Dnr: STYR 2018/487

Annual Report of MAX IV Laboratory to the Swedish Research Council

2017

Contents

1 Introduction

In 2017 user operation restarted at MAX IV Laboratory. Meanwhile installation and commissioning of beamlines and continuous improvements of the accelerators have been ongoing. A major milestone in 2017 was the funding decisions on the beamline ForMAX and MicroMAX from KAW and the Novo Nordisk Foundation respectively. At the end of 2017 MAX IV Laboratory had 16 funded beamlines.

The operation of MAX IV Laboratory 2017 was supported by the Swedish Research Council (VR) grant 827-2013-2235. As a condition for the grant, MAX IV Laboratory has been asked to submit an annual report with emphasis on the activities at the facility. This report covers the year 2017 and includes the following items requested by VR:

- Organisational matters
- User operation, statistics and scientific output
- Accelerators at MAX IV Laboratory
- Engagement with industry
- International collaborations
- Financial report
- Communication and outreach

2 Organisational matters

At the end of the year MAX IV Laboratory had a total of 207 employees, see Figure 1. This small increase in employees as compared to 2016 does not reflect the large number of recruitments (80) that have been made during 2017. Many positions have been replacements, but a large number were recruited with start early 2018. The majority of recruitments were of staff members for MAX IV beamline projects and to the IT group. Figure 2 shows the organisation of MAX IV Laboratory in 2017.

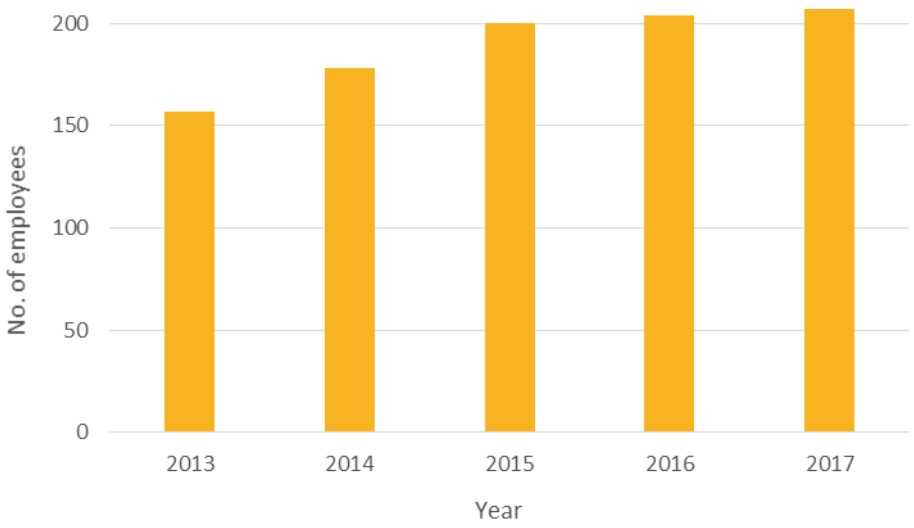

Figure 1. End of year numbers of MAX IV Laboratory employees for the years 2013-2017

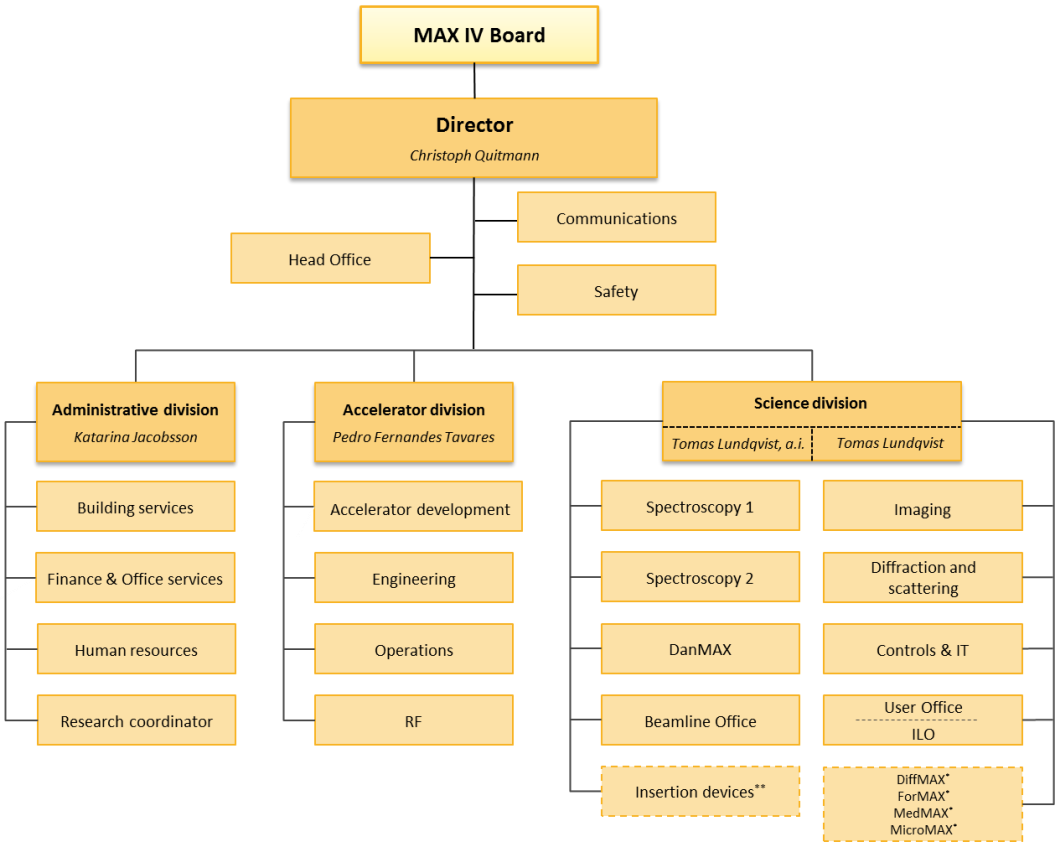

*Figure 2. MAX IV Laboratory organisation 2017. *indicates design projects, **indicates team*

A new advisory committee on work environment and safety, WEAC, was established during the year and had its first meeting in November.

To assist in the allocation of beamtime, Programme Advisory Committees (PAC) are appointed. Three PACs that cover the fields of Structural Biology, Nano Sciences and Spectroscopy were established in 2017, the members of each of these committees are shown in Appendix 1.

3 User operation

During 2017 user operation started in small scale at the new MAX IV facility with user access to the first operational beamlines and also to instruments not dependent of synchrotron radiation. At the same time installation and commissioning of beamlines has been ongoing.

Users obtain access to MAX IV Laboratory through a proposal system within the digital user office portal DUO. The DUO system at MAX IV includes proposal, review and scheduling tools, a user and publication database, as well as tools for safety and feasibility review. Submitted proposals are reviewed by beamline staff for feasibility and are subsequently sent to the PAC for scientific review. In parallel, our Safety teams performs safety review of the proposal. Based on the result from these reviews, MAX IV Management takes the final decision on beamtime allocation.

Table 1. Number of user visits to beamlines and instruments at MAX IV Laboratory in 2017

Beamline	visits
BioMAX	54
FemtoMAX	1
HIPPIE	2
NanoMAX	15
Total	**72**

Instrument w/o synchrotron radiation	visits
HIPPIE	4
MAXPEEM	16
SPECIES-APXPS	2
STM Laboratory	28
Total	**50**

3.1 User statistics

Beamlines BioMAX, NanoMAX, FemtoMAX and HIPPIE have been open to commission and/or open proposal calls, and have received users in 2017. In addition, MAXPEEM, SPECIES-APXPS and the STM-laboratory have taken users to their instruments, which can partly operate independently of synchrotron radiation. For these later experiments there have not been open calls, but access is managed in dialogue with the respective instrument manager. In total, MAX IV Laboratory had 122 user visits by 98 individual users in 2017, see Table 1.The user gender distribution was 36% women and 64% men.

In the first limited call to BioMAX and NanoMAX, which closed in January 2017, 38 proposals were submitted out of which eleven were allocated beamtime, see Figure 3. In addition, ten commissioning expert groups were given access to MAX IV Laboratory and helped the staff to further commission beamlines, in particular at BioMAX, NanoMAX, FemtoMAX and HIPPIE. These commissioning experts were selected in a peer reviewed commissioning call that took place in 2016.

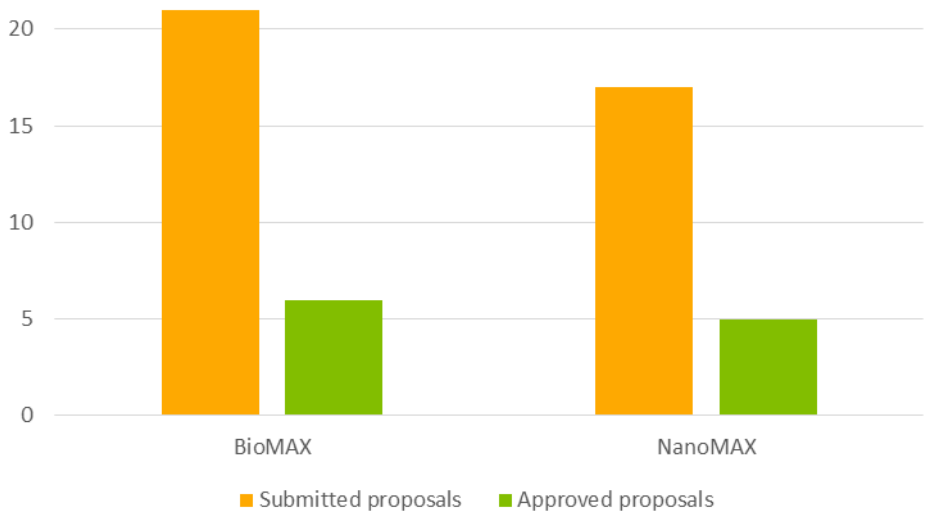

Figure 3. Number of proposals for beamtime to MAX IV Laboratory in the call for proposals closing January 2017.

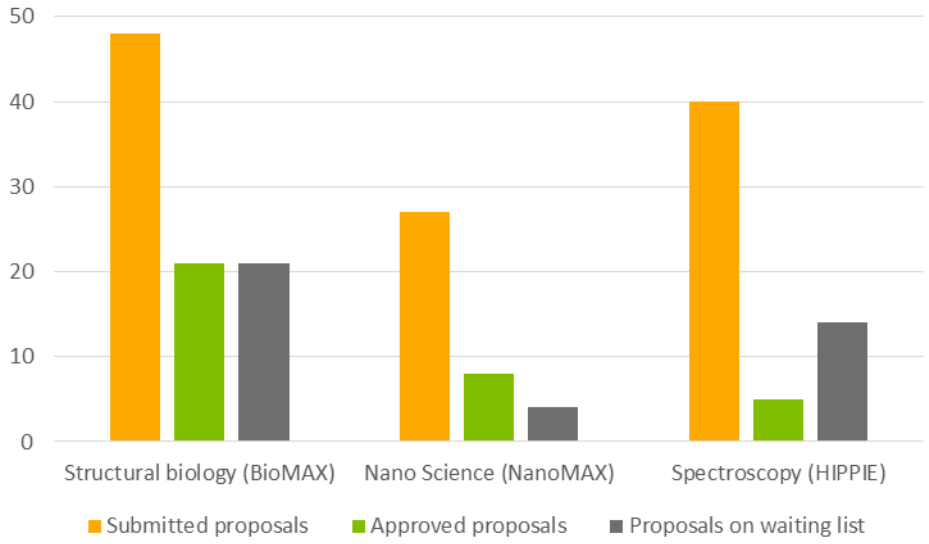

Figure 4. Number of proposals for beamtime per scientific areas to MAX IV Laboratory in the call for proposals autumn 2017.

The autumn call in 2017 was for proposals requesting beamtime at BioMAX, NanoMAX and HIPPIE. As shown in Figure 4 and Figure 5, there were far more proposals asking for more beamtime than the beamlines currently can provide for. Especially the HIPPIE beamline, which still require a high amount of commissioning, was very oversubscribed.

Due to the considerable amount of commissioning time still needed at the beamlines, there is currently limitations for how many proposals can be accepted. The highest ranked proposals were allocated beamtime late 2017 to spring 2018. In case more beamtime will become available during this time, some proposals were put on waiting list. A large number of good proposals had to be declined due to the lack of available beamtime at this point in time.

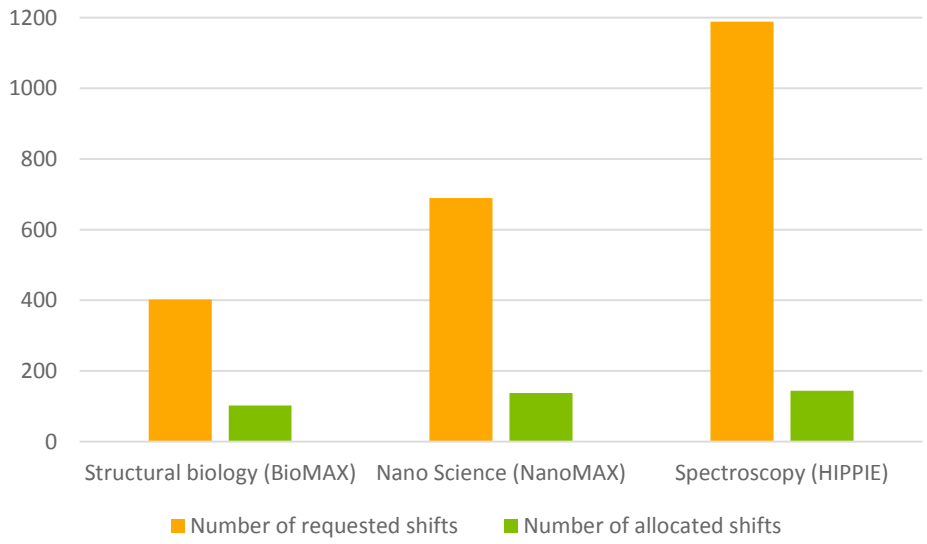

Figure 5. Number of requested and allocated shifts (four hours each) for beamtime at MAX IV Laboratory in the call for proposals autumn 2017.

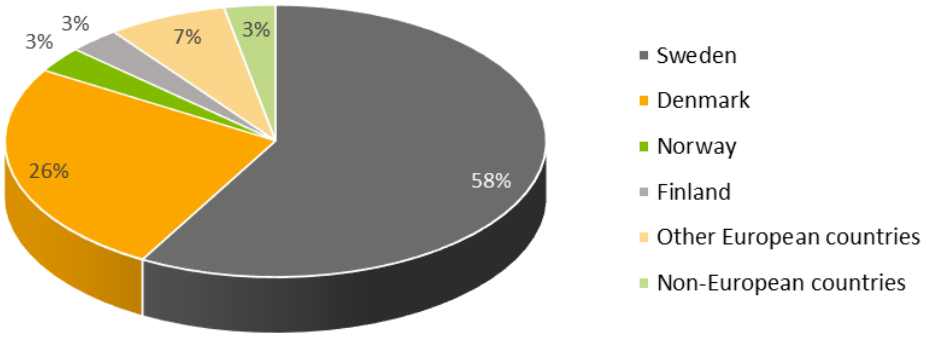

Figure 6. Distribution of users' home institution, 2017.

The vast majority of users in 2017 came from the Nordic countries, see Figure 6. In total we had users from nine different countries and 26 different institutions during the year.

3.2 Scientific Output

The yearly numbers of publications published with results produced at MAX IV Laboratory the past ten years is shown in Figure 7. As the figures depend on self-reporting by users, usually done in connection with submissions of applications for beamtime, they are underestimated and also lag behind by about one year. In addition, since the proposal calls in the past three years have addressed a rather limited user community at the operational beamlines at MAX IV Laboratory there are more unreported publications than usual. The last 15 years until 2015, there was on average one publication per day of operation of the MAX-lab facility. In the last years these publications have been divided approximately equally over the fields of physics, chemistry and life sciences.

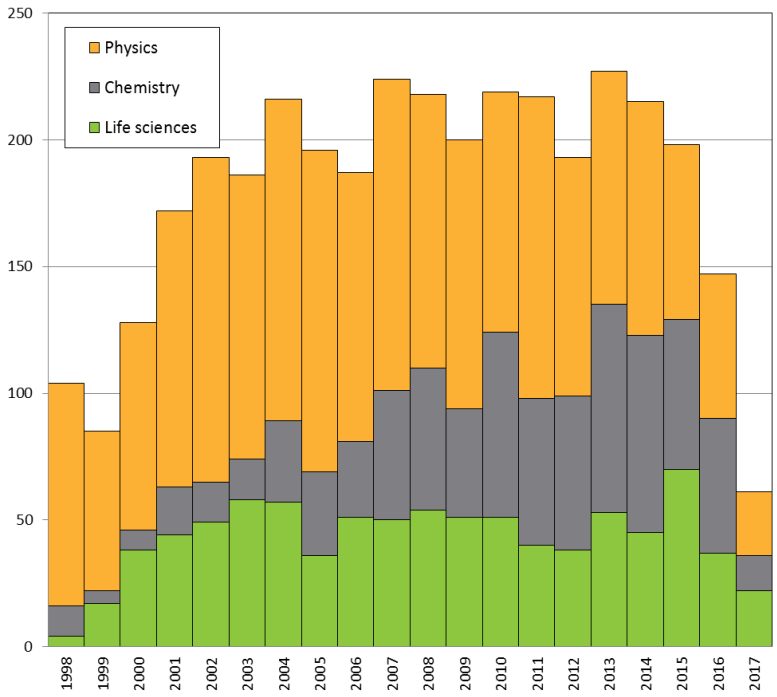

Figure 7. Number of reported peer-reviewed publications produced at MAX-lab and MAX IV Laboratory 1998-2017

The first scientific article with results based on data collected at a beamline at the new MAX IV facility was published in 2017. The data was collected at BioMAX in December 2016 and published in an article in Acta Crystallographica (Acta Cryst. (2017) D73, 804-813). The article presents a new method for solving protein structures of challenging samples. The method can also be used for the labelling of proteins in order to make it possible to follow them in cells using imaging methods. This work also resulted in the first three-dimensional structure of a protein solved by data collected at BioMAX. It has been deposited in the international protein data bank (Structure of Nb36 crystal form 2).

4 Accelerators at MAX IV Laboratory

The year 2017 was marked by the start of regular user operations in the 3 GeV ring as well as by continuous improvements of the performance and reliability of the MAX IV accelerators. A major effort during the year was devoted to setting up the legal, administrative and technical requirements in preparation for round-the-clock accelerator operations. Negotiations with labour unions were carried out during the whole year and allowed the implementation, on a first phase, of two-shift accelerator operator support including weekends and, on a second phase (concluded in late November) of a full three-shift 24/7 operations scheme. Moreover, negotiations for round-the-clock on-call technical support were initiated. Hiring and training of the required personnel, including the appointment of a new Head of Accelerator Operations in an internationally advertised recruitment process was completed in late December, marking an important step in bringing MAX IV Laboratory to full user operations.

Accelerator availability was systematically followed up during the whole year and reliability bottlenecks were identified. In total, the MAX IV 3 GeV ring was scheduled for 1 452 hours of delivery to beamlines, having achieved an uptime of 92.6 %. The main causes of downtime were infrastructure-related faults (air conditioning, water cooling), vacuum trips generated by beamline conditioning and RF system trips generated by faults in the delivery of energy to the MAX IV campus (even very short, tens of milliseconds, interruptions in the main power line can have significant consequences to the running of the accelerators). All these points are being acted upon – in particular, the installation of a rotating converter that can supply the whole MAX IV campus with electrical power and render the facility insensitive to external perturbations. This is a major project initiated in 2017 and planned to be fully delivered by summer 2018.

Work on a future soft-X ray laser beamline that can use the 3 GeV MAX IV linear accelerator as a driver had big a boost during 2017 with the approval of a project submitted to the Knut and Alice Wallenberg foundation to fund a conceptual design (CDR) study. The CDR project will take two years (starting March 2018) and is a collaborative effort of MAX IV Laboratory, Lund University, Stockholm University, KTH Royal Institute of Technology, Stockholm, (joined in the Stockholm Uppsala Free Electron Laser Centre) and results from an initiative of the Swedish user community that requests short pulses of coherent light in the 1-5 nm wavelength region.

Technical highlights of the linear accelerator in 2017 include:

1) Duplication of the last pair of RF accelerating units, which made the system fully modular and redundant, significantly improving reliability.
2) Demonstration of normalised RMS emittance below 1 mm.mrad and FWHM pulse length below 160 fs.

3) Implementation of a beam containment system to protect the FemtoMAX undulators in case of missteering of the electron beam, a prerequisite to the continued commissioning of FemtoMAX.
4) Installation of a Gun Test Facility, which will allow further development and characterisation of high brightness electron sources without interference with routing running of the linac.

Technical highlights of the 3 GeV storage ring in 2017 include:

1) ~300 mA stored beam current in multi-bunch mode.
2) Implementation of top-up injection with closed undulator gaps and open beamline shutters.
3) Installation and successful commissioning of a new multipole injection kicker, which allows a significant reduction of residual orbit perturbations generated at injection, rendering top-up injection nearly transparent to the beamlines.
4) Successful installation and commissioning of a longitudinal kicker cavity, which allowed better control of coupled bunch instabilities at high current.
5) Successful installation and commissioning of a second diagnostic beamline, which allows direct measurements of the electron energy spread.

Technical highlights of the 1.5 GeV storage ring in 2017 include:

1) ~260 mA stored beam in multi-bunch mode
2) Achievement of full longitudinal stability at high current with the use of passively operated harmonic cavities.
3) Commissioning of a bunch-by-bunch feedback system in the transverse and longitudinal planes.
4) Installation and commissioning of five insertion device chambers and four insertion devices.

5 Engagement with industry

The large interest and engagement from the forestry industry in MAX IV Laboratory in general, and the ForMAX beamline in particular, has continued to dominate the industrial activities at MAX IV Laboratory also in 2017. The Treesearch initiative, a collaboration between academia, industry, private foundations and the Swedish government, was launched in September. Treesearch aims to create a world-leading open research environment contributing to the development of competences and knowledge that enables future innovations based on the forest. An important aim of Treesearch is to make ForMAX available for industrial and academic research. The ForMAX preprojects are ongoing, aiming to show the use of synchrotron radiation techniques for industrial research and the development of experimental environments for industrial needs. The first test experiments have been performed at the PETRA III facility in Hamburg.

Inspired by the successful engagement with the forestry industry, we have pursued our “sector by sector” approach towards new industrial sectors. By engaging in the Strategic Innovation Programmes (SIP) funded by Vinnova, the Swedish energy agency and the Swedish research council Formas, we have approached the metals industries in a project within the ‘Metallic Materials’ SIP. The first phase of the project spanned most of the year and included interviews and workshops. The theme for the first workshops “welding and corrosion” was selected by the industrial partners. A second phase of the project was funded and lunched just before the end

of the year. With the Treesearch initiative, we are also involved in the 'BioInnovation' SIP and we have also have initiated dialogues with partners interested in the SIPs 'Medtech4Health' and 'Grafen'.

MAX IV Laboratory has received funding for a two year position from Vinnova to strengthen our industrial relations function. The recruitment process started at the end of the year for completion early 2018.

We continue to engage in activities, workshops and symposia to raise awareness of techniques of interest to industry at MAX IV Laboratory. Although MAX IV beamlines have not been open for proprietary access in 2017, we have worked closely with our industrial partners to meet their needs. As an example we have assisted one of our Swedish costumers in high speed radiography experiments at the ESRF synchrotron. During the year we have prepared for industrial users at MAX IV Laboratory by establishing the legal framework for proprietary access. The first proprietary access users are planned for the beginning of 2018 at the beamline BioMAX.

MAX IV Laboratory is engaged in the Horizon 2020-project CalipsoPlus where the activities dedicated to support industrial networking as well as access for SMEs to research infrastructures were started this year. With these activities the project aims not only to strengthen the industrial knowledge of research infrastructures such as MAX IV Laboratory, but also to tie valuable connections between European synchrotrons and their industrial relation offices.

Our collaboration with RISE, Research Institutes of Sweden, continues. During the year we have had a number of joint proposals for funding. An example is the NextBioForm centre funded by Vinnova, a consortium of 15 partners including both academic and industrial partners, coordinated by RISE with the aim to develop novel methods for formulation of biologics.

We participate in the SWEbeams initiative that we believe will be of great importance in defining the ecosystem of partners that needs to be created in order to facilitate industrial use at MAX IV.

6 International and national collaborations

MAX IV Laboratory is collaborating with many other synchrotron facilities to exchange scientific and technological ideas. These collaborations are crucial for the development of beamlines and accelerators at MAX IV Laboratory. The management and staff of MAX IV Laboratory are active on the international scene of synchrotron radiation science as for example members of advisory committees for other facilities.

MAX IV Laboratory is an active partner in LEAPS, the League of European Accelerator-based Photon Sources, which is a strategic consortium initiated by the directors of the synchrotron radiation and free electron laser (FEL) user facilities in Europe. The primary goal of LEAPS is to actively and constructively ensure and promote the quality and impact of the fundamental, applied and industrial research carried out at the respective facility and that is of greater benefit to European science and society. A consortium declaration was signed by the member facilities in November, during the LEAPS launch event in Brussels.

An agreement defining Finnish participation and support to MAX IV Laboratory was signed in November. According to this agreement, the Finnish partners will contribute to the operational cost of the MAX IV Laboratory, to specific infrastructures as well as provide know-how.

A list of international agreements and collaborations put in place during 2017 is found in Appendix 2.

7 Financial report with comments

The result and budget for operations at MAX IV Laboratory 2017 can be found in Table 2. Comments to the outcome are found below the table.

Table 2. Result and budget for 2017 (kSEK)

Funding	**Funding**	**Budget**
Lunds University	53 790	55 290
Vetenskapsrådet, Grants	310 848	320 000
Academy of Finland	0	2 200
Total Funding	**364 638**	**377 490**

Director	**Cost**	**Budget**
Staff cost	-140 074	-153 163
Lund University OH	-19 848	-19 848
DM Ex Contingency	-14 915	0
Transfer to Linköping University	-1 000	-1 000
NLF Phase 1 project deficit	-4 703	-4 151
Director groups	-5 852	-7 361
Total Director	**-186 392**	**-185 523**
Administration	**Cost**	**Budget**
Rent	-66 246	-74 571
Facility cost	-22 077	-27 499
Deposition MAX IV decomm 2016-2107	-2 000	0
LU Staff	-2 863	-1 978
Admin groups & Decomm MAX-lab	-8 761	-8 540
Total Administration	**-101 947**	**-112 588**
Accelerator	**Cost**	**Budget**
AFSG	-20 060	-21 641
Accelerator groups	-5 522	-5 426
Total Accelerator	**-25 582**	**-27 067**

Science	**Cost**	**Budget**
Science Directors	-1 143	-2 227
Design Projects	-340	-414
DanMAX co-funding	-1 249	-1 578
Beamline Office	-3 752	-4 224
IT & Controls	-8 298	-10 110
Beamlines groups	-11 613	-13 153
Total Science	**-26 395**	**-31 706**

RESULT	**Cost**	**Budget**
Cost	-340 316	-356 884
Total cost	**-340 316**	**-356 884**

Comments to the outcome

FUNDING:
The payment from Finland has been delayed and will be executed 2018.

DIRECTOR:

- Staff cost: Many recruitments that were scheduled for 2017 were postponed to 2018. Staff cost is therefore under budget with approximately 13 MSEK.
- DM Ex Contingency: 15 MSEK for co-funding of KAW beamline projects and the transfer package projects.

ADMINISTRATIVE DIVISION:

- Rent: The outcome for rent is 8 MSEK below budget due to Q1 D-building rent was mistakenly charged 2016 (4 MSEK) and because STIBOR was lower than estimated (4 MSEK).
- Facility cost: below budget mainly due to lower electricity cost.

SCIENCE DIVISION:

- IT & Controls: investments lower than budget due to delayed purchases.
- Lower spending in workshops and travelling than was planned for.

RESULT:
The positive result for 2017 (+25 MSEK) increased our agency capital to 36 MSEK (from 11 MSEK in 2016) as planned. The purpose of this reserve is to mitigate the interest rate risk.

The forecast for end 2018 is a reduction of the agency capital to 26 MSEK.

8 Communication and Outreach

MAX IV Laboratory operates an active outreach program and is operating on popular social media platforms. The interest for study visits from schools, companies, universities and the general public from Sweden, as well as from abroad, has increased considerably over the years. It has continued to do so also this year, to the extent that we are not able to accommodate all requests. During 2017, the visitors centre MAXESS welcomed almost 1 600 visitors from schools, different associations and organisations who were given presentations of MAX IV Laboratory (and ESS). At the MAX IV facility itself nearly 8 000 visitors were received during 2017. Most of these had some link to either funding or use of the facility, but visits from the general public are also included. In late 2017 a new system for logging visitors was implemented to enhance efficiency and improve statistics.

A new science communication officer was recruited in 2017 in line with the overall ambition to focus more on the science done by users and staff.

Our web site www.maxiv.se is the main channel for seeking information and news about the MAX IV Laboratory, its development, technical details on beamlines and examples of the research conducted. Table 3 shows the number of visits to our website.

Table 3. Visits to www.maxiv.se

Visits		**Unique visitors**		**Page views**	
2017	*2016**	*2017*	*2016**	*2017*	*2016**
100 000	56 000	41 000	28 000	422 000	203 000

**The web page was launched May 2016 so numbers should be read with that in mind.*

The social media channels are targeting different groups and interests and the content posted and language used reflects this – Twitter (English) for the scientific community, Facebook (Swedish) for the regional geographically close community, LinkedIn (English) mainly for job postings and Instagram (English) for photos and weekly scientific and technical updates. See Table 4 for details on number of followers at the different social media channels.

MAX IV Laboratory is working hard to take advantage of the ever-increasing interest from other research facilities, research organisations, companies and scientists worldwide. MAX IV Laboratory participates actively in several projects, for example, lightsources.org, ESS & MAX IV: Cross Border Science and Society , The Bridge Forum, SWEbeams, PARI – workshop on Public Awareness of Research Infrastructures, EuroScience Open Forum (ESOF), Big Science Business Forum and the Association of European-level Research Infrastructure Facilities (ERF-AISBL). These projects all aim to raise awareness of synchrotron and/or neutron techniques through targeted outreach both to users and general public.

An important event to bring users and MAX IV Laboratory staff together is the annual User Meeting. The 2017 meeting, arranged 13-15 March in Lund, combined sessions discussing the status and prospects of different aspects of MAX IV Laboratory with parallel sessions covering the science that will be supported at MAX IV Laboratory, poster session and site visit. The meeting attracted more than 300 users and other stakeholders from Sweden and abroad. A number of satellite meetings were held in connection to the user meeting. For a list of these meetings, as well as others arranged during 2017, see Appendix 3.

Table 4. MAX IV Laboratory on social media channels

	Followers		**Impressions**	**Time spent (minutes)**
	2017	*2016*	*2017*	*2017*
Twitter	2 400	1 850	321 000	
Facebook	2 400	2 200		5 100
LinkedIn	2 700	2 350	229 000	
Instagram	625	50		

Development over time. Empty cells indicate that statistics are not available or applicable.

Appendix 1

Members of the three Programme Advisory Committees.

Structural Biology		
Margarida Archer Frazao	Instituto de Tecnologia Quimica e Biologia (ITQB)	Portugal
Sine Larsen	University of Copenhagen	Denmark
Ralf Ficner	Georg-August-Universität Göttingen	Germany
Ehmke Pohl	Durham University	UK
John McGeehan	University of Portsmouth	UK

Nano Sciences		
Oliver Bunk	Paul Scherrer Institute (PSI)	Switzerland
David Le Bolloc'h	Université Paris Sud	France
Gema Martínez Criado	CSIC – Instituto de Ciencia de Materiales de Madrid (ICMM)	Spain
Laszlo Vincze	Ghent University	Belgium

Spectroscopy		
David Mueller	Forschungszentrum Jülich	Germany
Virginia Perez Dieste	ALBA Synchrotron Light Source	Spain
Wendy Flavell	University of Manchester	UK
Phil Woodruff	University of Warwick	UK

Appendix 2

International agreements and collaborations entered in 2017

Partners	Title
Aarhus University (ISA), Ankara University, Consorcio para la Construcción, Equipamiento, y Explotación del Laboratorio de Luz de Sincrotrón (CELLS), Centre Nationale de la Recherche Scientifique (CNRS), Stiftung Deutsches Elektronensynchrotron DESY, Diamond Light Source Ltd, Elltra-Sincrotrone Trieste SCpA, Installation Européenne de Rayonnement Synchrotron (ESRF), European XFEL GmbH, Helmholtz-Zentrum Berlin för Materialien und Energie, Helmholtz-Zentrum Desden-Rossendorf, Istiuto Nazionali di Fisica Nucleare, Karlsruher Institut fuer Technologie, Lund University (MAX IV), Paul Scherrer Institut, Radboud University (FELIX), Synchrotron Light for Experimental Science and Applications in the Middle East (SESAME), Societé Civile Synchrotron Soleil (SOLEIL), Uniwersytet Jagiellonski (SOLARIS)	CALIPSOplus Consortium Agreement
Canadian Light Source Inc. "CLSI"	Extension of Memorandum of Understanding for Cooperation in the Advancement of Synchrotron Science between MAX IV Laboratory and Canadian Light Source Inc.
ALBA Synchrotron, Stiftung Deutsches Elektronensynchrotron DESY, Diamond Light Source Ltd, Elltra-Sincrotrone Trieste SCpA, ESRF the European Synchrotron, European XFEL GmbH, FELIX Laboratory -Rabound University, Helmholtz-Zentrum Berlin för Materialien und Energie - HZB, Helmholtz-Zentrum Desden-Rossendorf - HZDR, ISA, Centre for Storage Ring Facilities - Aarhus, Laboratori Nazionali di Frascati - INFN, MAX IV Laboratory - Lund University, Paul Scherrer Institut, Physikalisch-Technische Bundesanstalt PTB, SOLARIS Uniwersytet Jagiellonski, Synchrotron SOLEIL	LEAPS Consortium Declaration
European Spallation Source ERIC (ESS)	Memorandum of Understanding
University of Oulu	Operation Collaboration Agreement between MAX IV and University of Oulu
University of Helsinki	Research Agreement between Lund University, MAX IV Laboratory and University of Helsinki

Appendix 3

Meetings arranged or co-arranged by MAX IV in 2017

Name	Date	Location	Nbr of participants
Infrared Chemical imaging for the future	March	Uppsala	51
iBiomat: Imaging Biological and Soft Matter	March	Uppsala	99
How can industry make use of the tools available at MAX and ESS?, (MAX4ESSFUN)	March	Lund	78
UM17	March	Lund	300+
NGLDM - The next generation for Low Density Matter	March	Lund	48
The 4th High Data-Rate Macromolecular Crystallography (HDRMX) Meeting	March	Lund	43
DiffMAX, The Material Sciences and Diffraction	March	Stockholm	29
IPAC	March	Copenhagen	1200
ESRF Council Meeting	June	Lund	51
BIR2Gain workshop för metallindustrin	June	Lund	50
CERN Accelerator School	June	Landskrona	100
Electronic phenomena studied in the Nordic countries, MAX4ESSFUN	July	Lund	48
Swedish-Japanese Workshop on Nano-Structure Science by Novel Light Sources	October	Lund	60
European User Offices Meeting	October	Lund	42
Workshop - Optical solutions on phase 3 beamlines	November	Lund	10
Workshop on Synchrotron X-ray and Neutron application to Food Science and Technology	December	Lund	82
Workshop - Lessons learned hard X-ray monochromators	December	Lund	20