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Why large research infrastructures can be built despite small investments?

MAX-lab and the Swedish research infrastructure

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This project has analyzed Swedish universities, set in terms of internationalization and new demands.

The project addresses questions about the on-going structural changes to the Swedish research and education system. There are three themes. The first theme raises the question about financing, the second about the universities as strategic actors and thirdly how universities interact with society, in particular the knowledge link between universities and businesses.

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Abstract

There is no clear-cut small-scale/large-scale divide in research policy. Even smaller countries attempt to have a presence in highly competitive fields, and do make important contributions in them (although much of their research is repetitive and follows rather than leads the 'research frontier'). Similarly, many small countries rely on international research facilities in large-scale and cost-intensive fields, but also maintain national facilities in these areas. How, then, has Sweden managed the small states dilemma in research policy? This broad issue will be analyzed by a focus on the evolution of a national research facility, MAX-lab. The MAX IV project is under consideration and preparation, and the MAX-lab organization has realized the challenges built in the project. Our material indicates that several of the issues that are confronting the Swedish research system (growing internationalization, needs for prioritization, new relations with the private sector, reorganization of universities, et cetera) are present in the case of MAX-lab. Its history – and its future – is the history and the future of Swedish research.

Introduction: Large-scale research facilities and Swedish research policy

Small states face a policy dilemma in research: how should a country that produces one percent of the total scientific output in the world, organize its research activities? Should it try to spread its resources evenly over the whole spectrum of research, to maximize its capacity to absorb results produced elsewhere? Or should it, instead, specialize in certain niches, to increase its international visibility, even at the price of 'ignorance' in many important areas? Should it try to develop its own infrastructure for expensive research fields, or should it instead maximize its participation in international research facilities?

The answer to all these questions is in many cases to try to pursue all of these strategies at the same time. There is no clear-cut small-scale/large-scale divide in research policy. Even smaller countries attempt to have a presence in highly competitive fields, and do make important contributions in them (although much of their research is repetitive and follows rather than leads the 'research frontier'). Similarly, many small countries rely on international research facilities in large-scale and cost-intensive fields, but also maintain national facilities in these areas. How, then, has Sweden managed the small states dilemma in research policy? This broad issue will be analyzed by a focus on the evolution of a national research facility, MAX-lab.

The Swedish research policy system is pluralistic. The institutional set-up in research policy is rather widely dispersed, i.e. many different policy agents have been set-up to implement (but also to some extent formulate) research policy. Policy coordination, on the other hand, has been notably weaker. Sweden has no designated ministry for science. Instead, research affairs are cohabitants with education, ranging from pre-school to graduate training in the same political setting. This political level is also, following the tradition of small cabinets and large administrative bodies, rather weak in its steering of the research system, mainly concentrating on the formulation of broader political goals. There have been attempts at coordinating research as a policy field, the first of which was taken already in 1962 when the governmental research committee, at the time chaired by the Prime Minister Erlander, was established. A new attempt at strengthening the 'steering core' was taken in the 1980s, when a system of three-year research bills was introduced, where all R&D policies were included in the same governmental bill. By this, coordination between policy areas was to be strengthened. A concerted effort was also expected to create political and financial space for more adventurous investments and initiatives.

After 20 years of a so called coordinated research policy at the central level, we can conclude that policy coordination is still relatively weak and that instances of concentration around a few broadly-based goals are rare. The research policy system has also been notoriously weak in identifying (and serving) needs for large-scale initiatives, with long delays in the decision-making procedure. In some cases, the government has relied on private sources (e.g. genomics, proteomics).

The administrative system is decentralized is a similar manner. Basic research has remained the cornerstone of the national research council's mandate, while industrial innovations and other types of 'applications' have been relegated to mission-oriented agencies with a special task to fund and support applied research and academic-industrial collaboration. The research councils themselves are also strongly decentralized in their decision-making structure, and resource allocation within and between research fields are primarily determined in a collegial manner. After a funding reform in the 1990s, international collaboration has been integrated into the activities (and funding portfolio) of the research councils (and today in the Swedish Research Council), together with the funding of large-scale facilities. Priorities for national and international collaboration as well as large-scale facilities are set by a government agency as part of its budgetary considerations. Thus there is no established structure through which the government could grasp the initiative and make policy reconsiderations to initiate an effort of the size necessary to establish a large-scale research facility. As we shall see, such initiatives must have their roots elsewhere. The formation of KFI – the committee for research infrastructure at the Research Council – can though be seen as a first attempt at least on paper to create such a structure within the system.

Some numbers that are rather striking may serve as an illustration. The Ministry of Education, in whose responsibilities are included research policy overarching management of all governmentally funded research in Sweden, employs a total of 9 people whose primary agenda is focused on higher education and research. At the Swedish Research Council, an estimate of 80 full time people works with research issues. Adding the governmental agency Vinnova, which might be considered an equally important player in the research policy field, about a hundred people are employed at governmental agencies for the task of governing the Swedish public research system. In total, the number of full time researchers at the Swedish universities and university colleges can be estimated to around 20000. These numbers – even though they are incomplete and represent only a rough estimate – makes a clear point: the power must lie elsewhere.

Still though, universities in Sweden have relatively weak steering systems, where resources generally are earmarked for so-called research areas (vetenskapsområden). Universities have the possibility of redistributing resources between research areas, but often follow the ring-fenced allocations from parliament (which in themselves follow historical resource trajectories). Universities therefore tend to have limited resources – and limited legitimacy – in creating and opening new areas, and redirecting resources for new and/or cost-intensive initiatives. Therefore, such costly and well-aligned targeted efforts within the university system are critically dependent on a university management dedicated to a long-term commitment to the research area(s) concerned, in practice meaning viewing them as central to attaining the university's strategic goals. Such commitments are not always easy to make, given the competition for funds always present within the university.

The Swedish research system is decentralized and strong on breadth, continuity and incremental reforms (and with a flexible deployment of resources), but relatively weak in taking joint and demanding initiatives. When new areas emerge, it is not necessarily one agency or organization that take the lead. The issues of who decides, who funds, who carries out the work are not easily resolved in a highly decentralized system. Sweden also has a history as a scientific player of some magnitude; i.e. there is an idea of expansion and breadth in the system. The belief that the Swedish research should be all encompassing remains strong. The ideal that Sweden could have a presence in highly competitive, highly internationalized fields is vivid throughout the system – from the laboratory to parliament. At the same time, budget restrictions continue to grow, and more or more areas compete over scarce resources. Priorities are therefore seldom explicitly set, and large-scale investments can become very cumbersome for the system to manage.

A large-scale research facility – defined as a demarcated piece of experimental equipment with a total construction cost of more than hundred times the average yearly salary of the experimenter dedicated to using it – is a good example of a large-scale project of the kind discussed above. Large-scale research facilities are typically thought of as particle accelerators and telescopes – experimental facilities with very limited disciplinary belonging which puts the obvious question of usefulness and priorities in resource allocation in focus. Facilities such as CERN (the European Laboratory for Particle Physics) or ESO (European Southern Observatory) operate at an extraordinary high cost, given that they support comparably small scientific communities. Translated to the local Swedish university case, a research facility need not be overwhelmingly huge or costly to qualify as large-scale also in this respect. Swedish universities traditionally have the task of facilitating a broad spectrum of disciplines, and the concentration of resources within the university to a large-scale research facility might in itself be considered controversial.

Increasing financial constraints, the challenge of new needs and demands, institutional change and the rearrangement of inner and outer boundaries are inevitable processes in the change of academic science. According to Ziman (1994, 2000) they are generally visible and evident throughout the whole system, and summarized under the concept of the dynamic steady state of science. This state is steady but not static in the sense that the unpredictable progress of scientific research will be forced to take place under severe resource limitations. At the same time and in close interaction thereto, institutional change and rebuilding of alliances will take place, all in all transforming the organization, management and performance of science into a new 'Post-Academic' reality. Science will thereby adjust to the steady state of a fixed envelope of resources simply by the loosening of previously rigid structures in new dynamic, changeable and unpredictable customs. An academic research institution need naturally not be large-scale or in any other sense stand out among others to be affected by – and become forerunners of – this change, although the most visible examples perhaps are the largest institutions. The case we are about to present as an insight to the structures and channels by which a research policy system of high ambitions but limited impact facilitates an initiative of extraordinary character might very well best be understood in the light of Ziman's PAS theories.

How does a generally weak research policy system like Sweden's handle an initiative of extraordinary character, such as MAX-lab? The question might be reformulated as to how MAX-lab as an institution manages to establish itself, develop and grow large-scale within the Swedish system. We will attempt to answer that question by closely examining the history of MAX-lab in its context of national and local interests, expansion of scientific objectives and instrumental opportunities, change of user demands and institutional response, and the continuous struggle to make do with a limited resource envelope: Where do initiatives originate? How do different levels of interest relate, and how do they collaborate? How are demands formulated, plans carried out and critical decisions taken? And how, given the weakness of the Swedish system and its institutional landscape, is a successful large-scale project undertaken?

MAX-lab, a Swedish National Laboratory

Synchrotron radiation was first detected in 1947 as the unwanted waste product of particle accelerators used in High Energy Physics for the purpose of colliding particle beams (Elder et al. 1947). The light produced by an accelerated beam of electrons is not just very bright and strong, its wavelength covers the wide spectrum from infrared radiation to x-rays (which includes visible and ultraviolet light), giving synchrotron radiation extraordinary good potential as a research tool. Since the 1970s, particle accelerators has been constructed for the sole purpose of producing the light, which has lead to enormous leaps in performance of the machines and vast improvements of the experimental techniques. Today, representatives from almost all disciplines within the natural sciences are frequent users of the light, and new application areas are constantly discovered and exploited. This not only makes synchrotron radiation one of the most useful experimental techniques in the natural sciences today; the continuous exploitation of new areas of usage during the past two decades has also given synchrotron radiation a status of very promising and full of possibilities also in a future perspective.

A typical synchrotron radiation laboratory is built around a storage ring, named that way because of its main purpose, to store the accelerated electrons that produce the light. Once a certain amount of electrons are injected to the ring's vacuum chamber, they run around at a velocity near the speed of light, passing through so called bending magnets and insertion devices, where they by changing direction in a given manner produce light.[1] The light is brought out of the ring to beamlines, where it passes a monochromator in which the preferred light with respect to wavelength and intensity is collected. Through a variety of optics devices, designed mainly to focus the beam, the light finally arrives at the experimental station (normally called end station), where the actual experiments are done. Depending on the technique, one single beamline can support several end stations.

The variables deciding what kinds of experiments are possible to conduct on a synchrotron radiation laboratory are multiple. Different experiments make use of light in different wavelengths, and every accelerator has its own technical characteristics and therefore specific possibilities regarding what kind of light can be produced. Down the stream, monochromators, vacuum chambers and detectors, along with a myriad of other technically particularities, decide what experiments are possible to conduct. This trivially implies the aforementioned wide variety of experimental possibilities, but it also means that beamlines to a large extent are built to be unique, also on a global level. A beamline perfectly suitable for one particular lab or ring may not at all be possible to mount on another ring, and if it were, might not at all give the same performance of experiments.

Beamtime, i.e. access to a running experimental station in a synchrotron radiation laboratory, is normally given to research groups on the basis of international peer reviewed competition. The principle for granting access to beamtime is common for most synchrotron radiation laboratories throughout the world, with minor differences. In principle, anyone can apply for beamtime, regardless of disciplinary, institutional or national belonging. The applications for beamtime at a laboratory are reviewed by an external peer review committee, who have been given the task of selecting the applications for allocation of beamtime on the basis of scientific excellence, usually meaning an assessment of the quality of the scientific case, the track record of the applicants, and the purely technical possibilities of conducting the experiment successfully. Beamtime is free of charge for everyone, with the only demand that the

[1] A storage ring is never really a ring, but rather a polygon. The bending magnets are located in the angles of the polygon and the insertion devices (so called *wigglers* and *undulators*) at the straight stretches. When the electron beam is bended by a magnet, it looses energy that is emitted in the form of synchrotron light. Wigglers and undulators are collections of a large number of different magnets that bend the electron beam back and forth several times and thereby cause energy loss and light production. With wigglers and undulators, light of a greater focus and intensity is possible to produce. Normally only one beamline is set up per bending magnet or insertion device, making the total beamlines possible for a ring to support exactly twice the number of angles in the polygon. (Margaritondo 2002)

results be published. Many laboratories also offer industrial users the possibility to buy beamtime.

MAX-lab is a Swedish national laboratory for synchrotron radiation research, located on the northern university campus of Lund University. MAX-lab operates three storage rings with a total of about 15 beamlines,[2] and also facilitates a research program in nuclear physics. MAX-lab is run as a so-called special entity ('särskild verksamhet') within the university, which means that the university is the formal employer of the staff. The operation of the facility is however the responsibility of the Swedish Research Council, which supplies an annual operational budget of about SEK 60 million. The laboratory is governed by a board, composed by two representatives from each party of interest, the university, the research council and the user association, and an independent chairman. The board appoints the director and the committees. Beamtime at MAX-lab is granted through applications that are reviewed once every year by the Program Advisory Committee (PAC). Formally, no considerations other than those regarding scientific excellence are made when beamtime is allocated. In practice, there are exceptions of this, which we will come back to later. MAX-lab is mainly an academic institution. Not only does it function more or less exactly as any department within the university structure; management and operation of the laboratory has a stamp of academia. The machine group, responsible for running the storage ring, consists mainly of the same people as the university department for accelerator physics, headed by professor Mikael Eriksson. The coordinator for the synchrotron radiation activity is also professor of synchrotron light instrumentation, Ralf Nyholm. The close ties and the near collaboration between the laboratory and its host university, manifested partly by this coordination of academic activities and laboratory operation is regarded an important link between the cultural belonging of the user community and the management of the lab. To some extent, these matters are manifestations of the healthy relationship to the host university. In the latest Swedish Research Council's Review of the Swedish National Facilities, this is strongly emphasized: "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." (Vetenskapsrådet 2002).

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[2] Counting the beamlines at MAX-lab can be done in different ways, depending on what one chooses to name an individual beamline or end station. The number 15 is therefore an average with the reservation to give or take three.

The definition of large-scale research facility used in the beginning of this chapter, namely that a facility is large-scale when its complete setup of experimental equipment has a total construction cost of more than hundred times the yearly salary of the average user, is indeed applicable on MAX-lab. It might be appropriate to point out here that so far not having used the term Big Science is deliberate. Big Science is a concept to which is attached a great deal of ambiguity, partly due to a transit of the term from scientific to popular culture and thereby from the vocabulary of analysts of scientific practice and policy to the language of all and everyone, which points at its "linguistic attractiveness" and "analytical intractability" (Capshew & Rader 1992). The terms large-scale and small-scale facilities, on the other hand, are easily defined as above and not loaded with rhetoric power. They might therefore very well be used to highlight important and interesting characteristics at the core of the synchrotron radiation facility, perhaps especially MAX-lab.

The synchrotron light source laboratory is a large-scale facility for small-scale research. Most experiments conducted at MAX-lab are done by groups of less than five people, undertaking research projects funded and organized in an ordinary academic manner. Nothing distinguishes a group doing experiments at MAX-lab from its counterparts in the home institution not using synchrotron radiation, of course apart from the fact that they happen to be traveling to Lund from time to time. This combination of small-scale and large-scale might seem trivial, but two things related to this are important to remember for the following. First, a large-scale facility supporting a great number of small-scale scientific projects from a wide range of disciplines can be built and developed step-by-step, growing gradually from small to large as new user groups continuously are added. This might actually undo the fact that policy formulation, coordination and implementation needs to be strong in order to make it happen. Second, the representation of a wide variety of scientific disciplines among the user community might prevent disputes over distribution of funds and asymmetric research investments. This would in turn ease the overall process of establishing consensus around decisions and gain policy stability in a dispersed system. Let us keep in mind these corollaries of the above large-scale/small-scale conceptual reflection when we now start the account of the history of MAX-lab.

The offspring of particles and politics

Against the background of synchrotron radiation based research being the originally unwanted child of particle physics, it is somewhat ironic that the first steps towards MAX-lab was taken in the outcome of a rather distressing debate over Swedish involvement in the upgraded joint European particle physics laboratory CERN II. In the beginning of the 1960s CERN – located in Geneva and once upon a time the first European inter-governmental collaboration after World War II – found itself in the midst of the 'energy race' between the scientific efforts of the two superpowers of the time. At the time, an upgrade of the laboratory (which meant the construction of a larger accelerator) was deemed necessary (Krige 1996), but the effort was initially regarded as to big for the existing organization and inter-state collaboration and was therefore treated as a second, independent research program and laboratory.[3] For Sweden as well as many other countries, this lead to the first real science policy debate over CERN, containing the nowadays well-known arguments of utility, purpose and domestic resource scarcity. The eventual decision – that Sweden should join the so called CERN II – was based mainly on considerations of Swedish scientific 'reputation' in Europe and pressure on the highest Swedish foreign policy level (Hadenius 1972, see also Widmalm 1993).

At the same time, accelerator physicists in Lund had been constructing their own accelerator for nuclear and particle physics experiments. This accelerator, called LUSY (Lund University Synchrotron), was of a comparably reasonable size, measuring only a few meters in diameter, and had its home at the department of physics in Lund. As a result of the rather significant Swedish science policy decision to join the 'new' CERN collaboration – and thereby concentrating the financial efforts on particle physics research on the laboratory abroad – LUSY:s financial support from the Swedish Atomic Research Council (Atomforskningsrådet) was discontinued, with the effect of the closing down of the whole project. The surrounding research group, who had anticipated the coming end of LUSY and therefore had extended their activities to cover other areas and conducting experiments on other accelerator laboratories abroad, took the opportunity to plan a new accelerator project based in Lund, with new and complementary performance and scientific opportunities. A combination of scientific and engineering talent and vision, great support from the rector and central administration of the

[3] Even the location of the new laboratory was under discussion, despite the site of the existing CERN lab in Geneva. In Sweden as in most other member countries discussions took place on whether to apply for hosting the lab. However, it was eventually decided that the laboratory should be located at the same site as the original one.

university and the research council's request for the group in Lund to reformulate their research program, gave rise to the MAX concept. The council, as well as Lund University, acted vigilantly positive, and the plans could continue to live. During the rest of the 70s, the MAX accelerator was built piece by piece, with no overarching financial support but with the aid of several smaller budgetary contributions continuously granted the MAX project group. By the end of the decade the accelerator in itself, "the naked MAX", was financed, but the group was lacking money for experimental equipment for nuclear physics research. Some lively ambassadors of a new experimental technique under the name of synchrotron radiation came to their aid.

Towards the end of the 70s, when the problem of financing the MAX accelerator project was almost solved, the planned research activities of the project were still entirely focused on nuclear physics. It is possible to elaborate on the thought that the research council, having agreed to fund the ring itself but not the intended research programs, had a rather pending attitude towards the MAX project. This is not to be treated exclusively as a historical oddity, but rather as an illustration of the contrasts between the general science policy approach towards well-known nuclear and particle physics accelerator projects and the coming synchrotron light research programs. Undoubtedly though, the inclusion of synchrotron light in the MAX project caused a clear shift in the attitude from the Swedish research councils.

Ideas had been drafted already in the mid-70s that the MAX accelerator could be used for producing synchrotron light, and through the initiatives of a few visionary people, proposals for funding of a "National Synchrotron Light Source" were submitted to the research council, with the clear intention of expanding the purposes of MAX to include the production of synchrotron radiation. Although according to Forkman (2001) people on central positions in the Swedish research councils regarded synchrotron light a "high risk project" (a fact that we will have reason to get back to later), key persons with experience of the growing interest of synchrotron radiation based research in the United States raised positive voices for the idea early on, and with the growing support from both the MAX group and related research groups in Linköping, Gothenburg and Uppsala, the work group appointed by the research council to inquire the possibilities of expanding the MAX project to include synchrotron light soon stated its support of the project. It is highly appropriate to question the possibilities of survival for the accelerator and nuclear physics program if not the idea had been raised to devote the MAX project partly to synchrotron light. It is also somewhat significant to the story of MAX-lab that the eventual main purpose of the laboratory – to function as a national research facility providing synchrotron light to experimenters – was not included in the original plans for the laboratory. Making ends meet with funding and organization of the laboratory and research program seems to have been an ever-lasting series of obstacles to overcome, but the MAX group continued to work on the accelerator, seemingly unaffected by matters of money. In 1979, the MAX accelerator was inaugurated, still located in the experimental hall where once LUSY had been running. A few years later, MAX was moved to a larger building, so that space could be given to beamlines and end stations.

During the following years, the potentials of synchrotron radiation seemed to become evident to both policymakers and scientists at most levels of the research system in which MAX found itself. Once it was established as a synchrotron light source project, MAX' potential as a large national scientific resource was recognized by central Lund University officials. In 1981, the board of the university laid down the statutes for MAX-lab, in which it was clearly formulated that the laboratory was a common facility for Swedish science, and that international researchers also should be granted access to the laboratory. Already at this point, before MAX-lab got its status as National Laboratory, an organization was established that ensured close contacts with both the research council on national level and the host university locally. MAX-lab gained its real entrance on national policy level in the government's budget proposition of 1982. There, the wide potential of synchrotron radiation was acknowledged, and MAX-lab was mentioned as a possible "unique" piece of research infrastructure for both Sweden and the Nordic as a whole. The government granted the project a financial contribution to cover expenses related to the national use of the facility, "as a first step". In the same paragraph the governmental ambition to establish MAX-lab as a national research resource is stated. When MAX I was inaugurated in 1987, it had the status of a Swedish National Laboratory (Forkman 2000).

Home made accelerator, home made organization

Important to remember here is the means by which the original storage ring MAX I came into being. It is widely recognized that MAX I was[4] a 'homemade' accelerator. This trial and error work mode of the MAX group when building the accelerator had its part to play in the success story. 'Homemade' accelerator refers primarily to the technical design. MAX I was built piece by piece and under severe budget constraints, which meant that the accelerator group, lead by 'the Wizard' Mikael Eriksson, never really knew whether the project they were devoting years of their lives to would ever be finished. The construction of a piece of comparably large-scale research infrastructure under such conditions is not only a rare exception but also a fascinating story. It does also play an important part in the eventual success of MAX-lab, not least in the narrow and purely technical sense that it forced the accelerator group to design and construct its machines at the cutting edge of both technical and financial effectiveness. Rather unnoticed, in the shadow of the larger players in the field, extraordinary technical solutions have been developed at MAX-lab. Some would claim that neither MAX II nor MAX III would ever have come into being if it weren't for the innovative skills of the machine group, skills that – it is claimed – can only be learned when one is forced by a limit of financial resources. But shortage of funds and the amazing technical innovativeness of the machine group also had its obvious effects on the organization surrounding the accelerators. This has lead to the evolving of a complex, diversified and rather fluid organization of MAX-lab. In contrast to other laboratories of comparable size, MAX-lab is to a large extent organizationally dependent on informal and decentralized decision-making processes.

As already mentioned, the experimental stations at a synchrotron light source are separate entities with technical specialties of their own. A complete beamline with experimental station is normally just as costly as an accelerator ring to build, which makes the whole laboratory a kind of assemblage of very specific and costly separate entities. In effect this means that no complete experimental setup at MAX-lab has ever been a fully financed from the start. Although the research council(s) and the Wallenberg foundation together stand for the most part of the financing and all initiatives are coordinated centrally at MAX-lab, every project has been organized and funded on its own; the three storage rings, the injector, and the total of about 15 beamlines. The operation budget of

[4] And is. MAX I is still running, supporting both the nuclear physics research program of MAX-lab and producing synchrotron light for experiments.

MAX-lab has never had the scope for planning, designing and building beamlines. Instead all of the beamlines and experimental stations have been thoroughly constructed by external groups in collaboration with MAX-lab staff. In some cases even the continuous maintenance and administration of beamlines has been 'outsourced' to the groups involved in design and construction.

This way of financing a National Laboratory and large-scale research facility is an immediate consequence of the pluralistic and dispersed Swedish research policy system. It has always been the articulated policy of the Swedish research council(s) that experimental equipment at MAX-lab for the most part should be financed separate from the annual operational budget provided by the council. As an example, the operating costs of MAX-lab 1998-2002 was 83,6 MSEK, while funding of scientific equipment[5] at MAX-lab, in other words funds applied for either by MAX-lab as organization, in-house MAX-lab scientists and other staff, or external groups of researchers with ties to the laboratory, amounted to 171,6 MSEK in the same period (Vetenskapsrådet 2002). A beamline project at MAX-lab has its typical origin in initiatives among the various informal networks of user groups and communities. Such initiatives are developed and refined into concrete proposals through the informal and formal management structures at the laboratory. The importance of the informal mechanisms in this process is stressed by the fact that the real origin of the initiatives, along with the original reasons for appointing a certain external group of researchers to the design and development of the instruments, are nearly impossible to trace. In the words of the managers, administrators and committee members of MAX-lab, as well as the researchers, initiatives of this kind just "happen".

This has two peculiar organizational dimensions. First, the separation of funds for the facility in the categories operational costs and funding of scientific equipment marks a principally important decentralizing function, reinforcing the small-scale/large-scale divide and thereby – as we would argue – making the facility possible at all for the stakeholders to handle. This is because of the mentioned weakness of the Swedish research policy system, in which the scientific community as a whole and in the specific fields covered by MAX-lab, the host institution (Lund University) and the formally responsible governmental agency namely the Swedish Research Council all are situated.

[5] Including funds not only from the research council(s) but also from private foundations and companies.

Second, the division of funding channels gives rise to decentralization also in the internal organization of MAX-lab. Through different formal or informal agreements, specific research groups are given rather significant responsibilities for parts of the scientific instrumentation in the lab. The design, construction, commissioning and continuous maintenance of scientific instrumentation of the kind at MAX-lab are heavily demanding activities, and there is simply no way MAX-lab could put up neither the money nor all the skilled personnel required, partly because the financial resources for such activities would rather be found in the funding of scientific equipment than in the operational budget. Therefore the responsibility for experimental stations, from the writing of the application for funds in the design phase down to user support and technical maintenance when the equipment has been taken into usage, has been to a large extent given to external groups. Applications for funds for experimental instrumentation can be written by any group and submitted to the Research Council's special body for 'expensive equipment' ('dyrbar utrustning'). The choice of the lab as to which projects to support in the referral process – and thereby what experimental equipment the lab chooses – is done by the Program Advisory Committee on mission from the board. This way, initiatives always come from the users, but the final decision what instrumentation to build is divided between MAX-lab and the Research Council.

To compensate for the money and time certain external groups are devoting to instrument development at MAX-lab, they are given special privileges in the beamtime allocation process. At two beamlines, so called PRT:s (Participating Research Teams) have been established as the model for this. The normal peer review procedure of beamtime allocation in the Program Advisory Committee (PAC) is then short-circuited and the PRT:s are given a specific amount of the scheduled beamtime to allocate to experimenters within and outside the PRT on their own account. At one of the beamlines in question, I511, the PRT is given 75% of the scheduled beamtime, and they are required to use at least 25 of those 75 percent for so called collaborations, where they invite external groups to use the beamline. At the other one, I311, 50% is given to the PRT and 25 is required to go to collaborations. Even though only two of the beamlines at MAX-lab have so called PRT arrangements, all of them have come into being by the help of people and money external to MAX-lab. At beamlines not equipped with a PRT, the Program Advisory Committee is supposed to take into account the work done by external groups when beamtime is allocated, though of course only after the scientific merits of the applications have been judged. The routines and procedures by which arrangements of this kind are done are not always crystal clear. No formal regulations exist for the Program Advisory Committee to rely on when allocating beamtime on the basis of external groups' investments on the beamlines. The contracts between the MAX-lab management and the PRT:s are either outdated or non-existent, and in fact not all members of PRT:s know what is exactly stated in those contracts. These are unmistakable examples of the informal organizational structure developed at MAX-lab. Many agreements are made on the basis of informal relations and trust and many responsibilities are carried out on the basis of personal devotion or the day-to-day recognition of immediate needs. This comparable lack of organizational structure is probably at least partly the result of MAX-lab being a thoroughly academic project, a small-scale initiative that has grown evolutionary through the years, as opportunities has been given or coincidences have concurred. Some involvement of traditional academic organizational features can be detected, such as the existence of an 'Old Boys Network' that makes the establishment of formal agreements and writing of contracts unnecessary, and a general 'Barter Economy' of which the above described arrangements on beamlines with no PRT is a good example.

The system has strong advantages. The 'outsourcing' of beamline planning and construction – in some cases even operation – is the extreme of an important planning strategy used by most large-scale laboratories in the world. Scientific planning and development of instrumentation – on the short-term as well as long-term – need always be done in close proximity to the existing and potential users. Often the experimental techniques and sophisticated specialties of instrumentation demand not only continuous collaboration with advisory committees of experts but also active involvement of the users. Most laboratories have learned this, and initiatives are often summoned at conferences, further developed at special meetings with potential users and sometimes even the temporary engagement of researchers in the construction phase on site. The direct 'outsourcing' of instrument development through the agreements with certain external research groups means in practice that the users build their instruments themselves. This can be seen as strengthening of the already important small-scale/large-scale divide, but it is also a kind of ensuring scientific excellence or usefulness. Formulated in a rhetorical question, what better expertise in instrument development are to be found than the ones that will use the instrument? The aforementioned Review of the Swedish National Facilities acknowledges this: "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" (Vetenskapsrådet 2002).

Expansion and growth

MAX I opened for experiments in 1987. Ten years later, in 1997, the 1,5 GeV storage ring MAX II opened, marking a major upgrade of the laboratory making possible the expansion of the areas of research to eventually include structural chemistry, biology, medicine and pharmaceutical sciences. Such research is done with the use of light of a shorter wavelength, so called hard x-rays, which for technical reasons aren't possible to produce with the MAX I ring. The opinions differ among the key persons in the MAX-lab history whether it was at all recognized during the planning and design phase of MAX II that the ring could be used also for producing hard x-rays. Clear though is that the MAX II initiative didn't primarily build on the ambition to expand the scientific possibilities to new disciplines but rather on the will to unleash a more powerful scientific resource to the existing user communities. In the written motivation for the grant, the Natural Sciences Research Council (NFR) mentions only the disciplines atom physics, molecular physics and condensed matter physics among the disciplines supposed to benefit from the construction of MAX II (Forkman 2000)[6].

But powerful it was. Two important things made MAX II large-scale as opposed to its predecessor MAX I. First, it was an aligned effort, a coordinated initiative from a purposeful group of machine constructors, instrument developers and forefront researchers. This meant that it got attention and became an 'issue' in the whole of the Swedish research policy system, from university department level up to research council or even ministry. Second, it did indeed expand the scientific opportunities at MAX-lab, which increased the number of stakeholders and made the project engage a larger number of discussants. The debate that followed must be seen in this context. In a short-term and hands-on perspective, the arising question of course concerned the financing of

[6] The council furthermore states that "MAX II in a highly favorable manner complement the Swedish commitment to research with x-rays at ESRF in Grenoble" (Forkman 2000). As opposed to MAX II, ESRF (European Synchrotron Radiation Facility), a joint European facility, was already on the drawing board supposed to cover a wide wavelength spectrum and serve a broad community of users also from chemistry, biology and medicine.

the facility as such, but the amount of money eventually granted to the construction of the ring did not amount to more than about SEK 60M in today's prices. The real pledge, done by the council particularly in that they commit to make funds available for scientific instrumentation and running costs[7], and by the Swedish scientific community in general, in that they agree to add MAX-lab to the envelope of natural science research projects of national interest, is a far greater one. Some influential biology and chemistry representatives in the council opposed, primarily with the argument that MAX II was a physics laboratory with possible areas of expansion in other natural science disciplines, but far to much of a gamble given that the real scientific opportunities for biology and medicine weren't sufficiently investigated. Arguments were also put forward that a project of this size would kill other initiatives for a long time ahead, initiatives that not necessarily were scientifically competing but for which no financial resources would be left if the commitment to MAX II was to be made. It is said that the eventual success of the project within the council, which lead to the government decision in January 1991, was the work of a few dedicated individuals who managed to convince the council of the project's importance for the broader Swedish scientific community. It is not at all a rash conclusion that the real leap for MAX-lab onto the national scientific stage was taken through MAX II. Things did evolve one after another and MAX II is not even at present date equipped with end stations to make full use of its potentials.[8] As mentioned earlier though, the decision taken by first and foremost the council but also the various actors in the decentralized and informal Swedish research policy system in the early 1990s to give MAX-lab its full support, was a long-term and large-scale commitment.

Expansion of scientific opportunities means expansion of user community, and most important is perhaps the development of beamlines and end stations for structural chemistry, biology and medicine. Voices have been heard claiming that the 21st century is the "century of biology", and one of the initiators of the structural biology beamlines at MAX-lab, professor Anders Liljas at Lund University, calls MAX-lab "Our Hubble Space Telescope". Regardless of the rhetorical attractiveness of such statements, MAX-lab as a whole has only gained from the broadening of scientific base, especially when taking into

[7] Which indeed is not a bargain. The money needed for beamlines and experimental stations, including day-to-day operation, maintenance and occasional upgrades has so far amounted to more than twenty times (average) the grant for the 'naked' accelerator (Vetenskapsrådet 2002).

[8] This is said with the reservation that the 'full potential' of MAX II is not easily grasped, and the step-by-step construction and commissioning of scientific instrumentation at MAX-lab is still ongoing, due partly to the fact that new areas of application are continuously discovered and investigated.

account that industrial firms have been engaged in the laboratory as a direct consequence of the expansion to pharmaceutical applications. With the widening of the scientific base, MAX-lab has grown in importance for the whole of the Swedish scientific community.

Extensive involvement of users

MAX-lab was initially a small-scale university laboratory and the MAX I ring was originally planned and designed to support only a marginally larger user community than the one already found within the department of nuclear physics at Lund University. Hence including synchrotron light in the plans for MAX-lab meant not only a technical revision of the laboratory but also a complete change of perspective in terms of flexibility and outreach. At the time, synchrotron radiation was a relatively new experimental tool, and it is reasonable to claim that no immediate user community was to be found within Lund University. Instead, would-be user groups from other Swedish universities responded to the MAX-lab plans and became associated with the laboratory early on. This was especially the case for Uppsala.

Professor Kai Siegbahn at Uppsala University had won the Nobel Prize in Physics 1981 "for his contribution to the development of high-resolution electron spectroscopy" (Nobel Foundation 2006), immediately turning Uppsala into the "capital of spectroscopy" and making possible the extension of the experimental groups at Uppsala University Department of Physics. Even though it is told that Professor Siegbahn himself initially kept a very skeptical attitude towards synchrotron light and MAX-lab,[9] other groups identified the possibilities to develop the technique further with the help of synchrotron light. The largest MAX-lab user group subsequently established itself in Uppsala during the years of construction of the first MAX I beamlines, and took part in planning, building and commissioning of instruments from the beginning. Also smaller groups in Linköping and Gothenburg joined in the preparations. In this early history of MAX-lab, two things are especially important to note. First the fact that these groups were exclusively physicists, and second that the users came from elsewhere in the country (and to a small extent from abroad), particularly Uppsala.

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[9] It is said that Professor Kai Siegbahn regarded MAX-lab a rival institution to his own. Later, when results started to arrive, he is said to have grasped the possibilities of synchrotron light and become a great supporter.

Generally, one can say that MAX-lab was a designated physics laboratory before the opening of MAX II. Not only was the lab initially planned and designed to be a nuclear physics lab, the first beamlines and experimental stations were built by and for physicists. In comparison with MAX-lab and its users today, this meant that the early user community was both very small and relatively homogenous, not only with respect to academic discipline but also work mode. The later development of the MAX II ring and the beamlines for structural chemistry, macromolecular crystallography and the like, has broadened the user base significantly in numbers, but has also meant that the laboratory as experimental site has become heterogeneous and multifaceted with respect to the everyday work of the experimenters. Broadly, two distinct groups of users nowadays populate the laboratory. The first type generally consists of surface physicists, condensed matter physicists, or atom physicists. One of the main distinguishing characteristics of most physicists using synchrotron light for experiments is that they tend to be scheduled in longer blocks of beamtime, sometimes up to three weeks and seldom or never shorter than one week. Most physicist MAX-lab users call their own laboratory work "experiments" and in general they need to maintain a solid base of knowledge regarding the whole laboratory's technical system, from the vacuum tube, the magnets and the insertion devices down to the monochromator, the optics and the experimental chamber at their own station. Even though it is claimed to be decreasing, the general interest in instrument development and design and construction of beamlines and experimental stations is high among these users. Both of these features have to do with the dynamic and generic nature of the physics experiments done with synchrotron light. The quality of the output data of the experiments is decided by a large number of factors, all of which must be known and corrected by modification of different pieces of the equipment on site. In the words of one experimenter, a beamline and experimental station is "like an old car (…) everything is not always working perfect." It is crucial for these researchers to know the experiment and the instrument good enough to be able to identify inaccuracies in the output data and judge whether it is caused by insufficient quality of their measured sample or the technical system of the instrument. For these reasons, physicists often work in close collaboration with technical support staff at the beamlines and in-house scientists.

Opposite to the typical physics users are the crystallographers. These users have a usual beamtime block of one or two days and their work is generally of a routine character, meaning that the experiment in itself is standardized and often involves very little if any technical modification and optimization of the equipment. The common way to refer to work of this kind in the laboratory is not as 'experiments' but 'measurements', also among the researchers themselves. Determination of a protein structure by hard x-ray light from a synchrotron is a procedure with a critical phase, but not in the direct use of the light but in the preparation of a crystal to measure. Preparation is always done in the home laboratory, and the work at the synchrotron radiation laboratory is the standard procedure of mounting a crystal at the experimental station and collecting the data. It is the quality of the crystal and not possible inaccuracies of the instrumental setup that decides whether a measurement is successful. Therefore the demand for deeper knowledge or understanding of the inner secrets of the accelerator is very low. Exceptions do of course exist, but crystallographers are in general satisfied as long as the light is on, and they care very little about the possible reasons for beam loss. If possible, these users would probably be happy to let someone else do their measurements at the synchrotron. The fascinating concept of remote control measurements, developed among others at the ESRF (European Synchrotron Radiation Facility) in Grenoble, France, has been introduced to meet exactly these demands; users can send their crystals per mail to the synchrotron and handle over to in-house personnel to do the actual work, themselves only monitoring the procedure over the Internet.

As mentioned earlier, the original user community at MAX-lab consisted solely of physicists. The small size and informal character of the organization made these original users very influential on the institution and organization. Even though the ambition is clear to keep disciplinary variety in all committees, in the board and the staff, MAX-lab is to a large extent still run by physicists, and mainly physicists from the original small group of MAX-lab enthusiasts. In pure numbers of users, there is nowadays only little domination of physicists in the laboratory. For the academic year 2004-2005, the total number of registered synchrotron radiation users was 572, of which 281 (approx. 49%) were physicists, 126 (approx. 22%) chemists, and 165 (approx. 29%) had life sciences as disciplinary belonging.[10] Here is important to point at the fact that the category of users

[10] These numbers are not absolutely accurate, and the disciplinary borders are somewhat fuzzy. The numbers are based on the user's own registration; every user is supposed to log in to the computer network and submit name, home institution, beamline used, beamtime period, supervisor of the experiment and discipline. There are no real restrictions on this – some users neglect to register but are granted access anyway, they are therefore not included in the statistics. Also the disciplinary division

described above and coined 'physicists' corresponds fairly well to the user group named 'physicists' in the user statistics. Although the numerical domination of physicists in the lab is diminishing, it is clear that the physicists in most cases still are the most influential user group. This is of course due to physicists generally spending more time in the laboratory and interacting more with in-house scientists, technicians and administrative staff. These users are also to a larger extent involved in lab questions over injections, beamtime schedules, organization of maintenance tasks and the like, since these are matters often directly or indirectly affecting the scientific performance of their experiments. Generally speaking, he overall relationship between the visiting physicists and the laboratory is thus of a rather different kind than the one between life science or chemistry users and the laboratory. Exceptions are of course normal and variations great. All in all, these differences in user-laboratory relationship that build on the general work mode differences between user groups, has meant that the physicists still enjoy a dominating position in the laboratory. This is not at all to say that physicists or members of a particular branch of physics has privileges over other user communities in any of the formal processes by which the continuous MAX-lab scientific mission is carried out. The main point is that the differences between disciplines and user communities are valid and evident also when it comes to the organizational development of the lab. The ongoing process of extending the scientific base to cover other areas and disciplines continues to place new demands on the organization, as new users with a sometimes radically different experimental work mode and atypical relationship to the instruments are to be served. One immediate consequence is the 'loyalty' of the users. During the academic years of 2003/04 and 2004/05 the structural biology beamline I911 at MAX-lab experienced severe technical problems, which both decreased the number of beamtime shifts granted to users and of course had negative impact on some users' experiments. This lead to a measurable decrease in applications for the coming years, indicating that the crystallography users react quickly to bad machine performance and take their experiments elsewhere, which is confirmed by MAX-lab staff. The often self-chosen lack of interest in the technical performance of the ring, the beamline and the end station equipment is thus coupled with a lack of patience with operational instability and technical problems. Nothing of the like has happened at physics beamlines. This example is put forward primarily to point out the possible challenges that meet the laboratory when new user groups from other disciplines, with different habits and demands, are to

between physics, chemistry and life sciences is not exact: users may choose their own disciplinary belonging during registration, between these three broader areas.

be served and supported. Perhaps the scientific disciplines shouldn't be given too much emphasis is this respect; there is always a problematic dimension of ascribing certain characteristics or common behavioral patterns to disciplinary or sub-disciplinary groups. The differences in work mode, interaction and relationship to the laboratory put forward in the above are not claimed to be valid for any other representatives of the mentioned disciplines but only the groups under study here. Elevating the groups of physicists that once built MAX-lab to this level of importance is only an attempt to put further emphasis on the existence of a very strong and important academic culture of MAX-lab, a culture with continuously growing demands put on it to communicate and collaborate with representatives of several other academic and non-academic cultures. Industrial usage has entered at MAX-lab but hasn't so far become a large enough portion of the activities for general conclusions to be drawn, but the extension of user communities in new disciplinary directions has had highly visible effects that serve well to symbolize the challenges an academic culture can meet when its areas of interest are broadened.

It would be reasonable to assume that at least part of the reason for Lund University to commit to hosting the MAX-lab project would have been the possibilities for existing university departments or research groups to benefit from the establishment of a synchrotron radiation source at the university campus. Strangely enough, this was not at all the case: Although potential users of course existed, their number was not big at all and their interest has been described as moderate by Forkman (2000) and others. The real potential user community was to be found in Uppsala, where Nobel laureate Kai Siegbahn led the progress in high-resolution electron spectroscopy. The physics department in Uppsala quickly became an important external hub of synchrotron radiation users, and has continued to function as important external collaborative institution for MAX-lab ever since.[11] Most interesting is perhaps not the over-representation of Uppsala physicists but the initial under-representation of Lund physicists. It is realistic to ask the question how an initiative like MAX-lab could earn its support from the central university administration and the faculties without being a project with clear advantage for Lund to pursue. The answer and one key to the history of MAX-lab might be that the actual case – MAX-lab initially not giving advantages to

[11] Three of the perhaps most important positions within the MAX-lab organizational structure were until recently held by Uppsala professors: the director of the laboratory Prof Nils Mårtensson, the chairman of the Scientific Advisory Committee (SAC) Prof Joseph Nordgren, and the chairman of the Program Advisory Committee (PAC) Prof Börje Johansson. 41 individual users from the Department of Physics, Uppsala University visited MAX-lab in the academic year 2004-2005.

specific areas with already strong positions within the university – made it easier for the university to handle the initiative. In the large university structure, competing interests from different disciplines are probably easier convinced to give their support to a project that is not favoring one or a few of them.

Outlook: The next step

MAX-lab have developed evolutionary from a small-scale nuclear physics project well within the frames of an ordinary university department to a national facility with a mission to serve the whole of the Swedish natural science community and a great portion of international users. We have pointed before at the fact that synchrotron light sources are flexible laboratories also in the purely technical sense; instruments may be substituted, new areas of application may be added and the scientific user base extended. This has been the case with MAX-lab, and still is. The ambitions of the in-house staff, the committees and the directorate to constantly look for new improvements and developments of the scientific possibilities of the facility – at every level – might best be understood by the metaphor used by MAX-lab's present director, professor Nils Mårtensson, that MAX-lab in itself ought to be seen as "a giant research project". The ambition and determination to constantly reach for a new development or optimization is vivid within MAX-lab, and is largely due to the academic nature of the laboratory. Therefore, new projects continuously get drafted.

At present time, the largest scientific project ever in Sweden is planned at MAX-lab, namely the new ring MAX IV with surrounding laboratory. MAX IV is at the same time an overwhelmingly great leap and a natural next step in the development of MAX-lab. The user community has grown continuously since the opening of MAX-lab, and it is judged to have a potential of expanding for many years to come. MAX IV is more than an upgrade of the existing facility, it is by and large a completely new project and – should it be realized – the ultimate commitment of Sweden to become one of the leading European countries in synchrotron radiation. On the policy level therefore MAX IV is an overwhelmingly large project, especially given the premises. On the scientific level however, it is only the natural next step. The gradual evolving of leading expertise in accelerator physics and synchrotron radiation instrumentation, along with the piecemeal establishment of front-end scientific research in the related field places the demand for upgrade and expansion. The synchrotron radiation user community have kept and managed the initiative during the whole history of MAX-lab. The fact that the very same user community now has its focus on MAX IV makes the project an inevitable consequence of history.

At the same time, MAX-lab operates within the dynamic steady state. Along with expansion and upgrades comes the broadening of areas to cover, the extension of existing alliances and the establishments of new ones, and not least the rearrangement of institutional practices. Nobody would disagree on that MAX-lab so far has been a success story, given the constant resource scarcity. In the words of the Research Council's review panel, MAX-lab "provide remarkable scientific output" in proportion to its operating budget (Vetenskapsrådet 2002). Some things that have evolved as results of the resource scarcity are important to keep also when MAX IV is established, such as this effectiveness and the generally excellent ability to stimulate and facilitate initiatives from the grass roots of the user community. The fluid and informal organizational structure and the barter economy-like short-circuiting of the peer review system through the PRT:s and the informal agreements are though severely improper in a larger laboratory establishment. The real challenge for the management of the laboratory is the walk on the tightrope between the transformation to a more appropriate laboratory organization and the keeping of the healthy climate of commitment and spirit.

Conclusion: MAX-lab is a microcosm of the Swedish research system

The evolution of synchrotron light based research, and in particular its widening circle of applications and the ensuing demands for a different scale and scope of synchrotron lights facilities, highlight both the opportunities and limitations of the Swedish research strategy. MAX-lab emerged as a result of a combination of piecemeal solutions, bottom-up approaches, local initiatives and a do-it-yourself strategy, and decentralization. It was never anticipated that a facility like the MAX-lab of today should emerge. It was a local initiative that grew in an evolutionary manner, eventually gaining a broad constituency. Therefore, we might coin MAX-lab the laboratory that was never intended to be. The key conclusion here is the highlighting of the inability of the system to anticipate the eventual outcome of the project. It was not until results showed and the internal scientific reputation of MAX-lab was somewhat established that policymakers to a greater extent realized its success and its potential. Synchrotron light is a rather new experimental resource for the natural sciences, and in Sweden synchrotron light is synonymous with MAX-lab. The politics around the laboratory and the development and facilitating of initiatives has lied within the university structure, on different levels and locations, during the whole of the MAX-lab history.

Parallel with MAX-lab's growth as a laboratory, new disciplines have gradually associated themselves with synchrotron light and the original user communities has expanded and strengthened themselves. But the key lies in acknowledging that the importance lies exactly with the users. Being the laboratory that was never intended to be, MAX-lab is also the laboratory that should never have survived. The fact that the laboratory not only have survived but also made it to significant size and importance in a national perspective is most of all due to the user-involvement. A few dedicated and visionary individuals developed the ideas and the plans, and a few dedicated and visionary individuals made the plans pass through the council. The support from Lund University and the forging of National Facility and academic institution on the university level helped retaining the original academic spirit and the close proximity to the user groups also during expansion.

That MAX-lab has maintained its thoroughly academic character despite being a designated national research facility for the last twenty years has made the maintenance of the laboratory strongly dependent on a system of informal coordination, underfunded flexibility and heroic efforts from small groups of committed staff. This combination successfully took MAX-lab into the third generation of synchrotron lights facilities a decade ago, and still manages to keep the facility on a fairly competitive international position. This has among other things gained MAX-lab its great reputation, both domestically and internationally.

It is ironic that a laboratory that was never intended to be and that should never have survived has managed to take hold of and developed scientific opportunities that never was anticipated but whose promising future was grasped only by a few enthusiasts. After all, MAX-lab is the only Swedish National Laboratory of its size. Today, MAX-lab is a vital part of the strategic goals of Lund University. It is also viewed among the most important strategic assets for Swedish research. Against the background of this paper, it is though not only possible but perhaps also necessary to argue that the ways by which MAX-lab of today has come into being – what might be called the ideal collection of coincidences, opportunities and small-scale initiatives – is the only possible way in which large-scale research facilities can be established in Sweden.

But the story does not end here. The MAX IV project is under consideration and preparation, and the MAX-lab organization has realized the challenges built in the project. Our material indicates that several of the issues that are confronting the Swedish research system (growing internationalization, needs for prioritization, new relations with the private sector, reorganization of universities, et cetera) are present in the case of MAX-lab. Its history – and its future – is the history and the future of Swedish research.

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