitor centre is a popular public attraction and the staff of the observatory are active in public education programs in the local region both in schools and in the public in general. The fascination of astronomy for young people is an important means of introducing them to the physical sciences and is an important contribution towards the development of a more scientifically literate society.

The users' perspective

The facilities have been used to full capacity within the constraints of the operations budget. There is a large involvement of the OSO staff in the observing program, largely reflecting the historical interests of the group. The national and international community are being well served by the OSO and we have found no evidence of discontent about the operations at either Onsala or La Silla. The recent oversubscription by a factor of 3 for the use of the SEST reflects the importance which the community attaches to the bolometer array camera. The importance of an instrument such as the bolometer array is that it makes the science of millimetre astronomy much more accessible to the community of astronomers at large and has been very widely welcomed. In practical terms, it makes the process of making observations in millimetre astronomy much more akin to the procedures in optical astronomy which are the main interests of some of the larger groups in Sweden.

We understand that the OSO uses well tried and tested procedures for the allocation of telescope time. The time allocation panels make every endeavour to include as wide a range of users as is feasible in the observing programs.

As the 2000 review of Astronomy and astrophysics in Sweden indicated, the OSO has a well deserved international reputation and the facilities have enabled many swedish astronomers to make forefront contributions to astronomical research. The facilities are therefore very competitive internationally. This has also placed the swedish astronomical community in a strong position to make a strong impact upon radio and millimetre astronomy in the ALMA era. We foresee that the OSO will have a key role to play in maintaining a strong presence for swedish astronomy on the international scene through the development and operational phase of the ALMA project.

Importance of OSO for swedish R&D, industry and society

The review of Astronomy and astrophysics in Sweden of 2000 gave many highlights of the program of the OSO which indicate that it is an international centre of excellence in millimetre astronomy. This conclusion was confirmed by the present review.

The OSO has a very good record of cooperating with swedish industry. Examples include the development of the ODIN spacecraft and its instrumentation, the development of the APEX prototype submillimetre telescope for Chajnantor, instrumentation for ESA programs such as the FIRST mission and the monitoring of the GPS satellite network.

The international community participates in all the major programs managed by the OSO. The SEST is jointly managed with ESO, as will be the APEX telescope which will soon be installed on Chajnantor. The program of VLBI is necessarily an international program, and for high frequency observations the location in Sweden provides important baselines which enable excellent coverage of the UV plane to be obtained.

One of the great strengths of the OSO's program has been its receiver technology program. The OSO has gained a world-wide reputation in millimetre receiver technology. Recent successes have included the construction of a millimetre receiver for the ODIN satellite. At present, receivers are being developed in the context of the ALMA project. Although a small group, this activity, which is strongly supported by the Chalmers university of technology, gives Sweden an important international role in advanced receiver technology.

Future plans and budget considerations

The continued operation of the OSO as a national and international facility for radio and millimetre astronomy formed the core of the future plan. It also involves the following new programs:

- Real-time VLBI with the expanded European VLBI Network

- Full involvement in the development of ALMA and acting as a national support centre for ALMA.
- Exploitation of APEX up to the highest observable frequencies of about 1.5 THz.
- Involvement in the ESA Herschel-FIRST space observatory for far infrared wavelengths, specifically the quasi-optics beam alignment system, now being constructed at the Chalmers university of technology.

Other programs are further in the future and would involve participation in:

- The STEAM project, the follow-on mission from ODIN.
- The MAMBO project, the French Mars orbiter.
- Participation in the square kilometre array telescope project.

The Review Panel agrees that this represents a natural projection of the current program into the future and offers excellent opportunities for the swedish astronomical community.

The director had a clear list of priorities if extra resource became available. These were:

- Locally: three more science/engineering positions. These include an astronomer, a geoscientist and a microwave engineer. Funding for 3 to 4 more research students would also be prioritized.
- Internationally: Real-time link to international research networks which would allow real-time VLBI, participation in the e-grid and access to the virtual observatory.
- A 60% increase in funding of the JIVE program for European VLBI.
- Clear funding for APEX receiver technology and operations. Already 6.5M SEK has been received from the Wallenberg Foundation for receiver technology, but a further roughly 13 MSEK is required to complete the program.
- A small budget for new projects.

The Review Panel fully recognizes the need to strengthen the budget of OSO but makes the important point that an increased allocation of funds should be linked to the role of OSO within a National strategic plan for swedish astronomy (see below). Because of financial constraints, ESO will withdraw the operational support for the SEST in 2003, and the director has made efforts to find alternative partners in the project to enable operations to continue. The issue of a continued operation of the SEST needs to be considered urgently in the context of the proposed national plan for astronomy.

Because of the tightness of the budget, the director was not able to identify any savings which could be made within the present program. Any savings would have to be at the expense of staff costs which would necesssarily mean reduction in the scope of the programme. This would undoubtedly cause major damage to the program.

As mentioned in Recommendations, page 13, the Review Panel identifies the need for a strategic plan for astronomy in Sweden. The Panel urges the Swedish research council to take a leading role in initiating the development of such a strategic plan to clarify the role which the OSO might play in the future development of the swedish astronomy program.

One important element in such a strategic plan would be to define the role of OSO as a National astronomy technology centre. It currently carries out that role in radio and millimetre astronomy, but it could take on a broader role in the support of optical and infrared instrumentation as well. There are several considerations which should inform that discussion. These should include the importance of maintaining an instrumentation capability within Sweden for all the wavebands in which swedish astronomers wish to participate in internationally so that they can exercise greater leverage upon the design of the future projects and also gain strategic advantages during the construction and operational phases. It should also consider whether or not there is a need for a national support centre for the use of international facilities abroad.

Concluding remarks

The Onsala space observatory is an excellent organization, well run by a dedicated team of enthusiastic astronomers and support staff. Like the other facilities we visited, the program is seriously underfunded and we concur with the director's proposals for enhancement of the support to enable the investments in the facilities to be realized.

Recommendations

The Observatory has an exciting menu of future programs and we can strongly endorse this program. We suggest that these proposals should be considered in the context of a National strategic plan for swedish astronomy, which we strongly recommend should be a priority for the swedish astronomical community. As part of that review, we suggest that consideration should be given to the possibility that the OSO becomes an Astronomical technology facility for a broader range of astronomical technological programs, including the optical and infrared wavebands. The Review Panel suggests the establishment of a National astronomy advisory panel within the Swedish research council to enable coherent discussion of national priorities within the context of the strategic plan for astronomy as a whole to take place.

MAX laboratory (MAX-lab)

The facility

The MAX-lab has a clear mission as the swedish national synchrotron radiation light source, serving a large, dynamic, and growing community in the fields of physics, materials science, chemistry, and biology. It stands out among the four National Facilities as a source of basic infrastructure support for swedish science and technology broadly defined.

Over the last 20 years, the MAX-lab has evolved from a small accelerator facility for use in solid state and nuclear physics into a laboratory of EU Large scale facility status serving a rapidly increasing user community of currently 600 scientists in various fields of science, and from many different universities in Sweden and abroad. The output of the laboratory in terms of publications and conference presentations with high scientific impact, as well as in terms of PhDs clearly demonstrates that it is a very successful operation.

This development has been made possible by ingenious and creative contributions of a dedicated staff, by the strong engagement of highly competent user groups from almost all swedish universities, and by the recognition of the accomplishments and new opportunities of MAX-lab by the scientific community in Sweden as a whole.

The laboratory has become the centre of a very effective network, stimulating communication and exchange between swedish scientists from many different disciplines in an international context. Making use of the new opportunities offered by superconducting wigglers in MAX II, the laboratory widened its scope significantly and now includes new forefront activities in materials science and structural biology. MAX III will improve in a very cost efficient way the capabilities of the laboratory for its core activities in spectroscopy, which are of crucial importance for the rapidly growing nano-scale research. The new opportunities for soft X-ray inelastic scattering experiments are of special interest. The new protein crystallography beamlines at MAX-lab guarantee the strong swedish molecular-biology community easy access to state of the art equipment for high-throughput structure determination, which is a prerequisite for competitiveness in structural genomics and proteomics work.

The opportunities offered by MAX-lab are complementary to those of the European synchrotron radiation facility, ESRF, in Grenoble, France. The strong involvement of finnish and danish scientists in design and construction of new beamlines at MAX-lab demonstrate the importance of the laboratory on the scandinavian scale.

MAX-lab gained a very high reputation worldwide for its foresight by careful planning the radiation sources, the beamlines and the instrumentation together with highly competent user groups. As a result, the laboratory could offer novel instrumentation for cutting edge research in emerging fields of science in a timely fashion.

The laboratory has largely met the goals set out in 1999 and has received very strong support from its user community. If milestones had to be rescheduled because of technical problems or lack of resources it was intensively discussed with the user community. The laboratory has been very successful in attracting outstanding scientists from Sweden and abroad to serve on its scientific advisory committee and its two program advisory committees, which follow the activities at MAX-lab very closely.

MAX-lab is a first class 3rd generation synchrotron radiation facility serving fields of science where the swedish community performs at its best. The laboratory and its user community are very innovative in science driven planning of future equipment for cutting edge research. The scale and the cost of the facility fits well the swedish and scandinavian boundary conditions. If the laboratory's plans for increasing the number of beamlines and insertion devices at MAX II and MAX III are pursued, the overall efficiency of the operation of the laboratory, its scope and its impact on swedish and scandinavian science will increase significantly.

The science

Synchrotron radiation has a very strong impact in several fields of science, including atomic, molecular and cluster physics, surface and interface physics, nanoscience, the physics and chemistry of materials with novel properties and fast chemistry and structural biology. In continuation of the Uppsala tradition, MAX-lab gained an outstanding reputation in the high resolution photoelectron spectroscopy of atoms, molecules and surfaces. The studies of fs-dynamics by internal clocks, of metal quantum wells, of high temperature superconductors, of adsorbates and liquids gained special attention worldwide. Soft X-ray fluorescence spectroscopy of molecules, surfaces, interfaces and liquids is another outstanding research activity at MAX-lab. Concerning future trends, X-ray crystallography on biological macromolecules should especially be mentioned because over the last 10 years it changed from a rather esoteric approach to an indispensable tool in structural biology and brings a very large user community to the synchrotron radiation facilities world wide.

The synchrotron radiation research at MAX-lab compares very well with that at the world's most advanced synchrotron radiation facilities. As examples for the very high quality of this research three recently achieved results can be mentioned:

- An X-ray diffraction study on the catalytic pathway of horseradish peroxidase (HRP) at high resolution. Preserved redox states for all five oxidation states of HRP could be shown for the first time.
- Soft X-ray absorption and emission studies of solid and liquid water, using a novel method of studying liquids in vacuum, which provided new information on the electronic structure and hydrogen bonding in condensed water.
- A valence photoemission and X-ray emission study of the superconducting fulleride, K3C60, which provided new insight into the formation of the spectral features involving different bulk and surface components.

The nuclear physics effort at MAX-lab is a small, quite highly focused activity that stresses low energy, high resolution tagged photoproduction from protons and light nuclei. Recent successes include high resolution studies of nuclear energy levels populated in (γ,p) and (γ,n) reactions, a high precision measurement of the neutron electric and magnetic polarizabilities, and a study of specific levels in ^{14}N populated via the $^{16}O(\gamma,np)^{14}N$ reaction. The future program plans to take advantage of an energy upgrade to 250 MeV, and includes studies of pions in nuclei and photodissociation of ^{3}He. The former is said to provide information about chiral dynamics in QCD and the latter to probe models of three body nuclear forces. There are many other low energy electron and photon scattering facilities in the world, but none at present has so low an energy and so good a resolution. High resolution indeed gives MAX-lab a niche within the international nuclear physics program. Nevertheless, the questions being studied at this facility are not at the forefront of nuclear physics: Nuclear energy level studies and pion production in nuclei are mature fields that have not been related to more fundamental issues. The same can be said of chiral dynamics in *nuclei*, as opposed to isolated nucleons. These physics opportunities would not justify a stand-alone program or commitment of significant new resources. However, in light of its small marginal cost the present program should be completed.

Innovative accelerator research leading to the development of new storage ring components like Landau cavities and multi-function magnets, and the very cost efficient construction of the storage rings and the insertion devices at MAX-lab are the bases for the success of the laboratory.

The organization

The organisation of the MAX-lab is quite similar to that of national synchrotron radiation facilities in other countries. The intense cooperation between the management, the laboratory's Science and program advisory committees, and the very active user organisation is characteristic for a facility strongly driven by user demands. The user community and the staff include a large number of outstanding scientists with a strong science program. The management is to be congratulated for balancing successfully the different user interests so far.

However, the situation will become more difficult in the very near future because the strong user groups feel the current shortage of PhD students in physics and have to cut back their traditionally very efficient support of other user groups. This shortage in experienced manpower also leads to a slowing down of the installation of new instruments, a field where MAX-lab is still at the forefront but could lose this leading position if no additional staff is provided. Additional efforts will also be needed to incorporate the new users from the fields of structural biology and material sciences, which are used to a quite different scientific environment and culture in their home laboratories. Unfortunately, the leadership of the laboratory is currently overwhelmed with day-to-day operations due to this very difficult funding situation.

The organisation and the management of MAX-lab have demonstrated admirable flexibility in dealing with new developments and in adapting the laboratory's goals appropriately. This is especially true for the accelerator and beamline activities. The organisation fits the current needs of the facility very well. On the other hand it would be good for the laboratory if the leading scientists in charge could find more time for their own research, for teaching at their university and for strategic planning of the future of the laboratory and of synchrotron radiation research in Sweden as a whole.

In the past, most of the MAX-lab users came from physics and chemistry university departments which have built up experience in building and operating synchrotron radiation beamlines and instruments over the years, and the users transferred this know-how to the new students and users of their equipment. The host group was also motivated to introduce new groups because of common scientific interests. Worldwide this situation has changed in two respects:

A) The insertion device synchrotron radiation sources, the beamlines and the instruments, as well as the interplay of all these components have reached a new level of sophistication. For adequate use of such instrumentation highly qualified staff with permanent contracts is needed at the beamline in order to support the users professionally and to accumulate experience on site. MAX-lab should present a list of this additional personnel needed.

B) The number of MAX-lab users increased strongly in the past and will increase even more strongly in the coming years because of the new hard X-ray experimental stations in protein crystallography and materials science. Here the beamtime needed to complete an experiment is in general much shorter than in spectroscopic work. However, the users from structural biology in particular are not trained in operating sophisticated instrumentation; coming from an environment where commercial apparatus is used in general. Because of the priorities in structural biology research these users are in general even not interested to learn how to operate a beamline. With 5 new crystallography beamlines under construction at MAX-lab it is urgent for the laboratory to work out a plan for the operation of these instruments for the new type of users and to present the needs to the funding agencies. In this context the resources needed for automating the use of the beamline as much as possible should also be presented.

It is very difficult to compare the budget of a Swedish National Facility with that of similar facilities abroad, because of the mixed funding by different institutions and because of what the Review Panel called the "shadow economy" in the swedish system. Nevertheless, one may refer to the budget of BESSY II in Berlin, Germany, which is a 1.7 GeV 3rd generation storage ring for a similar spectral range to that provided by the MAX-lab. By the end of 2001, BESSY II operated 16 bending magnet beamlines and 10 insertion devices serving 19 beamlines. By the end of 2003 BESSY II will operate 23 bending magnet beamlines and 14 insertion devices serving 24 beamlines. The total budget of BESSY in 2002 amounts to about 200 MSEK. Subtracting from this number the partial budgets for infrastructure, administration, part of the operations cost of the accelerator and funding of new scientific equipment, which in Sweden comes from the host university and private foundations, about 100 MSEK remain for the comparable part of the BESSY budget, that is, about twice the visible budget of MAX-lab.

Strong leadership will be needed to develop a vision for the future of MAX-lab as a National Facility in programmatic terms. The laboratory is blessed with truly imaginative accelerator physicists who should be planning strategically to stay at the forefront of synchrotron radiation research. However, there can be no doubt that the budget of MAX-lab has to be increased substantially if the laboratory is expected to make best use of its potential and to stay at the forefront of synchrotron radiation research for the benefit of swedish research.

The Review Panel notices that the MAX-lab has the healthiest relationship with its host university among the four National Facilities. The vice-chancellor of Lund university clearly articulated the important place the laboratory has in the university's research and teaching agenda. The laboratory is well sited on the university's campus. Many laboratory researchers have university appointments. Many students work at the laboratory. Lund has been particularly far sighted in establishing chairs in accelerator physics, synchrotron radiation research, and synchrotron radiation instrumentation. The university sees facilitating world class research at MAX-lab as part of its fundamental research profile. One could hardly ask for a more positive relationship between a laboratory and its host university.

The users' perspective

There are users from 28 countries. About 55% of the users are from Sweden and 45% are from other countries. The swedish users are well distributed over the nation. All project proposals are treated equally on scientific merits by the Program advisory committee composed of very prominent scientists from Sweden and abroad. There is no distinction made in the allocation of beamtime for international, national, or local users.

The current management approach to aim for the most general consensus among the users and the laboratory seems to be very much appreciated by the MAX-lab user community. The laboratory makes all efforts to provide competent and efficient user support within the quite limited number of personnel. The situation is however becoming more and more difficult to sustain for the reasons mentioned above under The organization, page 39. Clearly, additional funds are needed to serve a growing user community composed of more and more inexperienced users of more and more complex instrumentation.

Importance for swedish R&D, industry and society

As mentioned above, MAX-lab is blessed with truly imaginative accelerator physicists who impress the world by their far – sighted planning of new components of the facility and the cost efficient realisation of these projects. This group is a most valuable resource for swedish science and technology with a very large potential for innovations in key technologies in a rapidly growing field of science with exciting perspectives for the future.

In Sweden there is a strong tradition of long term development of novel instruments within the physics departments of the universities. Through the collaboration between MAX-lab and the user groups, this tradition has been maintained in the development of the high-resolution photoelectron spectrometers and soft X-ray fluorescence spectrometers which are now manufactured and sold by commercial companies, for example, Scienta.

Fields of application-oriented research are, for example, surface and polymer studies, as well as a large fraction of the activities in protein crystallography. Thin polymer films are promising candidates for flat organic displays (Agfa). There is also interest in polymer films by the printing industry (TetraPac, swedish paper industry), and the strong interest of the swedish pharmaceutical industry in the emerging bio-structural research at MAX-lab is already visible.

MAX-lab is a centre of excellence tightly interwoven within the international network of sciences. It is recognised as a european large scale facility by the European union providing financial support for non-swedish users and is a highly esteemed member of the EU Round table for synchrotron radiation research and free-electron lasers. For swedish students and young scientists MAX-lab offers the invaluable possibility to take part in cutting edge science performed by international research teams. Of equal importance is the growing fertilization of interdisciplinary research brought about by the activities at MAX-lab. The laboratory acts as a very effective stimulus for swedish science.

MAX-lab is well positioned in the Copenhagen-Malmö region, one of the areas of strong economic growth in Europe. In this region there is also a considerable concentration of research laboratories and universities. Recently, the danish-swedish collaboration in synchrotron radiation research has been increased significantly with the construction of the structural biology beamlines in a collaboration between MAX-lab and the University of Copenhagen, but there is also a long lasting engagement of finnish research groups at MAX-lab who contributed substantially to the existing beamlines. The Lund campus has been suggested recently as the site of the European neutron spallation source ESS. If this project were to be realised, the Copenhagen-Malmö region would become a first rank european research area including MAX-lab.

Future plans and budget considerations

As detailed in the background material provided by the MAX-lab to the Review Panel, and in consensus with the user community, the laboratory has worked out a clear vision for a very attractive science program for the next 3 years.

This has resulted in a convincing plan for the installation of new beamlines and instruments, both at MAX II and MAX III. Here one should realise that the 700 MeV MAX III storage fills a gap in the spectral distribution of the synchrotron radiation available to users today. Because all new machines aim at reaching harder X-rays, mainly because of the needs of structural biology, the brilliance in the very soft part of the spectrum is far from optimal. This is unfortunate because the spectroscopy and spectro-microscopy techniques making use of this spectral range gain rapidly in importance for nano-scale science and technology, as well as for calibration purposes. In Germany the Physikalisch-Technische Bundesanstalt PTB just decided to build a low energy storage ring for this spectral range on the BESSY campus in Berlin.

With new superconducting insertion devices and more beamlines MAX II will play an increasingly important role for materials sciences and structural biology in Scandinavia. MAX-lab is just entering the domain of hard X-ray research and therefore the somewhat prudent approach for deciding on new X-ray beamlines at MAX II is understandable. The management seems to expect this user community to build up its strengths and to push for novel beamlines and instrumentation which will then be strongly supported by the laboratory.

MAX-lab bases its long term future on the construction of the 3 GeV MAX IV storage ring, which should provide high brilliance radiation over a wide spectral range by pushing the storage ring and insertion device technologies to their limits. Concepts of this kind are fully supported by the synchrotron user communities in all countries because novel facilities like Linac driven free-electron lasers will not replace the storage rings as versatile sources of high brilliance X-ray beams with applications in many different fields of science and an increasing user community. Nevertheless, the concepts of Linac driven light sources providing fsec pulses of highly coherent X-rays with peak brilliances almost 10 orders of magnitude higher than available today, which are pursued at a number of accelerator laboratories in Europe, the USA and Japan, are fascinating. It is planned to incorporate this new technology in the injector of MAX IV.

Full energy injection at 3 GeV is proposed for the MAX IV storage ring. The injector itself is a most challenging combination of concepts which needs extensive R&D before a solid proposal for the construction of such a facility can be made. It was made very clear to the Review Panel that the ideas presented in the background material are at present mainly used to define the most important research issues for the accelerator physics at MAX-lab. A grant proposal has been submitted to the Knut & Alice Wallenberg Foundation to finance these research projects as well as to finance the work to produce a design report for MAX IV.

Clearly, MAX-lab needs a substantial increase of funding. Without an increase of the operational budget of the MAX-lab, even today's activities would have to be reduced substantially by closing excellent beamlines, slowing down the instrumentation of the MAX III storage ring currently under construction and stopping even conceptual R&D for the future development of the facility.

Just to maintain the current level of user support and operation of MAX-lab, the annual institutional funding has to be increased by at least 6.5 MSEK (5 MSEK to match the funds from the SSF foundation, and about 1.5 MSEK from the STINT postdoc program). However, because state of the art beamlines have reached a new level of sophistication and need more expert beamline scientists at the facility in order to make best possible use of the equipment, the operational budget of MAX-lab should be increased even more.

It is recommended that the approved and partly funded new beamlines at MAX II and MAX III should be built without delay. MAX-lab should present to the funding agencies, including the private foundations, a detailed survey of the technical and scientific staff needed for operation of the enlarged facility in the medium and long term.

With 5 new crystallography beamlines under construction at MAX-lab it is urgent for the laboratory to work out a plan for the operation of these instruments for the new type of users and to present their needs to the funding agencies. In this context the resources needed for automating the use of the beamlines as much as possible should also be presented. Referring to recent developments in the US, where the NIH provides substantial funds for building and operating beamlines for structural biology at existing facilities and even for building new synchrotron radiation facilities with a strong program in the life sciences, the Review Panel recommends that ways should be investigated for getting the biology community directly involved in funding the infrastructure at the large scale facilities needed for their work. Protein crystallography is an example where synchrotron radiation is indispensable for cutting edge research.

With a reduced budget, Sweden would not be able to exploit the excellent opportunities that MAX-lab offers for science and technology. The instrumentation, both for MAX II and MAX III, would fall behind the minimum speed necessary for staying competitive in a scientific environment, which is characterized by new facilities such as the Swiss light source, which just became operational, and SOLEIL and DIAMOND under construction in France and the UK. Spain has decided to build a similar facility in the very near future and at DESY in Hamburg plans for an upgrade of the PETRA storage ring to a 3rd generation synchrotron radiation light source with beam qualities exceeding those available at the ESRF today are being pursued. With a reduced budget, the MAX-lab user community would loose confidence in the future of the laboratory, the user support by external groups would break down and there would be no alternative to closing down so many beamlines that the overall operation of the laboratory would no longer be justified.

As a whole, the MAX IV project is very exciting and technically most challenging. As such it could be one important core component in the formation of a National accelerator physics program, as suggested in the Recommendations (3.3) of this report. Driving the storage ring and insertion device technologies to the limits and building and operating Linac based light sources is the vision for X-ray sciences as seen by most people in the field. Strong synergies between the very large communities in synchrotron radiation and laser research are expected. In conclusion, electron beam physics with exciting perspectives for novel X-rays sources, as well as for linear colliders for particle physics, together with studying new concepts for the production of coherent short-pulse X-ray beams of extremely high peak brilliance, such as cascaded optical klystrons, energy recovery systems using superconducting Linacs, or free-electron lasers based on the principle of self amplified spontaneous emission, could become the goal of a National accelerator physics program.

Concluding remarks

The MAX-lab has a clear mission as the swedish national synchrotron radiation light source, serving a large, dynamic, and growing community in the fields of physics, materials science, chemistry, and biology. It stands out among the four National Facilities as a source of basic infrastructure support for swedish science and technology broadly defined. Its success is based on first class accelerator science and highly innovative, science driven instrumentation developed collaboratively with outstanding university groups. Worldwide, MAX-lab is recognized as one of the leading synchrotron radiation facilities producing first class science and is top in its core activities in spectroscopy.

Recommendations

The ongoing activities at the MAX-lab are vital and essential for swedish science and technology and the very competitive and challenging plans presented to the Review Panel are fully endorsed. Clearly, in order to maintain this position of an internationally leading synchrotron radiation organisation pursuing first class research, the funding has to be increased substantially. Without additional funding, including support for future accelerators, the laboratory will decline rapidly in its international standing. Furthermore, the Review Panel suggests that the program for the future development of MAX IV should be part of the proposed National accelerator physics program which capitalises upon the outstanding expertise of MAX-lab, MSL and TSL, together with their host universities. It is recommended that the Swedish research council takes immediate steps to initiate the development of such a concerted, national effort.

The The Svedberg laboratory (TSL)

The facility

The mission of TSL is to support and perform accelerator based research in nuclear and particle physics as a resource to the swedish and international communities. TSL provides a variety of particle beams from the cyclotron and in the CELSIUS accelerator/storage ring, as well as a number of experimental areas and detectors. Existing beams include:

- Protons from 20 MeV to 1.36 GeV
- Light ions up to 470 MeV/nucleon
- Heavy ions up to 8 MeV/nucleon
- Mono-energetic neutron beam from 20 to 180 MeV

Electron-cooled ion beams are available in CELSIUS with momentum resolution 10^{-4} to 10^{-5}. An energy upgrade is planned for CELSIUS, which would bring its maximum proton energy up to 1.95 GeV and its maximum light ion energy up to 700 MeV/nucleon. Experimental facilities and detectors at TSL include:

- A hydrogen pellet target and a cluster jet target in the CELSIUS ring.
- The WASA detector, a 4π spectrometer surrounding the pellet target. Its main detector components are a straw tube tracker inside a thin (0.18 X_0) superconducting solenoid and a segmented CsI (Na) calorimeter.
- The CHICSi detector at the cluster jet target. CHICSi is a highly segmented, compact Si- and GSO-based detector system with particle ID for hadrons and fragments down to very low energies.
- A neutron beam facility for interdisciplinary research.
- A proton beam facility for treatment of tumors in the head-neck region and of arterioveinous malfunctions.
- Heavy ion irradiation equipment for interdisciplinary research.

The array of facilities available at TSL is broad and impressive. Some of the instrumentation is at or near the state of the art; some is older, but in general everything appears to be well maintained and operated. The facility shows a high level of competence in accelerator and detector physics.

As stated in the contract between TSL and the Swedish research council, the main performance goals for the past several years were motivated by the rare η-decay program and therefore focused on the CELSIUS ring and the WASA detector. Completion of the target and detector for full meson yield and preparation for rare η-decay studies were expected in Autumn 2000; dedicated runs for η-decay measurements were planned for 2001.

Other goals for TSL included:

- Installation of the CHICSi detector (2000) and system test (2001)
- Neutron elastic scattering experiments (2000–2002)
- A broadband proton beam for treatment of patients (2000)

The WASA/Pellet Target program is making progress but has missed its projected goals. The detector is complete, although completion was delayed. The delay appears to be due to electronics – planned electronics were replaced with recycled/borrowed equipment because of the cost – and the pellet target, which took longer than expected to operate stably. The pellet target is still not operating at its design specifications; the average pellet diameter is 37 µm (25 µm desired) and the number of pellets/sec is 5000 –10000 (20000 desired). Nevertheless, it is capable of delivering reasonable luminosity now and is likely to do better in time. A pellet target test station will be constructed later this year at a cost of 800 kSEK to enable further development and improvement without compromising CELSIUS/WASA operations.

Current goals for the rare η decay project were not presented clearly to the Review panel, so it was impossible to judge how well this key program is doing. As best we were able to determine through discussion with experimenters, the rare η-decay program is now expected to start in the autumn of 2002 at a luminosity of about $10^{31}cm^{-2}sec^{-1}$. Measurements of the 3π, single Dalitz, $\eta \to \pi^+\pi^- e^+e^-$, $\eta \to \pi^+\pi^-\gamma$, and double Dalitz decay modes of the η are foreseen for this first run. An initial run could yield branching ratio sensitivity in the range 10^{-5} – 10^{-6}. Sensitivity that would be significant for the $\pi^\circ e^+e^-$ mode (10^{-8} to 10^{-9}) is expected to be achieved in 2 to 3 years. We could not judge the accuracy of this projection. In any case this is a significant postponement of projected goals. Although the KLOE detector at DAϕNE is running and has recorded $\sim 10^7$ decays, there is not much concern about being “scooped,” because KLOE apparently has less resolution in the e^+e^- channel.

In the CHICSi program about 500 detector telescopes are mounted and data has been taken with a part of the detector. Target and projectile fragmentation region detectors have been installed.

Neutron beams were supplied to a number of users for dosimetry, single event upset, and cross section measurements.

The broadband beam for proton therapy and the facility for the treatment of supine patients is not ready. Again, progress is being made on these goals but they were not met on time.

The science

The scientific program of the TSL programs spans a considerable range of important scientific topics. The WASA rare η-decay program is generally considered to be of high scientific value. In particular, observation of a non-zero branching ratio for $\eta \rightarrow \pi^{\circ} e^{+} e^{-}$ would be extremely interesting. At the other extreme, the ongoing program of low energy meson production studies was judged to have no clear objective and we could not see any potential for it to lead to new understanding of nuclear or sub-nuclear physics.

The rare η-decay project lies at the core of TSL's physics program for the next several years. If recent performance is an accurate indication, further delays can be expected. It was not at all clear that the goal of providing a significant limit on, or measurement of, the rare CP violating decay, $\eta \rightarrow \pi^{\circ} e^{+} e^{-}$, is realistic or that the laboratory management has developed a practical plan to reach it. A full technical review of this aspect of the TSL program seems necessary before proceeding further.

A program in low energy neutron scattering, neutron induced fission, and neutron irratiation studies is carried out at the 20–180 MeV quasi-monoenergetic neutron beam facility.

The low energy heavy ion work at CHICSi addresses interesting questions concerning the nuclear equation of state at low temperature and density. Some of these issues are being addressed at other laboratories with similar capabilities. On its own, the heavy ion program would not warrant the continued funding of TSL. The medical (proton therapy), material science (ion track technology) and other interdisciplinary research and development programs at TSL certainly enhance the core program. The people running these programs at TSL are active, energetic researchers and they represent an important potential aspect of the laboratory's future development. However, at present, the interdisciplinary programs are not ambitious or extensive enough to assume a central role in TSL's research program.

The scientific productivity of the laboratory appears stable over time.

The organization

The management organization at TSL appeared to be weak in the area of scientific direction. The laboratory management did not show the Review Panel that it had a clear vision of the relative importance of the different elements of its program. For example, at the review roughly equal time was devoted to the rare η-decay program and to the nuclear meson production experiments. There was no presentation describing the pathway which would lead to a significant limit on the CP violating decay. Since TSL is seeking to serve swedish science under severe funding constraints, it is important that the quality of the science be carefully scrutinized and resources allocated according to priority. By exercising greater scientific leadership in prioritizing its program the laboratory management could better optimize the scientific impact of its limited resources.

As mentioned above, the reasons why certain parts of the program failed to meet previously projected goals was not easy for the Review Panel to ascertain. Also the laboratory management did not demonstrate that it had recognized and dealt with these issues, whatever they were, in an organized and effective way. In the future, the laboratory leadership must take a stronger role in program management. This can be done with:

- Timely and proactive attention to the milestones and goals of the scientific program;
- Prioritizing of the research program and application of TSL resources to problem areas in a way that respects those priorities.

The staff headcount is about 50. It is a lean and efficient staff; there is little redundancy and there is some dependence on the users' participation in operations. The organization of the staff appears to meet the needs of the laboratory and its users. The technical and administrative functions are well executed. As indicated above, however, the evaluation team judged that the organization should take a stronger hand in the management of the scientific program.

As with all the Swedish National Facilities evaluated in this report, the TSL organization is extremely cost effective. The staff is expert and experienced; it accomplishes a lot on a very tight budget.

During the site visit, the evaluation team had the opportunity to interact with many scientists on the TSL staff, as well as Uppsala faculty members and other users. Although we did not hear explicitly about plans for future staff development, it was clear that there are several strong younger scientists, who could play a role in the future leadership of TSL.

The users' perspective

There are about 400 users of the TSL which represents an increase by about 30 % since the 1997 evaluation. The main part of this increase comes from the international user community, which contributes almost 60 % of the number of users. The fraction of national users stayed almost constant.

The TSL has developed sufficient infra-structure for supporting the user groups logistically as well as technically. The group of users has representatives in a local advisory committee which provides the laboratory management with advice on personnel and administrative matters.

The PAC, which is appointed by the Uppsala university and consists of prominent national and international scientists, allocates beam time solely according to scientific quality and technical feasibility. It also serves as an advisory committee on short, medium and long term perspectives.

The day of presentations ended with an open discussion of priorities and plans. This involved university and laboratory management, staff and users, as well as the Review Panel. It seemed to the panel that there were appropriate open channels among the principals that would allow for a critical evaluation of the future program of TSL.

Importance for swedish R&D, industry and society

As indicated above, TSL is the home of important modern skills in accelerator and detector development. TSL is also providing resources to research and development efforts in areas other than nuclear and particle physics. These skills and resources are the basis for TSL's future development.

The The Svedberg laboratory has the necessary resources to provide infrastructure support to sweden's nuclear and particle physics communities in their international endeavors in Europe and the USA. TSL has instrumentation development expertise and particle beams that are capable of supporting these activities at forefront levels. One area in which this is currently taking place is in the use of neutron beams to study the radiation hardness of detectors in the ATLAS experiment at CERN. Another area in which TSL technical expertise can couple to international research activities is the pellet target development. There is interest in the target technology at GSI and Jülich. Yet another is in the development of superconducting solenoids – a TSL student who worked on the development of the thin solenoid coil for WASA now has major responsibility for the ATLAS solenoid at the LHC facility at CERN.

Other opportunities may exist, but the evaluation team did not hear about them during the site visit. It was clear to the evaluation team that even after CELSIUS has completed the compelling aspects of its experimental program, TSL could contribute to swedish nuclear and particle physics at the international level as an infrastructure support laboratory, as many other laboratories in Europe and the US have done in the past.

The WASA and CHICSi experiments and the support of interdisciplinary research indicate that TSL can develop, implement, install and operate modern detectors for nuclear and particle physics. These skills constitute a major resource that could define TSL's international role.

The small, but intense interdisciplinary programs in material and bio-medical physics have attracted important industrial partners.

Future plans and budget considerations

The performance on past benchmarks and the presentation of future goals contributed to the somewhat disturbing impression that there is within TSL an aversion to thinking about the longer-term future of the laboratory. The laboratory views itself as mainly a nuclear and particle physics laboratory with some secondary applications-related work. The Review Panel doubts that this is a good model for the future. In any event, the laboratory's vision must be subjected to critical self-assessment and to strategic thinking in the context of the future of swedish science. We saw little evidence that this critical responsibility of top management is getting appropriate attention. This may be due in part to the press of more immediate concerns, the constraints of underfunding, and the shortage of qualified staff. Nevertheless, it is a serious concern for the future viability of TSL. The Review Panel, however, noticed that steps have been taken by the vice-chancellor and the faculty to make long term plans for accelerator physics and accelerator based research.

The The Svedberg laboratory users' and management's plans for the short to medium future include the completion of the Celsius/WASA project, continued low energy nuclear and heavy ion experiments, and continued development of the materials characterization and medical programs. The Review Panel was not presented with longer range plans. The panel's own thoughts about the possible role of TSL in a National accelerator physics program are described elsewhere in this report. If Sweden does not decide to integrate its many activities in accelerator and detector physics, then it is difficult to see a long term future for TSL.

TSL's operating budget is about 42 MSEK/year at present, with roughly half of this coming from the Swedish research council. Additional funds would make needed additional running time available, would allow faster progress on development projects and would probably give management the luxury of more time to think strategically about the laboratory's future. Any significant reduction would result in the loss of essential staff and services. This in turn would compromise the present mission.

Concluding remarks

At TSL we found a laboratory consumed with short term problems. It is struggling to keep its flagship program moving forward in the face of funding shortages that have required descoping and detector and beam development problems that have delayed the project. Other activities range from interesting work on the nuclear equation of state, through valuable programs in material characterization and medical physics, to relatively low priority work on meson production in nuclei. The laboratory seems to be blessed with a strong group of accelerator and detector physicists who have developed interesting new technologies including the pellet target. We saw little evidence of long range planning and no clear vision for a future in world-class nuclear and particle physics beyond Celsius/WASA. We believe the future of TSL lies in the possibility of establishing a swedish National accelerator physics program. If this idea goes forward we would expect TSL management and users to play a central role.

Recommendations

TSL should reexamine the relative priorities of the elements of the present program and phase out the least important activities in order to concentrate resources on the highest priority activities. TSL should also develop more formal project plans with sufficiently frequent milestones (several per year) and clear goals. The management should monitor progress and direct appropriate resources to the highest priority elements of the program.

The rare η-decay program is the flagship effort of TSL in nuclear and particle physics. Experience shows that attempts to improve limits on rare decays usually require much greater investments of time and effort than originally anticipated.

This program must be evaluated in depth by an independent technical review panel before further funds are invested in it. We place high priority on this review and it should be performed in a timely fashion. If the CELSIUS/WASA experiment can obtain interesting results, presumably in the form of new limits on rare η decays, especially the CP violating decay to $\pi^\circ e^+e^-$, in a reasonable time frame, then the project should be strongly supported. If not, it should be closed down.

TSL must develop a long range plan. This should include scientific priorities and scientific staff development and must take into account Sweden's national and international science mission in all the areas in which TSL has a role. The long range plan should attempt to look at least 10 years into the future. This planning exercise should be carried out in connection with a national review of accelerator science and technology and infrastructure support for swedish nuclear and high energy physics.

CVs of the expert panel

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Professor Aronson earned his B.A. summa cum laude in physics from Columbia university, where he won the Moritz Prize in 1964, and his Ph.D. in physics from Princeton university, where he was an NSF Graduate Fellow, in 1968. From 1968 to 1972, he worked at the University of Chicago's Enrico Fermi Institute for Nuclear Studies as a research associate. He then moved to the University of Wisconsin, where he was on the faculty until 1977.

Samuel Aronson joined Brookhaven's accelerator department in 1978 as an associate physicist, and was named physicist in 1979. He joined the Physics department in 1982, was appointed associate chair of the department in 1987, and deputy chair in 1988. In 1991, Aronson gave up this position and, as a senior physicist, served as head of the PHENIX group and the PHENIX detector project during the construction of RHIC, a challenge he successfully completed before he assumed his current position. Last year, Aronson was named a Fellow of the American Physical Society. Samuel Aronson's citation on his Fellowship certificate reads, "For contributions to nuclear and particle physics, including the physics of neutral Kaons, and the leadership, design and construction of the major experiments, D0 ("D-zero") at Fermilab and PHENIX at RHIC."

Kaons are elementary particles that Aronson studied to understand better how they fit into the Standard Model, the modern theory of fundamental physics. The D0 experiment at the U.S. Department of Energy's Fermilab in Chicago was successful, in 1995, in finding the top quark, an elementary particle whose existence helps to prove the Standard Model. And, since 1991, Aronson headed the effort to design, build, install and operate PHENIX, an experiment built by a collaboration of over 400 people from 50 laboratories and universities around the world. PHENIX is a detector at Brookhaven's newly operating Relativistic Heavy Ion Collider (RHIC), which may help scientists discover and study the quark-gluon plasma, a state of matter predicted to have existed in the earliest moments of the universe.

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Professor Jaffe received his AB, summa cum laude in Physics from Princeton, where he was Valedictorian of the Class of 1968. He received his MS and Ph.D. degrees from Stanford in 1971 and 1972 respectively. At Stanford he founded the Stanford Workshops on Political and Social Issues.

In 1972 Jaffe came to MIT as a post-doctoral research associate in the Center for theoretical physics. He joined the faculty in 1974. From 1975 until 1979, he was an A. P. Sloan Foundation Research Fellow. Professor Jaffe has spent sabbatical years at the Stanford linear accelerator center (1976), Oxford University and the European Center for Nuclear research (1978-79), at Boston university (1986–87), and at Harvard university (1996–97). He has served on the program advisory committees of several national laboratories including the Stanford linear accelerator center and Brookhaven national laboratory. He now serves as a member of the Science and engineering steering committee of Brookhaven national laboratory. For many years he was the chairman of the Advisory council of the Physics department of Princeton university. Since 1996 Jaffe has been an advisor to and visiting scientist at the RIKEN-Brookhaven Research Center. He spent the fall term of 1997 on leave from MIT at the RIKEN-Brookhaven Center. In February of 1998 Jaffe was named director of the Center for theoretical physics at MIT.

Professor Jaffe is a fellow of the American physical society and the American association for the Advancement of science. He has been awarded the Science council prize for Excellence in teaching undergraduates (1983), the Graduate student council teaching award (1988), and the Physics department Buechner teaching prize (1997). In January 1998, Jaffe was named a Margaret MacVicar Faculty Fellow (1998) in recognition of his contributions to MIT's teaching program.

Professor Jaffe has been very active in MIT affairs. He was co-founder of the Symposium at MIT, an interdisciplinary faculty program dedicated to improving communication and the exchange of ideas within the faculty. In 1992 he was elected to a term as chair of the MIT Faculty which concluded in June of 1995.

In 2000 Jaffe was named to the Morningstar Chair in MIT's School of science.

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Professor Longair was born in 1941 and educated at Morgan Academy, Dundee, Scotland. He graduated in electronic physics from Queen's College, Dundee, of the University of St. Andrews in 1963. He became a research student un the Radio astronomy group of the Cavendish laboratory, Cambridge, where he completed his PH.D. in 1967. From 1968 to 1969, he was a Royal society exchange visitor to the Lebedev institute, Moscow, of the USSR Academy of sciences, where he worked with academicians V.L. Ginzburg and Ya. B. Zeldovich.

Longair held a fellowship of the Royal commission for exhibition of 1851 from 1966 to 1968 and was a fellow of Clare Hall, Cambridge from 1967 to 1980.He has held visiting professorships at the California institute of technology (1972), the Princeton institute for advanced studies (1978), the Harvard-

Smithsonian astrophysical Observatory (1990) and the Space telescope science institute (1997). From 1980 to 1990, he held the joint posts of the Astronomer Royal for Scotland, regius professor of astronomy of the University of Edinburgh and director of the Royal observatory, Edinburgh. He is a professorial fellow and vice-president of Clare Hall, Cambridge. He was deputy head of the Cavendish laboratory with special responsibility for the teaching of physics from 1991 to 1997. He is now Head of the Cavendish laboratory.

Professor Longair has received numerous awards, including the first Britannica Award for the Dissemination of learning and the enrichment of life in February 1986. In December 1990, he delivered the series of Royal institution christmas lectures for Young People on television on the topic 'The Origins of Our Universe'. From 1991–1992, he was president of the physics Section of the British association for the advancement of science. He was awarded the 1994 Science prize of the Saltire Society-Royal Bank of Scotland annual award. In 1995, he was Selby Fellow of the Australian academy of sciences and took a lecture demonstration entitled ' Measuring the Fundamentals' round all the state capitals of Australia. He was the chairman of the Gemini-board, the international project to build 8-metre telescopes in the Northern and southern hemispheres, for the years 1994 and 1995. He was chairman of the Space telescope science institute council for 1995-6. He was president of the Royal astronomical society 1996-8. He was awarded the CBE in the 2000 new years honours list.

Professor Longairs primary research interests are in the fields of high energy astrophysics and astrophysical cosmology. He has written eight books and many articles on this work. His other interests include music, mountain walking, art, architecture and golf.

Dr. Irène Nenner

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Irène Nenner is deputy director of the « Division des Sciences de la Matière » of the Commissariat à l`Energie Atomique » in Saclay.

Dr. Nenner received her PhD degree in 1975 in Paris XI University in Orsay in the field of low energy electron molecules collisions, on the basis of a three years experimental work done at Yale university in USA, as a research assistant.

In late 1975, Dr. Nenner was recruited as a researcher at the CEA-Saclay in the Physical Chemistry Department. She became involved in the field of molecular photophysics using far ultra-violet synchrotron radiation from the national French facility « LURE » in Orsay. Her scientific activities focussed on photoionisation and dissociation processes in molecules after valence core level excitation. After different group leadership positions in Saclay and LURE, she became interested in physical chemistry problems of astrophysical interest, especially the properties of earth analogues of interstellar dust.

In 1992, Dr. Nenner became deputy director of the LURE facility and at the same time led the group in charge of the SOLEIL project, the French third generation synchrotron radiation machine.

In 1995, Dr. Nenner was appointed again at Saclay and has occupied different management positions: first, as the head of a laboratory involved in laser-matter interactions, new ultra-violet sources, molecular spectroscopy and dynamics, nanoparticle physics and theoretical chemistry, second, as the head of a department specialising in atomic and molecular physics, condensed matter physics and physical chemistry: from then to the present time, as Deputy director of the Division « Sciences de la Matière », which coordinates all fundamental science in physics and chemistry carried out at the CEA with a special delegation for the synchrotron radiation and short pulse laser programs.

In 1998, she was awarded the title "Chevalier de l`ordre de la Légion d`Honneur".

Dr. Nenner has published some 150 articles in international reviews and conference proceedings and has given 55 invited talks in conferences and workshops, as well as numerous invited seminars in many laboratories around the world.

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Professor Schneider is Director of research at DESY, Hamburg, Germany, in charge of "Synchrotron radiation research and free-electron lasers".

The solid state physicist Prof. Dr. Jochen R. Schneider is professor of experimental physics at the University of Hamburg. He came to DESY in 1989. 6 months later he became Leading Senior Scientist and in 1993 Head of the Hamburg synchrotron radiation laboratory HASYLAB.

Professor Schneider started his professional career as an electrician and electrical engineer. In 1965 he began to study physics at Hamburg where he graduated with a PhD performed at the Institut Laue-Langevin (ILL) in Grenoble. Afterwards Jochen R. Schneider became a scientist at the ILL. In 1976 he went to the Hahn-Meitner-Institute in Berlin. His scientific work focussed on ”Experimental physics and crystallography", a field in which he also habilitated at the Technical university Berlin in 1982.

At DESY Professor Schneider concentrated his scientific research on instrumental developments, electron charge density studies of solids and the characterisation of structural phase transitions, which can be investigated very efficiently with high energy synchrotron radiation from the DESY storage rings ”DORIS" and ”PETRA". Recently his main field of interest was the realization of so called free-electron lasers which will be used at DESY to produce X-ray laser radiation with wavelengths down to 0.1 nm, offering completely new perspectives for structure research in physics, chemistry, materials science and the life sciences. Prof. Schneider has served on various commissions and expertise boards in Germany, Great Britain, France, Switzerland and the United States of America. In 2001 he was awarded the European crystallography prize for his "pioneering work on the application of gamma-ray spectroscopy and his high-energy synchrotron radiation studies, as well as his more recent involvement in the development of free-electron lasers".

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Gunnar Öquist is Professor of plant physiology at Umeå university.

Gunnar Öquist studied chemistry and biology at Uppsala university where he graduated in 1967, and he received his PhD in plant physiology in 1972 at Umeå university. After a post doctoral period including stays at Lund university and Oregon state university he became Docent at Umeå university in 1976 where he became Professor of plant physiology in 1981. Gunnar Öquist has been visiting scientist at The Carnegie institution for plant biology, Stanford, at CSIRO in Canberra and at the University of Western Ontario, London.

Professor Öquist´s research field is photosynthesis with particular emphasis on stress and adaptation to contrasting climatic conditions.

At Umeå university he has been Chairman of the Department of plant physiology, Vice Dean of the Faculty of science, and Member of the Board of the University. He has also been member and secretary general of the Swedish natural science research council, Member of the Boards of the Swedish research council for engineering sciences, the Foundation for strategic research, and the European science foundation. Currently, he is member of the European research advisory board (EURAB). Gunnar Öquist is also member of the Royal swedish academy of science and the Royal society of Canada.

Terms of Reference

Evaluation of the swedish National facilities 2002

Procedure

The Swedish research council started its operations on January 1, 2001, replacing the Swedish natural science research council as the funding agency for the four Swedish National Facilities (NF), the MAX laboratory, Lund, the Manne Siegbahn laboratory, Stockholm, the Onsala space observatory, Gothenburg and the The Svedberg laboratory, Uppsala. The funding for each National Facility is regulated in a three-year contract and the existing contracts cover the period up to December 31, 2002. Following the established schedule for evaluations, the Swedish research council will organize a review of the National Facilities, evaluating and assessing scientific/technical/strategic issues according to the procedure described in this document. After completion, the results and conclusions of the review will be made public in a written report.

The Review panel

The review will be conducted by a "Review Panel" consisting of seven members. All members will be eminent scientists and/or research managers of international reputation, with broad views and expertise. None of the members shall be personally engaged in any of the National facilities.

The chairperson of the Review Panel, appointed by the Swedish research council, heads the review and is the rapporteur of the panel. A research officer from the Swedish research council acts as the co-ordinator of the review.

The members of the Review Panel will receive a small honorarium, according to the regulations of the Swedish research council. Travel costs and daily allowances will be reimbursed or paid by the Swedish research council.

Review schedule

– The Swedish research council shall name persons to act on the Review Panel not later than March 1, 2002.
– Each facility shall present a progress report and a work plan for the coming next (3+3)-year period to the Swedish research council not later than Jan 25, 2002

- Site-visits by the Review Panel to the different National Facilities shall take place during June 2002.
- A review report shall be presented to the Swedish research council not later than the end of July 2002.
- A printed version of the report will be made public before Sep 1, 2002.

Review procedure

The Review Panel shall investigate the scientific/technical/strategic capacities of each of the NFs. There should be a strong "science-driven" and "users-driven" motivation for each facility, i.e. a critical mass of challenging and timely problems in science, and, a critical mass of committed researchers in Sweden (with particular emphasis on young researchers) who are capable of moving science forward through their use of the facility. For each of the National Facilities the science potential should be evaluated in an international perspective, including international facilities of swedish interest like CERN, ESO and ESRF.

The Review Panel is asked to give the Swedish research council general advice on how to allocate resources to the National Facilities for the next (3+3) years. The panel is specifically asked to consider two hypothetical cases of future budgetary outcome and propose the course of action for each existing facility in case of

1. an increase by roughly 15 MSEK of the total Swedish research council budget for the NFs
2. a decrease of the total budget by a similar amount.

The proposed action may include the discontinuation of one (or more) facilities, or withdrawal of national status for one (or more) facilities if such status is found unjustified. A discussion of "next-generation" facilities should be included if this is considered relevant.

In basic terms, the scientific/technical/strategic evaluation of a facility should comprise:

- an analysis of the scientific goals already achieved and to be achieved in the coming (3+3) year period through the operation of the facility under study

in light of

- the strategic scientific value, impact and timeliness of these goals for the advancement of science and/or technical development within the domain(s) of the facility, in an international context
- the procedures developed by the facility for following up on these goals

- the management of the facility, its appropriateness with regard to the projected goals and function of the facility
- the technical performance of the facility, its appropriateness and efficiency with regard to the projected goals, compared to the state of the art internationally (its uniqueness or complementarity)
- the importance of the facility for the standing of swedish research internationally (including, e.g., support from the European Union or other international organizations, bilateral agreements, etc)
- the staffing of the facility (in terms of permanent/temporary, technical and scientific personnel)
- the operational concept of the facility, in particular for serving expert users, non-expert users and commercial users
- the size and standing of the users community of the facility within the related international research communities
- the procedure for the selection and access of users
- the extent to which the facility acts as a centre for contacts between academic research and industry and society
- the extent to which the facility acts as a platform for the swedish exploitation of international facilities
- the ability to assume a leading role in swedish development of scientific instruments. (This technical dimension should be evaluated in an international perspective.)

The following points of balance should be clearly stated and easy to find in the report

- Internal/external use
- International/national/local use
- Swedish/international postgraduate studies
- Disciplinary/trans-disciplinary use
- Scientific/technological use
- Academic/industrial use
- Research personnel/technical and administrative personnel
- Degree of scientific aim and direction/service ability