Vetenskapsrådet

REPORT FROM THE REVIEW OF THE MAX LABORATORY

VETENSKAPSRÅDETS RAPPORTSERIE 5:2010

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Lund, May 2009

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PREFACE

The Swedish Research Council (VR) is a governmental agency with the responsibility to support basic research of the highest scientific quality in all academic disciplines. It is also part of the Council's remit to evaluate research and assess its academic quality and success.

The Council for Research Infrastructures, RFI (former Committe for Research Infrastructures, KFI) at the Swedish Research Council has the overall responsibility to ensure that research infrastructure of the highest quality is expanded and exploited. Specifically, the Committee advertises and evaluates applications, participates in international collaborations and works on monitoring and assessments. As part of the overall responsibility for research infrastructures RFI oversees and evaluates the two Swedish National Facilities – Onsala Space Observatory and the MAX-laboratory.

In 2003 RFI decided on the level of operational support to these facilities for the period 2004–2009. It was also decided that by the end of that period an international evaluation of the activities should be carried out to review the performance of the facility. RFI has therefore appointed an Expert Panel with the capacity to assess the research activities under evaluation in an international perspective. This report contains the findings and recommendations of the Expert Panel.

The members of the Expert Panel were Prof. Maria Arménia Carrondo, Universidade Nova de Lisboa in Portugal and Prof. Giorgio Margaritondo, Ecole Polytechnique Fédérale of Lausanne in Switzerland. Prof. Örjan Skeppstedt, Stockholm University, was appointed Chairman of the Expert Panel and Dr. Tove Andersson, Research Officer, VR acted as coordinator and secretary of the review.

The Swedish Research Council would like to express its sincere gratitude to the Expert Panel for devoting their time and expertise to this important task.

The Swedish Research Council would also like to thank the representatives of MAX-laboratory and Lund University for providing the necessary background material and giving informative presentations and for their kind hospitality during the Panel's visit to the observatory.

Stockholm 2010-03-10

Lars Börjesson
Secretary General
RFI, Swedish Research Council

PROCEDURE FOR THE REVIEW

The Committee for Research Infrastructures (KFI) of the Swedish Research Council (Vetenskapsrådet) decided in 2003 to increase the funding for operation of the MAX laboratory in Lund for the time period 2004–2009. It was also decided that by the end of this time, in 2009, a review of the activities at MAX-lab should be performed to indicate how the support was received and at what level further support should be given (Appendix 1: Terms of Reference). KFI appointed an international evaluation panel for this review, with a Swedish Chairman, *Prof. Örjan Skeppstedt*, Stockholm University, and secretary, *Dr. Tove Andersson*, Swedish Research Council. The members of the international panel were:

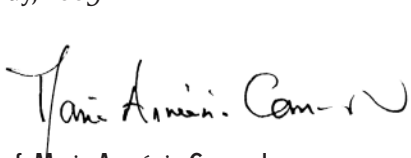
Prof. Maria Arménia Carrondo, Universidade Nova de Lisboa, Portugal
Prof. Giorgio Margaritondo, École Polytechnique Fédérale de Lausanne, Switzerland

Short CVs for the panel members can be found in Appendix 2.

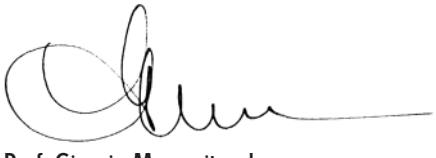
The panel received a background report from MAX-lab (MAX laboratory Background report 2009) together with additional material in April 2009, and made a site visit to MAX-lab on 3–5 May, 2009. The program for the site visit included meeting with MAX-lab staff and users as well as representatives from the faculty board at Lund University (Appendix 3). The panel also had time to plan and start writing the report together at MAX-lab.

The present document presents the views and assessments of the panel members. By signing they take full responsibility for the report. The Chairman and secretary confirm that the work was conducted in accordance with the statutes of the Swedish Research Council and that it was performed in an impartial manner.

May, 2009

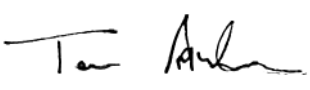


Prof. Maria Arménia Carrondo



Prof. Giorgio Margaritondo

Prof. Örjan Skeppstedt
Chairman



Dr. Tove Andersson
Secretary

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EXECUTIVE SUMMARY

The Review Panel analyzed in detail the documents concerning the past achievements and future plans for MAX-lab and the presentations of several staff members, users and academic officers. This enabled us to conclude that MAX-lab is a very successful enterprise in science and technology. Such a conclusion can be reached using international standards, in comparison with the top synchrotron facilities in Europe and in the world.

MAX-lab has specifically become a recognized leader in experimental methods based on soft X-rays. Its record of results and publications of recent years continued and enhanced the tradition of excellence already established by the laboratory. The role and impact are important both at the national and international level. MAX-lab is an extremely valuable resource for many Swedish scientists, a facility of reference for the entire Nordic region and the laboratory of choice for many scientists from other regions of Europe and the world.

MAX-lab has a factual, unmatched record of cost effectiveness both for the construction and operation of facilities. This is a striking point considering the very high quality of its sources and beamline instrumentation as well as the continuing attention to the user needs.

The fact that MAX-lab is within Lund University has very positive implications. This enhances its role in graduate education, for students from Lund and from all over Sweden and abroad. It makes also possible for the laboratory and Lund University to be one of the world centers for the education of new generations of accelerator scientists, in great demand and increasingly scarce supply everywhere.

Finally, MAX-lab constitutes an excellent platform for the forthcoming transition to MAX IV, in terms of instrumentation, know-how, user community, staff and management skills.

On this basis, we would like to formulate the following recommendations:

- To continue the financial support to the laboratory and increase it to the requested level.
- To enable in this way the laboratory to increase its user service and instrumentation development, with the objective to expand its scope to new techniques and disciplines.
- To continue and increase the current support to activities in domains that will be of interest for and easily transferable to MAX IV.

- To guarantee the continuity of operation and user services during the future transition to MAX IV.
- To preserve in the forthcoming years the outstanding patrimony of human resources of MAX-lab, as required for continuing cost effectiveness.
- To continue and expand the collaboration with Lund University for education in accelerator science.

INTRODUCTION

MAX-lab is one of the two National Facilities, which are presently funded by the Swedish Research Council. The National facilities, at that time MAX-lab at Lund University, the Onsala Space Laboratory (OSO) at Chalmers University of Technology, the The Svedberg laboratory (TSL) at Uppsala University and the Manne Siegbahn laboratory (MSL) at Stockholm University, were established in 1994–1995 by decision of the Parliament. Bilateral agreements were reached between the Swedish Research Council and the host universities in order to regulate the division of financial support and other responsibilities. The basic division of financial support is that the host university provides the site free of rent and pays the electricity and the Swedish Research Council pays for the operation. Additional resources for investments are obtained from the Research Council and other sources. 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 the board for the facility, two of the members being proposed by the Swedish Research Council.

All four National facilities established in 1994–1995 were reviewed in 2002 by the same international Review Panel. This panel came to the conclusion that all four facilities were unquestionably underfunded. The situation was deemed most difficult for MAX-lab, where researchers from outside institutions and universities routinely carried out tasks, which should be assigned to facility staff, assistant staff and technicians. At the same time the Review Panel assessed the ongoing activities at the MAX-lab as vital and essential for Swedish science and technology and it fully endorsed the plans for the future presented by the laboratory, which were considered very competitive and challenging. It was clearly stated in the evaluation report to the Swedish Research Council that without additional funding, including support for future accelerators, the laboratory would decline rapidly in its international standing.

As a consequence of the observations and recommendations of the 2002 evaluation the Research Council the same year made the decision to phase out its support to two of the facilities, TSL and MSL, in order to be able to give adequate funding to the other two laboratories and particularly to increase the support to MAX-lab. The phasing out of the support to TSL and MSL was made gradually over the years 2004–2006 and accordingly the funding from the Research Council to MAX-lab and OSO has gradually increased since 2004.

So called midterm evaluations of MAX-lab and OSO were made in 2007. These were done by panels composed of members from the ordinary Review groups within the Infrastructure Committee (KFI) of the Swedish Research Council. The report of the MAX-lab panel was very positive and expressed its full support for the increased funding asked for by the laboratory. In particular, the evaluation group emphasized the need for increased funding of user support motivated by new users of the laboratory. They also appreciated the innovative work by the accelerator group at MAX-lab and expressed the importance that it is given support for continued development work.

The present evaluation of MAX-lab is the second evaluation of the laboratory as a National Facility with international panel members. A parallel evaluation is made of the other National Facility OSO.

It should be noted that MAX-lab since several years has worked on a proposal for a new synchrotron radiation facility named MAX IV. The project was presented in the "2005 MAX IV Conceptual Design Report" and it has been evaluated both technically and scientifically by separate international panels in 2006. In June 2007, the Swedish Research Council reported to the Government about the conditions for the construction of MAX IV. The Government made positive statements in the Research and Innovation Bill, October 2008, about the need of MAX IV for the Swedish science community and asked in December 2008 the University Chancellor, Anders Flodström to present the conditions for a decision of funding of the construction of MAX IV. Based on Flodström's findings and other reports the Research Council, Vinnova, Lund University and Region Skåne signed at the end of April 2009 a common declaration to form a consortium for starting the fast development of MAX IV. In the document the consortium partners declared their agreement about a construction start during 2010 at the latest. As the MAX IV project was already carefully evaluated both technically and scientifically, the plans for the new facility are not a subject of the present evaluation.

MAX-LAB 2009

Since its foundation 23 years ago, MAX-lab has been one of the leading synchrotron light facilities in the world. With a systematic upgrade of its instrumentation and a constant attention to the needs of its users, it was able to provide for a broad community, both national and international, advanced photon sources and optical instrumentation for experiments in physics, chemistry, biology and other areas. It is one of the main producers, both quantatively and qualitatively, of results with synchrotron light techniques.

MAX-lab fits perfectly a model strategy that emerged in the past two decades for the optimal exploitation of synchrotron light techniques. In this strategy, high-level national facilities complement a very large central facility like ESRF. This makes it possible (1) for the national institutions (that are open to international users) to achieve excellence in specific and important domains, and (2) to prepare by practical experience the national communities for the effective use of the central facility. MAX-lab fulfils this role not only for Sweden but also for a broad region including the other Nordic countries and other parts of Europe.

With its present three storage rings of different energies – MAX I, MAX II and MAX III – the laboratory provides high-quality photon beams over a broad spectral range from the infrared to the hard X-rays. Constant improvements of the accelerator facilities produced excellent levels of beam quality, in particular with advanced insertion devices. The beamline instrumentation is also very sophisticated and innovative – and matches the most stringent technical requirements of the users.

MAX-lab places Sweden in a small elite club of nations as far as synchrotron light research is concerned. In Europe, only the UK, Germany, France, Italy, Russia and Switzerland reach at present a comparable status. Thanks to MAX-lab, Sweden is the unchallenged leader of the Nordic and Baltic countries. But its impact extends well beyond these boundaries to include more than 30 different nationalities. MAX-lab is a key member of the pan-European consortia IA-SFS and ELISA.

The reason for this very strong position is not only the general high quality of the infrastructures, service and environment but also the specific leadership in certain important areas. These include, for example, (1) experiments with microscopy, spectroscopy and structural techniques conducted under "realistic" conditions (ambient pressure, high pressure, high temperature, liquid environments etc.); (2) the effective use of synchrotron techniques in nanoscience and nanotechnology, facilitated by the interaction

with the Lund Nanometer Structure Consortium; (3) biological use of small-angle X-ray scattering, enhanced by the collaboration with an expert community of Danish users; (4) the traditional strength in advanced photoelectron spectroscopy in solids, atoms and molecules, continuing with the recent technical progress in time-of-flight spectrometry; (5) the use of synchrotron research for the conservation of the cultural heritage.

The forthcoming years are likely to further enhance the international position of MAX-lab, but will also bring some crucial challenges. The recent positive decision about MAX IV, a source with unprecedented beam geometry, opens new horizons for synchrotron science in Sweden and Europe. This will strengthen the present domains of excellence in Sweden and open up many new opportunities in areas like biomedical imaging and structural biology. The challenge will be to guarantee continuity – avoiding any interruption between the present high-level user support and the arrival of MAX IV. The requests of MAX-lab to the Swedish Research Council appear, in this context, fully justified and prudently conceived.

One important element of this transition will be the continuing effective response to the user needs, expressed by their representatives. In recent years, MAX-lab made specific efforts in this direction with emphasis on security, quality control, effective management of beamtime allocation, accelerator reliability and training of new users. A substantial increase in its operation funding will further expand these improvements.

In addition to a better support of the present users, MAX-lab is also seeking an expansion of its user community to new areas. The most evident phenomenon is the recent increase of the users from chemistry; other communities are also expanding, for example environmental studies. This is made possible by an evolution of the operation mode, from a strong participation of the users to the instrumentation development and operation – that favored physics – to a more intense technical assistance for less specialized user communities. This is a positive trend whose continuation requires additional resources, as requested by the laboratory for the forthcoming years.

A nuclear physics activity has through the years been carried out at MAX-lab besides the synchrotron radiation research. The experiments are performed with tagged photons produced in a bremsstrahlung target bombarded with electrons from the linac and the MAX I ring, which is used as a pulse stretcher. The nuclear physics activity is small but of high quality, with about 50 active users from 20 institutions (3 from Sweden). An upgrade of the facility in 2005, increasing the electron energy to 200 MeV, has opened up possibilities for experiments with photon-induced reactions over the pion-production threshold. The MAX-lab tagged photon facility has a well-

established position among the few existing photon facilities in the world. The nuclear physics activity should be supported for the period until the phasing out of the present accelerator structure when the MAX IV facility will take over.

SCIENTIFIC ACTIVITIES AND PERFORMANCE 2006–2009

Use of MAX-lab in 2006–2009

There have been many scientific achievements in the period 2006-2009 as documented in the MAX-lab Mid-Term and in the Background Reports. A list of highlights was described in detail in the last report together with a full list of publications over the last three years. These span from advances in the free Electron Laser directed activities to well established fields at MAX-lab such as macromolecular crystallography, time-resolved studies and various spectroscopic techniques and methodologies. Noteworthy is the application of EXAFS and IR studies to the preservation of historic Swedish heritage such as the VASA warship, which allowed the chemical identification of the areas that can be more affected by decomposition and eventually may prevent this to happen.

However the main achievements of MAX-lab in the past three years are correlated with most significant advances in techniques and methods that have and will increase the knowledge of samples in their natural environments, meaning chemical, biochemical and biological processes and reactions in the liquid state and in powders at normal pressures and temperatures. The most challenging developments along these lines will be briefly described.

State-of-the-art equipment was implemented at MAX II / I711 to study hydrogen storage materials using *in situ* powder X-ray diffraction. This is an important part of energy storage research. *In situ* studies of gas/solid reactions have improved our understanding of hydrogen release and uptake, and as an example among others, the nano-scale characterization of MgH_2 decomposition has suggested the use of different additives to improve the kinetics of this reaction.

Nanoscience with soft X-rays at I311 has been explored within the Nanometer Structure Consortium which is a Swedish Centre for the development of Nanotechnology and crossing areas such as Nanoelectronics and Nanophotonics, Materials Sciences and Physics. These studies concerned in particular complex devices and functional structures grown in nanowires. Very different materials can be combined and large strain tolerated. Nanowires can be positioned in ordered arrays and on devices, and these are very

popular due to their variable and tunable electronic/optical/mechanical properties. Studies with soft X-rays at I311 have also shown that doping of these nanostructures was found to be very important and could therefore be used to tailoring nanostructures growth. Nanobioscience systems have also been explored and three different imaging modes of human serum albumin, the most abundant protein in human blood plasma, adsorbed on a nanostructure made by focused ion beam lithography on a silicon substrate. These studies provided new insights on secondary electrons and on electrons from Si 2p. Developing new applications on nanoscience has already been fostered for MAX IV but extra staff is needed in the near future for proper development.

BioSAXS allows structural studies of biological molecules in solution and therefore is a very important and rapidly growing technique. Information derived from SAXS includes the determination of size and molecular weight of the scattering particles, but also *ab initio* methods can allow to obtain shapes and models for these particles in their natural environment in solution. One major development was a microfluidic chip system, properly designed to study and get the best combination of variables such as protein concentration, pH, salts, co-factors, ligands which will lead to an automated analysis enabling identification of suprastructural states or oligomers. Aims and future goals include the development of I711, of software to all users (I711, I911-4, MAX IV), of a "standard user chip" (BioXTAS-II), becoming a full partner of SAXIER-II and evolving towards a true high-throughput approach at MAX IV. Close links and cooperation have been establised with the reference group on this technique at EMBL in Hamburg.

Research at beamline I411 is done in the range 40 eV – 1 keV on gases, clusters, solid interfaces and liquids. A recent upgrade yielded a resolution of 45 meV at 400 eV. Simultaneous laser and spectrometry radiation has been used to probe many-electron effects during excitation and decay in, for example, alkali atoms. Of special interest are the unsaturated hydrocarbons which allow studying the role of core hole localization. An important example with impact in the industry was the study of acetonitrile fragmentation after N 1s resonant excitation. Metallic vapors, clusters and water clusters can be studied and in the last case, water molecules in different hydrogen bonding configurations can be established. Another very important application is the study by XPS of liquid jet, where ions in solutions, zwitterions and pH can be recognized. Solar cells can also be studied using the "core hole clock".

Many important contributions have and will be made to the understanding of these problems via these types of developments on X-ray and photoelectron spectroscopies. One of the major and more remarkable developments in the area is the new type of electron spectrometer, the angle

resolving time-of-flight spectrometer ARTOF, which combines dispersion based on electron optics with time of flight analysis and has been developed in a collaboration between MAX-lab, Uppsala University and VG-Scienta. A prototype was used in scientific projects, the first commercial instrument will be soon delivered to SPring8 in Japan and continuing development of instrument and software is ongoing at MAX-lab and will be further pursued in the future.

As far as the industrial impact of MAX-lab is concerned, we note the creation of SAROmics Biostructure. This is a company that offers protein crystallization, X-ray structure determination and NMR spectroscopy services accelerating the drug discovery process. It is based at MAX-lab in Lund, Sweden, conveniently located in the heart of Medicon Valley. An agreement was signed between SAROmics Biostructures and MAX-lab leading to beneficial effects for both parts. The company has 7 people and it was incorporated in May 2006 as a complete platform for protein structure determination and provides self-financed contract service. It performs high-throughput low volume crystallization using liquid handling, crystallization and imaging robotics for academic customers as well as to industry. Furthermore it helps spreading of MAX-lab's name in industry.

Comments to publications

The number of publications resulting from work performed at the MAX-lab has been high and stable over the period under analysis, with a total of 185 in 2006, 220 in 2007 and 181 in 2008. The quality of these publications can be appreciated by the type of journals where they have appeared, with some in highly ranked, high impact factor journals such as Science, Nature Structural Molecular Biology, Nature Nanotechnology, EMBO Journal, Journal of Biological Chemistry, Structure, Journal of the American Chemical Society, Physical Review Letters, Applied Physics Letters, Langemuir, etc.

THE PLANS FOR SCIENTIFIC AND TECHNICAL ACTIVITIES 2010–2013

We assess in a very positive way the plans presented by the MAX-lab management and their parallel objectives to continue the present, excellent user support while, expanding the user community to new domains, and to pave the way for a smooth and effective transition to MAX IV.

Concerning the planned scientific activities, MAX-lab will continue its role of excellence in the domains of microscopy, spectroscopy and spectromicroscopy (in particular experiments under ambient conditions), macromolecular crystallography, small-angle X-ray scattering, powder diffraction, time-resolved X-ray studies – with applications in a variety of domains, notably nanosystems and clusters, energy-related systems, molecules and biosystems. In preparation for the advent of MAX IV, the laboratory plans an expansion of its activities in biomedical imaging and structural techniques in general.

This combination of continuing strength and new initiatives motivated by MAX IV is a wise strategy. With good planning and sufficient resources, both objectives can be realistically achieved.

Among the specific instrumentation activities, we note the development of a most advanced streakcamera with photon-counting readout and the commissioning of a sophisticated spectromicroscopy facility (SPLEEM). With the further planned improvements, these instruments will put the laboratory at the forefront of time resolved experiments and synchrotron microscopy for nanoscience. The current improvements in the high-resolution angle-resolved electron spectroscopy instrumentation will enable MAX-lab to continue its leading position in the study of semiconductors and other systems. Likewise, the new beamline exploiting the variable polarization undulator will strengthen its role in magnetism investigations.

The recent and planned improvements of the instrumentation for molecular and cluster spectroscopy will have a positive impact on this traditional domain of excellence at MAX-lab. We specifically note the 3-dimensional momentum imaging spectrometer, the REBECCA facility, the new cluster sources and the two-color instrumentation. Equally important are other spectroscopy instrumentation developments such as the facility for electron spectroscopy in the liquid phase and the already mentioned ARTOF time-of-flight spectrometer.

The interest of MAX-lab for new user domains is well reflected by the plan for a novel beamline dedicated to environmental science based on X-ray absorption spectroscopy. Likewise, the management of the transition to MAX IV is an excellent justification for the planned new facility on tomography. Also important for this transition are the expansion plans for macromolecular crystallography, centered first on MAX II but with an eye on MAX IV.

The quality of the laboratory requires a continuing attention for the accelerators and a constant effort for their improvement. Considering again the future transition to MAX IV, these efforts must simultaneously meet two objectives: the preservation of the quality of all sources during the transition and a substantial improvement of the parts of MAX-lab that will be transferred to MAX IV. Important contributions within this framework were the recent upgrades of the MAX-injector, the improvements in the MAX II reliability and performances (upgrades of the insertion devices, the RF system and the vacuum system).

A major step in recent years was of course the commissioning of MAX III. The future plans include the stabilization of the electron beam in this machine, to solve the current problem of short Toushek lifetime.

The general activities in accelerator physics produced quite remarkable results, once again with specific impact on MAX IV. We note the development of innovative accelerator lattices with very high brilliance and the activities targeting free electron laser physics.

MAX-lab has interesting commercial activities with the promise of additional developments. We note two important elements: the launching of the SARomics company and the continuing collaboration with the VG-Scienta company. SARomics is in a unique position at the world level because of its proximity and interaction with the MAX-lab, making it possible to offer to customers the most advanced synchrotron-based structural techniques. In our view, this will be a winning factor with respect to the international competition.

The collaboration with VG-Scienta is most visibly realized with the development of the ARTOF system – that was recently commercialized in Japan and is being commercialized in China. VG-Scienta has given to Sweden a leading role in commercial synchrotron instrumentation for more than two decades. The ARTOF instrument shows promise of continuing this success for the foreseeable future.

THE ORGANISATION AND MANAGEMENT OF MAX-LAB

The main part of the operational budget of MAX-lab is covered by the Swedish Research Council. Lund University operates the laboratory based on an agreement with the Research Council. Lund University covers the cost for conventional facilities and utilities (primarily electricity). Furthermore, there are two academic programs under the Faculty of Natural Sciences, *Accelerator Physics* and *Synchrotron Radiation Instrumentation* which are placed at the National Laboratory. The Faculty and the Vice-Chancellor have financed these programs jointly.

MAX-lab is operated as an independent unit under the Vice-Chancellor of the University. The board of MAX-lab consists of six members plus the chairman appointed by Lund University. The Swedish Research Council selects two of the regular members, the MAX-lab Users Organisation selects two and the remaining two are selected by Lund University.

The Director, appointed for time periods of three years by the Board, leads the operation of the laboratory. There are three coordinators, one for synchrotron radiation (50%), one for nuclear physics (25%), and one for accelerator physics (25%).

The personnel are organised in four groups responsible for accelerators, beamlines, design and construction and administration. The academic groups of Accelerator Physics and Synchrotron Radiation Instrumentation are administrated in connection with the accelerator and beamline groups of the laboratory. The organisational plan is found in Appendix 4.

The MAX-lab external committees play an important role in the operation of the facility. The scientific Advisory Committee (SAC) of MAX-lab assists the Board and the management in setting the long-term scientific strategies. The SAC is also used to make an overall assessment of the scientific development of the laboratory itself and the scientific activities. The Program Advisory Committees (PAC) of the laboratory evaluate the beamtime proposals for the allocation of beamtime. The PAC is also involved in setting priorities for new beamline proposals.

The users and the user organisation (FASM) have important roles at MAX-lab. The development of the laboratory is to a large extent user-driven. The interaction between the laboratory and the user community is strong and constructive. The ambition of the laboratory is to maintain the possibilities for regular and informal meetings between staff and users.

The Review Panel notes that the main structure of the organisation has existed since the establishment of the Swedish National Facilities 1994-1995. It is apparent that the Lund university has given high priority to the research at MAX-lab and has actively supported the development of the facility. The establishment of the two academic programs *Accelerator Physics* and *Synchrotron Radiation Instrumentation* at MAX-lab under the Natural Science Faculty is highly appreciated and it is of importance that these programs can be maintained and developed further in the coming year when the MAX IV facility with a possibly changed organisation will be established. The panel finds that the organisational strong connection to the Swedish Research Council being the main fund supplier is healthy. The internal procedures for setting priorities by use of the SAC and PAC committees on applications to the Research Council and other funding sources have apparently been constructive and helped to establish the necessary budget conditions both for the operation of the laboratory and develop the accelerators, beamlines and instrumentation.

Considering the successful development of the MAX-lab since its establishment as a National Facility and especially the development during the last four-year period, The Review Panel strongly recommends that the present organisation is maintained during the forthcoming period. We understand that the organisation of MAX-lab has to be reconsidered when the organisation of the MAX IV facility with a new owner structure will be established. We recommend that possibilities are considered to maintain parts of the present organisational structure also when the MAX IV facility is established.

GENERAL ASPECTS AND ASSESSMENTS

Funding

One element is clear from the past and recent funding history of MAX-lab, as well as from its current financial request: the laboratory has an unmatched world record of cost effectiveness.

This fact, well known to all synchrotron light experts, can be easily demonstrated with many data. We would like to mention, for example, the comparison of the operation costs of MAX-lab (calculated according to the European Commission standards) with those of BESSY in Germany, Elettra in Italy and the Swiss Light Source (SLS). These facilities are relevant since their scope and national/international status are quite comparable to MAX-lab.

The comparison is striking: the yearly operation costs of Elettra are higher than those of MAX-lab by a factor of 3. The costs of BESSY and SLS are higher by factors of 2.9 and 2.0.

The operation budget of MAX-lab was substantially increased in recent years because of the decision to terminate the support of two other Swedish national laboratories. This is certainly a positive trend, but even with this increase the cost difference between MAX-lab and comparable facilities in other countries remains very high: MAX-lab continues to have very low costs both for the construction of facilities and for their operation.

This, however, can be a mixed blessing: on one hand, the MAX-lab management must be commended for a wise and prudent use of public money. But the continuing funding difference between the laboratory and its international peers raises an important question: are the budget restriction jeopardizing the full return of the instrumentation investments at MAX-lab?

The answer must be found in the historical development of the user community. The low cost of MAX-lab is primarily made possible by two factors: the competence and effectiveness of its personnel and management and the willingness of the users to actively participate in the technical operation of the facility. This second factor polarized to some extent the user community, limiting the participation of scientists that can profit from the synchrotron techniques but do not have the technical background to contribute to the operation.

This explains why, in the past, physicists dominated the user population. The funding increases in recent years partially corrected this imbalance and led to a better equilibrium in the user spectrum. However, the correction is

incomplete and some potentially important communities are still underrepresented – for example in medical and environmental research. This limits to some extent the overall impact of the investments in instrumentation.

Consider for example the recently commissioned instrumentation for SPLEEM. This is a very delicate system at the world forefront. A direct handling by the users without sufficient support by MAX-lab personnel would create unreasonable risks – and would likely deteriorate the system performances. Therefore, additional expert staff would be desirable to assist the users.

In similar beamlines at other laboratories, several full-time beamline scientists guarantee the user support. At MAX-lab, only one person can be provided. This limits the use of the SPLEEM instrumentation and the return of the corresponding investments. Similar conclusions are valid for many other MAX-lab beamlines.

The MAX-lab management is well aware of this problem and endeavors to correct it by seeking additional resources. These facts justify our full support of its requested increase in the yearly funding by the Swedish Research Council, from 61.1 to 85 million Swedish Crowns. Even after this raise, the funding of MAX-lab would remain, as stated above, at a much lower level than its peer institutions. But it would enable the laboratory to enhance its user assistance and its scientific impact by allowing (1) a series of instrumentation and facility improvements and (2) the hiring of additional, strongly needed beamline scientists to expand the assistance of users.

The financial and in-kind support of Lund University appears adequate at the present level. In fact, other synchrotron facilities in Europe do not receive comparable funding from academic institutions, even those in close proximity like the universities of Trieste or Grenoble. We commend Lund University for its generosity, but cannot reasonably ask for a boost in its funding. Considering the user-oriented objectives of the increase in the operation costs, an additional effort by the Swedish Research Council thus appears reasonable and justified.

If granted, such an increase will also pave the way to a better balance of the user spectrum for MAX IV. In essence, the future user community must be nurtured with a multi-year effort, and this requires a yearly operation budget for MAX-lab higher than the present level, as requested by its management.

User aspects

The users community is large and well represented and with a wide distribution from the Nordic countries. Other European countries are also strongly represented and some users come from far out countries such as China, Japan, USA or New Zealand. The largest community is from Physics, which is not surprising due to the nature of the services provided by MAX-lab, but a growing community of chemists has gradually been increasing since 1995-1996 and is now equivalent in numbers to the community from the Life Sciences. The number of users from industry is also noteworthy, with a slight increase in the last three years, and coming from Sweden and also other countries.

The users community is represented by a Users Committee and in general it is acknowledged that an excellent collaboration exists with MAX-lab. Security regarding handling of chemicals has much improved, easy access to MAX-lab and control systems have been improved and can be improved even more. Internal quality programs have been started but weekly reference spectra to check development of beamlines and stability of the rings would be of added value. Especially important is the support on the hard X-ray beamlines where users are often less experienced. Beam time is currently allocated for one year at a time. It works well for soft X-ray users but less well for hard X-ray users. There is need of a better system to accommodate users that experience problems at the facility, perhaps similar to the existing BAG system at the ESRF which could introduce more flexibility. This has been addressed by the MAX-lab management and there will be a proposal along these lines for the next years. Education, especially for hard X-rays, is also continuously needed. The increased support to users from MAX-lab is very important but there should also be an expansion of active education of new users to create well educated users.

Affordable accommodation for users to stay overnight close to MAX-lab is sometimes a problem and should be addressed in the future. Presently there is a nearby hotel and some restaurants. Travel expenses and lack of guest houses could in some cases prevent researchers (esp. junior scientists and women) from doing science at MAX-lab.

Balance issues and alternatives

Is there at present a reasonable balance between different users and different disciplines at MAX-lab? The answer must be found in the previous discussion of the budget increase request.

In the first years of the laboratory, the user community was dominated by physicists, willing and capable to contribute to the development and operation of the instrumentation. A similar situation also existed at most other synchrotron facilities worldwide. Thus, the spectrum of users and of disciplines did not match the full potential of synchrotron techniques – that can and should also impact chemistry, biology, medical research, environmental sciences, technology and other disciplines.

There is since 1996 a better user balance at MAX-lab with a substantial increase of biology and chemistry. But the situation can be further improved. The MAX-lab management appears fully aware of this challenge and willing to meet it. As already stated, this absolutely requires additional resources.

Another balance issue is the equilibrium between Swedish and foreign users. We find the present situation quite satisfactory. On one hand, the Swedish users are sufficiently numerous for the national role of the facility. In parallel, the foreign component gives the facility a remarkable international impact.

This role is particularly important for the Nordic countries, but not limited to them. MAX-lab is *de facto* a VITAL resource for the entire Nordic region, but with a much broader scope. The Swedish users profit from this situation because of the excellent international image of MAX-lab and of the numerous opportunities for international collaborations. In turn, this facilitates their use of other European synchrotron laboratories – most notably ESRF. All these facts lead to the conclusion that the present equilibrium between Swedish and non-Swedish users is optimal.

Is there a reasonable alternative to MAX-lab for Swedish science and technology? Not really: without it, the Swedish users could still access ESRF and other national facilities – but the experience of other countries shows that without a strong national facility the quality and quantity of synchrotron activities would degrade, confining Sweden to a second-rank role.

Operation of MAX-lab during the construction and commissioning of MAX IV

The effective transition from the present situation to MAX IV requires, as already stated, prudent planning to avoid a break in the service to users. Similar problems in other countries were dealt with by a variety of approaches. The corresponding practical experience shows that any substantial interruption of the service to users would have a negative qualitative and quantitative impact on their research.

The transition must thus guarantee continuity. Furthermore, it must pave the way to the effective use of MAX IV, with relevant differences with respect to the present spectrum of activities at MAX-lab. Specifically, certain areas that currently are not present or have a limited presence must be enhanced in the laboratory operation of the forthcoming years – without waiting for the commissioning of MAX IV. Biomedical imaging – primarily based on spatial coherence – provides an excellent example. We can also mention the need to expand the small-angle scattering and in general bio-oriented structural techniques.

SAMMANFATTNING PÅ SVENSKA

Granskningspanelen analyserade i detalj dokumenten om MAX-labs tidigare prestationer och planer för framtiden samt presentationerna från flera medarbetare, användare och administrativa chefer. Detta gjorde att vi kunde sluta oss till att MAX-lab är en mycket framgångsrik institution inom vetenskap och teknologi. Vi drar denna slutsats utifrån internationella standarder och genom att jämföra med de bästa synkrotronanläggningarna i Europa och världen.

MAX-lab har särskilt utmärkt sig som erkänd ledare när det gäller experimentella metoder baserade på mjukröntgen. MAX-labs dokumenterade resultat och publikationer under senare år fortsätter och förstärker den tradition av forskning i världsklass som laboratoriet redan etablerat. Laboratoriets roll och inflytande är viktiga såväl på den nationella som på den internationella nivån. MAX-lab är en mycket värdefull resurs för många svenska forskare, en referensanläggning för hela det nordiska området samt förstahandsvalet för många forskare från andra delar av Europa och från resten av världen.

MAX-lab har en oöverträffad historia av kostnadseffektivitet, både för konstruktionen och för driften av anläggningen. Detta är slående med tanke på den mycket höga kvaliteten på källorna och strålrörsinstrumenteringen och på det ständiga engagemanget i användarnas behov.

Det faktum att MAX-lab ligger inom Lunds universitet har många positiva följder. Det förstärker laboratoriets roll inom grundutbildningen för studenter från Lund, från resten av Sverige och från andra länder. Det gör det också möjligt för laboratoriet och Lunds universitet att bli ett världsledande centrum för utbildningen av nya generationer av acceleratorfysiker, som är mycket eftersökta och blir allt svårare att finna.

Slutligen utgör MAX-lab en utmärkt plattform för den kommande övergången till MAX IV, när det gäller instrumentation, sakkunskap, användargrupper, medarbetare och ledning.

Baserat på detta skulle vi vilja formulera följande rekommendationer:

- Att fortsätta det ekonomiska stödet till laboratoriet och öka det till den efterfrågade nivån.
- Att på detta sätt göra det möjligt för laboratoriet att ytterligare förbättra utvecklingen av tjänster till användarna och av instrument, med målet att utöka verksamheten med nya tekniker och discipliner.
- Att fortsätta och utöka det nuvarande stödet till verksamheter inom områden som kommer att vara intressanta för och lätta att föra över till MAX IV.

- Att garantera kontinuiteten i driften och i tjänster till användare under den framtida övergången till MAX IV.
- Att under de kommande åren bevara det enastående arvet i form av mänskliga resurser på MAX-lab, vilket är nödvändigt för den fortsatta kostnadseffektiviteten.
- Att fortsätta och utöka samarbetet med Lunds universitet inom utbildningen i acceleratorforskning.

APPENDIX 1: TERMS OF REFERENCE

Introduction

The Swedish research council funds two National Facilities, MAX-lab and Onsala Space Observatory. The national research facilities were reviewed in 2002/2003. Based on the results of the review a restructuring of the funding to the, at that time, four national research facilities it was decided to terminate the funding of two of the facilities over a three years period starting with the fiscal year 2004. One of the main reasons was to be able to operate the two remaining national research facilities with a higher financial support. The level of funding for the Onsala Space Observatory and MAX-lab has increased gradually from 2004. Before the end of 2009 the research council has to decide on the level of support from 2010.

MAX-lab is a Swedish National Facility for research with energetic electrons and synchrotron radiation. At present three electron storage rings for synchrotron radiation are in operation, MAX I at 550 MeV, MAX II at 1.5 GeV and MAX III at 700 MeV MAX-lab has also proposed to build a new synchrotron radiation laboratory, MAX IV. The detailed scientific and technical merits of this proposal are not part of this review.

The present evaluation is to examine in detail MAX-lab as a user facility and a national laboratory. After completion, the results and conclusions of the review will be made public in a written report.

Review Panel

The review will be conducted by a "Review Panel". The members will be internationally recognized experts, with broad views and expertise. None of the members shall be personally and actively engaged in MAX-lab.

The chairperson of the Review Panel is Professor Örjan Skeppstedt, Stockholm University. Professor Skeppstedt 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. Members of the working group for Molecular, Cellular and Material Research may attend the evaluation as observers.

Review schedule

The review shall be made during the spring of 2009 and the Panel shall have at least one site visit at MAX-lab. A preliminary report shall be presented to the Swedish Research Council not later than June 1, 2009.

Review procedure

The Review Panel shall investigate the general scientific/technical activity of the MAX laboratory in view the budget given to the activity. The new areas of science that has been developed during the last six year shall be highlighted.

The Review Panel is asked to write a report about the performance of the present MAX-lab. In this report the Panel is requested to:

- Evaluate, from an international point of view, the scientific quality of the ongoing activity.
- Comment on the role the increased funding from the research council has had on the scientific activity.
- Estimate if the user support is on an appropriate level compared to other synchrotron radiation laboratories.
- Identify the most important scientific achievements at MAX-lab during the last five years.
- Evaluate, as an alternative to MAX-lab the possibility for Swedish scientists to obtain sufficient beamtime at existing and planned synchrotron radiation sources.
- Comment upon the relation between international and Swedish users.
- Comment on the number of non university users.
- Estimate if the cost for running MAX-lab is appropriate and give an opinion what a 25% increase/decrease in the funding would mean for the scientific performance.
- Comment on the balance between different disciplines and users.
- Comment on the full operational concept of the facility, in particular for serving expert users, non-expert users and commercial users.

The panel is also asked to report about any other issue scientific, administrative or financial, which can be of importance for the research council when the new budget for MAX-lab is determined.

APPENDIX 2: SHORT CVS OF THE PANEL MEMBERS

Prof. Maria Arménia Carrondo

Vice-Rector of the Universidade Nova de Lisboa since 2007 and Professor at Instituto de Tecnologia Química e Biológica (ITQB), Universidade Nova de Lisboa (1998–present).
Current address: ITQB – Av. da República, 2784-505 Oeiras, Portugal
Born in V. N. De Famalicão, Portugal, in 1948.
Chem. Eng. by University of Porto, Portugal, 1971; Ph.D. in Chemical Crystallography, Imperial College of Science and Technology, University of London, UK, 1978.

Special assignments:
Vice-Director of ITQB (1996–2005). Member of the Executive Direction of IST, Technical University of Lisbon (1984–1987).
Coordinator of the Macromolecular Crystallography Unit and Leader of the Structural Genomics Laboratory at ITQB (1988–present).
Associate Professor at Instituto Superior Técnico (IST), Universidade Técnica de Lisboa, (1979–1998).

Elected EMBO member in 2000; European Medal for Bio-Inorganic Chemistry in 2004.

Representative of the Portuguese Government at the ESRF Council (1998–2002). Representative of the Minister for Science and Technology in the process that led to the Portuguese membership of ESRF in 1997. Users representative at the EC Round-Table for synchrotrons (1991–1996).

Member of the Scientific Advisory Board of the EMBL-PETRAIII project since 2008. Member of the Review Panel of the EMBL Hamburg Outstation in 2003.

Member of the Priorities Committee of the EMBL Hamburg Outstation since 2005. Member of the ESRF Review Committee in Life Sciences – Protein Crystallography (2000–2003).

Editor of *Journal of Biological Inorganic Chemistry* since December 2001.

Member of the European Crystallographic Association Committee for the Max-Perutz Prize (2006 and 2007). Officer of the Executive Committee of the International Union of Crystallography (1999–2005) and Chair of the IUCr Sub – Commission on the Union calendar (2002–2005). Officer of the Executive Committee of the European Crystallography Association (ECA) (1997–2000).

Member of the Organizing and Programme Committees of the Eurobic8, Aveiro, Portugal, 2006. Organizer of the EU courses BioCrys on "Fundamentals of modern methods in Biocrystallography", Oeiras, 2002, 2004, 2006 and 2008. Vice-President of the Organizing Committee of the FEBS meeting, Lisbon, 2001. Chair of the Organizing Committee of ECM 17, Lisbon, 1997. Member of the Programme Committee of ECM 16, 1995, Lund, Sweden and member of the Advisory Board for ECM 18, 1998, Prague, Check Republic and Member of the Programme Committee for ECM 19, 2000, Nancy, France. Founding Member of the Special Interest Group within ECA on Macromolecular Crystallography and Secretary between 1998 and 2001. Chair of this SIG since 2006.

Vice-President of the Portuguese Biochemical Society (1998–2004).

Coordinator for the ITQB participation as partner of the EU integrated project SPINE2-Complexes, the Specific Support Action TEACH-SG, the EU Infrastructure Cooperation Network ECM-INF2 and associated TID centre to the EU integrated project BIOXHIT.

Special Scientific Interests:

Protein Crystallograhy. Structural studies of protein and protein complexes of the innate immune system, metalloproteins and metalloenzymes. Application of methods involving data obtained in synchrotrons, namely methods based on Anomalous Dispersion.

Prof. Giorgio Margaritondo

Fellow, Amer. Phys. Soc., Amer. Vac. Soc. & Inst. of Phys. (FinstP, Chartered Physicist)

Professional Degree:
University of Rome I, Laurea of Doctor *Summa cum Laude* in Physics (1969).

Positions:

Present:	Vice-president for Academic Affairs (Provost) and (since 1990) full professor (professeur ordinaire) of applied physics at the Ecole Polytechnique Fédérale of Lausanne (EPFL), Switzerland. Concurrent Responsibilities: • President of the Council of the European Commission Integrating Initiative in Synchrotron and FEL Science (formerly : Coordinator of the European Commission Round Table on Synchrotron Radiation and Free Electron Lasers). • Adjunct Professor of Physics, University of Wisconsin-Madison and Vanderbilt University.
2001–2004:	Dean of the Faculty of Basic Sciences at the EPFL
2000–2001:	Head of the Department of Physics at the EPFL
1995–98:	Coordinator of the Experimental Division, Sincrotrone Trieste (Elettra), Italy.
1990–96, 2000:	Director of the Applied Physics Institute at the EPFL.
1978–90:	At the University of Wisconsin-Madison: associate director of the Wisconsin Synchrotron Radiation Center (1984–90); full professor of physics (1983–90); associate (1980–83 and assistant (1978–80) professor of physics.
1971–78:	Staff Member of the Italian National Research Council (CNR)
1975–77:	Resident Visitor, Bell Laboratories (Murray Hill), Surface Physics Department].
1969–71:	Postdoctoral Fellow of the Italian National Research Council.

Research:
Semiconductors, superconductors, interfaces, synchrotron light, free electron lasers, photoemission, spectromicroscopy, biological spectromicroscopy, X-ray imaging, radiology.

Honors:
Golden Plaquette of the University of Nova Gorica (2008); American Physical Society Outstanding Referee (2008); ISI Highly Cited Researcher in Materials Science (2003); SKORE-A Prize of the Swiss Science Agency (2002); Fellow and Chartered Physicist, Institute of Physics (UK) (1999); Fellow, American Vacuum Society (1998); Ranked 163 in the ISI list of 1120 Most Cited Physicist (1981–97); John Yarwood Memorial Medal of the British Vacuum Council (1995); Vanderbilt University McMinn Distinguished Lecturer (1994); Who's Who in the World (1992); Fellow, American Physical Society (1988); Who's Who in the Frontiers of Science and Technology (1985); Romnes Award (1983); Who's Who in Technology (1980); American Men and Women of Science (1979); International Junior NATO fellowship (1975); national fellowship (top ranking) of the Italian Education Department (1969); *Summa cum Laude* for PhD Thesis (1969).

Memberships:
Institute of Physics (UK) (Fellow); American Phys. Society; American Vacuum Society; European Phys. Society; Swiss Phys. Society; Italian Phys. Society; American Association for the Advancement of Science.

Teaching:

1991–present (EPFL):	Undergraduate general physics courses for civil engineering, mechanical engineering, rural engineering, chemical engineering and chemistry students; thesis advisor of PhD and diploma candidates; advanced semiconductor and superconductor physics at Vanderbilt University.
1978–1990:	Graduate and undergraduate Courses in modern physics, solid-state physics and advanced optics at the University of Wisconsin-Madison. PhD and MS thesis advisor.

Personal Data:
- Born in Rome, Italy, on August 24, 1946.
- Citizen of the United States of America.
- Married, two daughters.
- Fluent in English, Italian, French and Spanish.
- Author of books in English, French and Italian.

Publications and Talks – Summary:

643 Refereed articles, published or accepted (in press)
116 Nonrefereed publications
9 Books
23 Book Chapters
229 Invited talks at conferences
85 Colloquia and seminars
71 Contributed talks

APPENDIX 3: PROGRAM FOR THE SITE VISIT AT MAX-LAB ON 3–5 MAY, 2009

Site visit at MAX-lab for the review panel 2009 PROGRAM:

Time: 3–5 May, 2009
Place: MAX-laboratory, Ole Römers väg 1, Lund

Sunday 3 May:

17:00–19:00 Panel meeting

Monday 4 May:

9:00–9:15 Introduction by Örjan Skeppstedt

9.15–11.00 Overview of MAX-lab by Nils Mårtensson (Director of MAX-lab) and the MAX-lab staff

11.00–12.30 Short presentations of selected activities at MAX-lab:

Torben Jensen, Aarhus University – Hydrogen storage materials
Anders Mikkelsen, Lund University – Nanoscience
Bente Vestergaard, University of Kopenhagen – Bio-SAXS
Björn Valse, SAROmics AB, Lund – Offering services in structural biology
Gunnar Öhrwall, MAX-lab – The Scienta Art of 10k electron spectrometer
Svante Svensson, Uppsala University, Research at beamline I411

12.30–13.00 Lunch

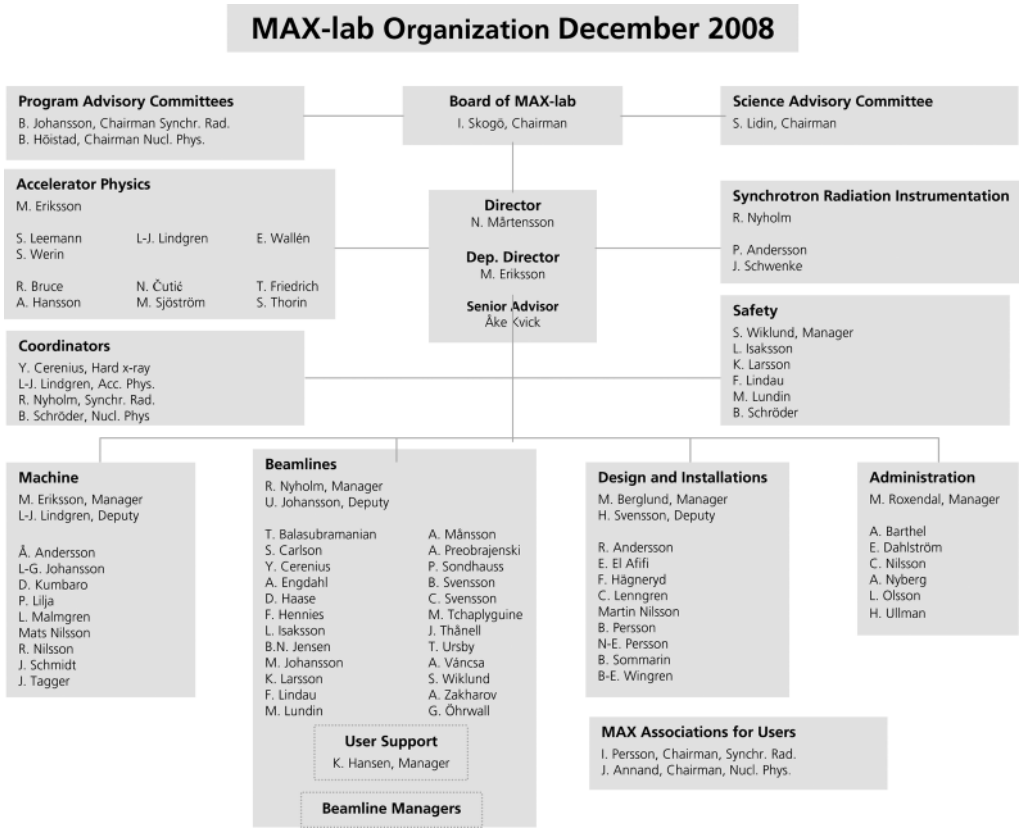
13.00–15.00 Discussion and comments about the activities at MAX-lab with Nils Mårtensson and a few representatives of the MAX-lab staff and Lund University

15.00–19.00 Closed meeting with the review panel for conclusions and preparation of the report.

Tuesday 5 May:

9.00–15.00 Closed meeting with the review panel for conclusions and preparation of the report.

APPENDIX 4: ORGANISATIONAL PLAN FOR MAX-LAB



The Swedish Research Council is responsible for granting operational funds to the National Facility MAX-lab, a synchrotron light facility in Lund, Sweden. The agreement in force from 2004 came to an end in 2009. A review of the MAX-lab activity was conducted during the spring of 2009, and the decision on continued grants was based on its results. The Review Panel of international experts declared that MAX-lab is an important facility for many fields of research in both Sweden and other Nordic countries and stated that the costs of MAX-lab are considerably lower than those of other comparable facilities. Accordingly, the panel recommended increased funds for the upcoming period. This recommendation served as guidance when the Committee for Research Infrastructures made their decision on the level of funding for MAX-lab for the period 2010–2012.

Klarabergsviadukten 82 | Box 1035 | SE-101 38 Stockholm | SWEDEN | Tel +46-8-546 44 000 | vetenskapsradet@vr.se | www.vr.se

The Swedish Research Council is a government agency that provides funding for basic research of the highest scientific quality in all disciplinary domains. Besides research funding, the agency works with strategy, analysis, and research communication. The objective is for Sweden to be a leading research nation.

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