

Annual Report of MAX IV Laboratory to the Swedish Research Council

2016



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1 Introduction

2016 has for MAX IV Laboratory been a year out of the ordinary in the sense that we have not had regular user operation. Since MAX-lab at Ole Römers väg was closed down 13 December 2015, focus has been on installation and commissioning of accelerators and beamlines at the new MAX IV facility. Meanwhile, decommissioning of MAX-lab has been on-going.

The operation of MAX IV Laboratory 2016 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 2016 and includes the following items requested by VR:

- Organisational matters
- User operation and scientific output
- Accelerators at MAX IV Laboratory
- Communications and outreach
- Engagement with Industry
- Financial report
- International contacts and collaborations

2 Organisational matters

The staff of MAX IV Laboratory stayed almost constant during 2016. At the end of the year MAX IV Laboratory had a total of 200 employees, see Figure 1. New recruitments were mainly of staff members for MAX IV beamline projects and to the IT and Safety groups.

As of 1 November 2016 MAX IV Laboratory has a new board appointed by Lund University in consultation with the Swedish Research Council and Vinnova.

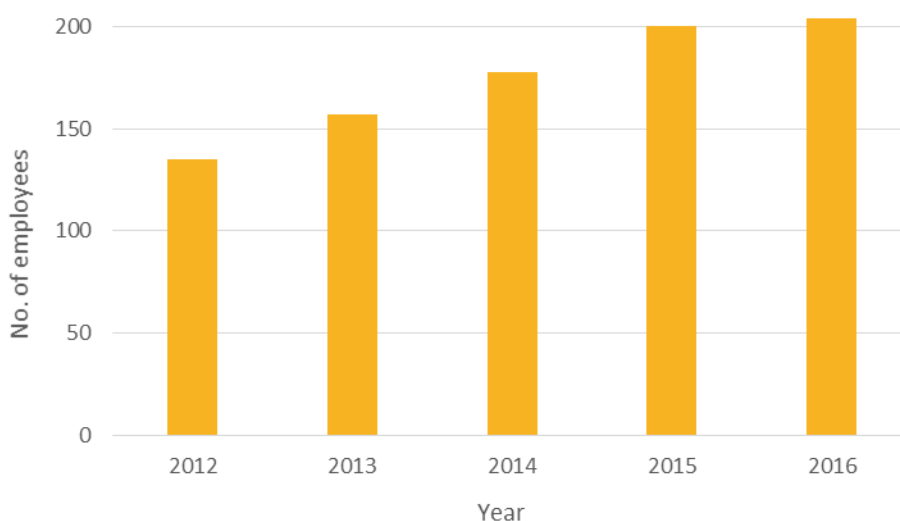


Figure 1. End of year numbers of MAX IV Laboratory employees for the years 2012-2016

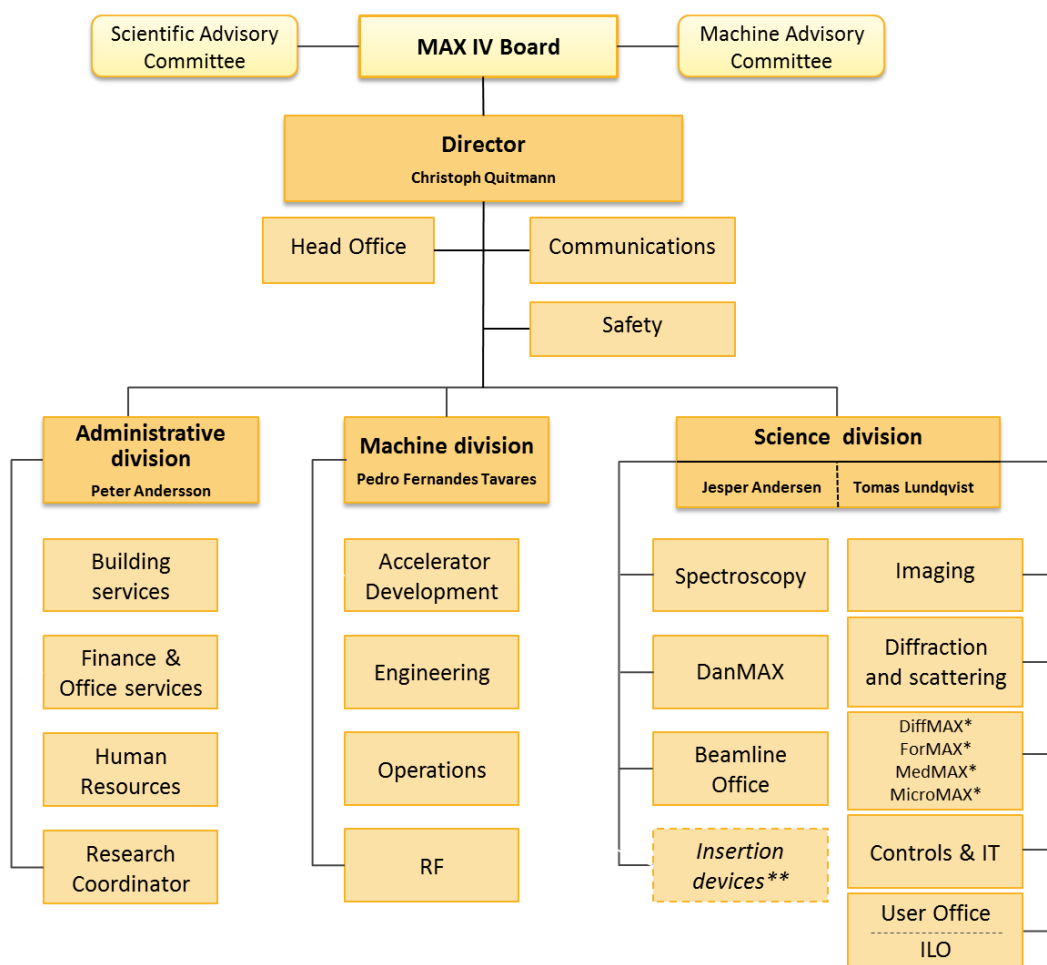


Figure 2. MAX IV organisation. *indicates design projects, **indicates team

The Science division underwent a reorganisation during the year to better reflect the situation at the new MAX IV facility with increased diversity in the beamlines. In the Administrative division the Finance group was merged with Office Services. Figure 2 shows the new organisation, which was put into place 1 October 2016.

3 User operation

In 2016 MAX IV Laboratory had no regular user operation. Instead focus has been on installation and commissioning of beamlines, as well as on other preparations needed in order to take users.

At the end of the year the first commissioning experts were received at MAX IV at the beamlines NanoMAX and BioMAX. The commissioning users had been selected from an open call addressing experts able to test the progress of the beamline commissioning and willing to support the local team in their work. Both academic and industrial projects were represented with scientists from Sweden and Denmark. These commissioning experiments confirmed that the beamlines are approaching readiness for user operation and in at least one case data of sufficient quality for a publication could be collected. The industrial experts at BioMAX performed successful feasibility experiments, verifying that this beamline is suitable for future industrial applications. The commissioning experts

have proven to be a valuable asset to benchmark user readiness for all parts of MAX IV: from User Office, safety and reception, to beamlines and IT.

The first call for proposals for beamtime at BioMAX and NanoMAX opened 13 December 2016, one year to the day after closing MAX-lab.

3.1 Scientific Output

The yearly numbers of publications published with results produced at MAX-lab is shown in Figure 3. As the figures depend on self-reporting by users, usually done in connection with submissions of applications for beamtime, they are most likely underestimated and also lag behind by about one year. In addition, since there has been no regular proposal calls the last two years, there are reasons to believe that there are even more unreported publications. In the last 15 years until 2015, there has on average been one publication per day of operation of the facility. In the last years these publications have been divided approximately equally over the fields of physics, chemistry and life sciences.

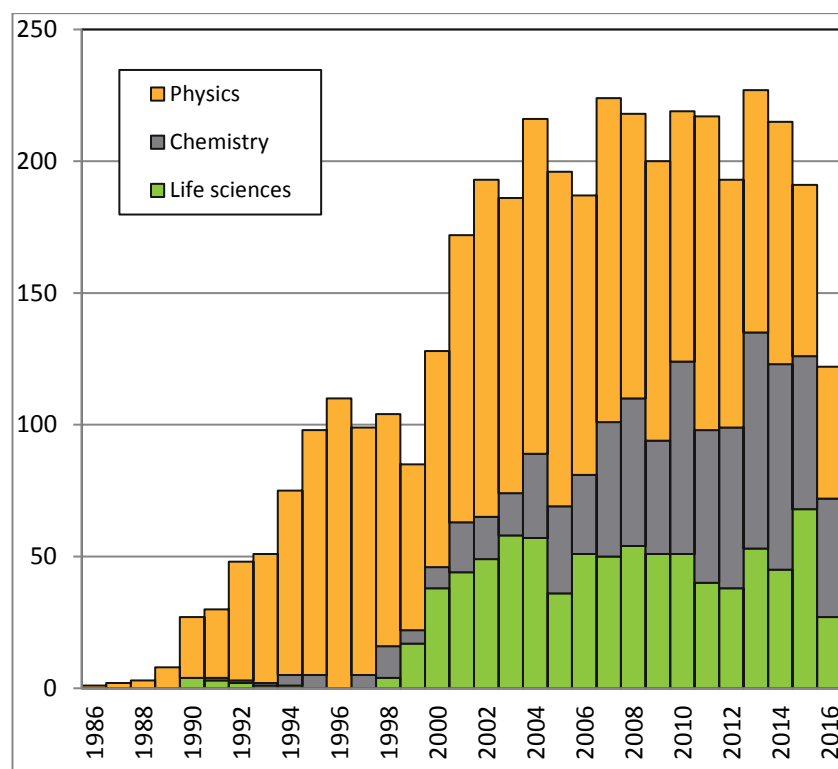


Figure 3. Numbers of reported peer-reviewed publications produced at MAX-lab 1986-2016

4 Accelerators at MAX IV Laboratory

The year 2016 was marked by a number of major milestones in the MAX IV phase 1 project. In fact, by the end of the year, all three accelerators that make up the MAX IV accelerator complex (the 3 GeV linear accelerator and the 1.5 GeV and 3 GeV storage rings) could deliver a performance level where commissioning of beamlines as well as first experiments using synchrotron radiation could be started.

The linear accelerator operated as an injector to the 3 GeV ring as well as a driver to the short pulse facility, SPF (mostly in the second half of the year), and during autumn also as an injector to the 1.5 GeV ring. During this time a number of improvements were implemented to the injector system, in particular:

1. automated mode switching to allow for serving both rings in top-up mode as well as the SPF, without manual intervention by the operators
2. possibility of injection into the rings using the photo-cathode gun, which increases redundancy and overall system reliability
3. emittance down to 1.2 mm mrad at 100 pC bunch charge
4. a fast and reliable means of adjusting LINAC beam energy based on trimming of the fill time of SLED cavities
5. on-line trajectory feedback for delivery to the SPF.

By February, the 3 GeV ring commissioning had progressed enough to allow the first two insertion devices (the in-vacuum undulators for the BioMAX and NanoMAX beamlines) to be installed and their commissioning initiated. During the following months insertion device and early beamline commissioning proceeded in parallel with further ring commissioning leading by June to the first experimental results being obtained at the beamlines. The summer shutdown and first months in autumn were dedicated to the installation of another three insertion devices. The performance of the ring was consistently increased along the year and the following results were achieved:

1. up to 200 mA stored beam current in multi-bunch mode
2. up to 8.5 mA in single-bunch mode
3. more than 85% injection efficiency, 20 mA/min injection rate at 2 Hz
4. emittance measured (at low current) 340 ± 30 pm rad
5. vacuum conditioning of NEG coated chambers proceeded at the expected rate leading to up to more than 5 A·h product of lifetime and current
6. initial difficulties with conditioning of RF cavities were gradually overcome and are now no longer an important operational concern
7. passively operated harmonic cavities and active bunch-by-bunch feedback systems successfully commissioned at currents up to about 120 mA
8. slow orbit feedback system implemented and under use during routine delivery for beamline commissioning and user experiments.

The 1.5 GeV ring was fully assembled and its sub-systems were tested by late summer. Commissioning started in early autumn leading, by the end of the year, to 120 mA stored beam current and close to 12 A·h of accumulated dose.

In parallel with accelerator commissioning and operation activities, a number of initiatives were set in motion in preparation for the start of user operation, including:

1. establishment of operations and maintenance procedures
2. establishment of performance measurement procedures
3. development of operation graphical user interfaces (GUIs) optimised for routine operation (in contrast to commissioning)
4. definition of spare parts pool and service contracts.

5 Communication and Outreach

MAX IV Laboratory operates an active outreach program and has been welcoming visitors from schools, companies, universities and the general public from Sweden as well as from abroad to both the MAX IV site and the visitors centre MAXESS (operated jointly by MAX IV, European Spallation Source (ESS) and Science Village Scandinavia). The interest for study visits has increased considerably over the years, and continues to do so. This year we have not been able to accommodate all requests.

The highlight of the year took place on 21 June, the brightest day of the year, when the MAX IV facility was inaugurated by Prime Minister Stefan Löfven in the presence of H.M. King Carl XVI Gustaf. More than 500 guests, including stakeholders, employees, politicians and representatives from academia and industry, attended the ceremony. The opening ceremony was preceded by two days when the MAX IV facility kept open house during which about two thousand visitors were received, and a science day to which researchers who have used MAX-lab in the past were specially invited. The media coverage of the inauguration resulted in 288 stories in Swedish and Danish papers, radio and TV, reaching a potential audience of almost 45 million people.

In May, the visitors centre MAXESS opened in the old miller's farm in Odarslöv close to the facility. Until the end of the year, almost 1 800 visitors from schools and different associations and organisations were given presentations of MAX IV here. At the facility itself nearly 10 500 visitors were received during 2016: Most of these had some link to either funding or use of the facility, but they also include visits from the general public, the majority in connection to the inauguration.

End of May 2016 a new web site, www.maxiv.se, was launched. Here visitors can get information and news about the facility, its development and the research conducted. From May to December the web site had 56 000 visits by 28 000 unique visitors doing 203 000 page views. MAX IV is present on Facebook (\approx 2 200 followers), Twitter (\approx 1 850 followers) and LinkedIn (\approx 2 350 followers) where we target the local (geographical) public, the scientific audience and potential employees respectively. In 2017, we will also re-start the MAX IV Instagram account with weekly scientific and technical updates.

MAX IV Laboratory is actively working to take advantage of the ever-increasing interest from other research facilities, research organisations, companies and scientists worldwide. The laboratory participates, for example, actively in the project "ESS and MAX IV: Cross Border Science and Society" which is co-financed by the European Regional Development Fund Interreg Öresund-Kattegat-Skagerrak (ÖKS). The three-year project, which started last year, is the largest project awarded under the Interreg Öresund-Kattegat-Skagerrak. It includes in addition to MAX IV and ESS 25 partners, among which eight are universities in the ÖKS-region. The project aims to raise awareness of, and enhance skills to, use synchrotron and neutron techniques through targeted training and outreach.

Another example of this out-reach work is MAX IV Laboratory's participation in The Bridge, a forum for discussion and hands-on work on how to collaborate between academia and industry to, through the use of the latest science, tackle the global challenges.

6 Engagement with Industry

Interest from industry in MAX IV Laboratory has grown over the year, aided by the exposure in media and elsewhere in connection to the inauguration, but also through our outreach activities during for example the Almedalen-week, Lund Grand Prix, TetraPak science talks and several industrial workshops. We have hosted many prominent visitors including stakeholders, leading industrialists and policymakers.

The large interest and engagement from the forestry industry in the ForMAX beamline has helped moving this project forward. In June, the Ministry of Enterprise and Innovation awarded KTH Royal Institute of Technology in Stockholm, Chalmers University of Technology and MAX IV Laboratory 20 MSEK over a period of three years for a pre-study aiming at the development of the ForMAX beamline at MAX IV and for the experimental environments development. The experimental environment development project was kicked-off by a workshop at MAX IV in September with participation from KTH, Chalmers and beamline personnel from MAX IV.

The successful experience gained from the ForMAX initiative, where the forestry industry joined forces with academia and research institutes and together reached out to MAX IV inspired us to take this approach towards other industry sectors. The Food and Packaging industries are one example of areas that could benefit from this approach. Together with the two industry associations Packbridge and Livsmedelsakademin we arranged a CEO-seminar at MAX IV in May. Several events with TetraPak exploring future collaborative projects have also taken place.

Interaction with the Swedish metal industry has intensified during the year. MAX IV has for example presented at the Innovation Summit on Metallic Materials workshop arranged by Materials Business Center in Lund and at a workshop exploring opportunities presented by MAX IV and ESS for the metal industry arranged by Jernkontoret and Swerea KIMAB in Stockholm. Together with Jernkontoret, ESS, Lund University and Swerea KIMAB, MAX IV is part of a Vinnova funded project through the Strategic Innovation Program (SIP) – “Metalliska material”. The ambition of this project is to establish a national platform for metal industry that want to use MAX IV, ESS and other large research facilities as well as providing training for industry through a series of workshops. During the year, we have engaged actively with the Vinnova SIPs. In May we presented MAX IV at the yearly program meeting of SIP-LIGTHer in Gothenburg and in September we hosted the yearly SIP-Program Management meeting at MAX IV.

We have reached out to the pharmaceutical industry. AstraZeneca, ESRF and MAX IV jointly arranged the two-day symposium ‘Synchrotron Applications in Pharma Innovation and Research’ in Mölndal with the aim of broadening the use of synchrotron and neutron methods within the Swedish pharmaceutical industry. By the end of the year we organised the Protein Structure Determination for Industry conference (PSDI) together with SARomics and Novo Nordisk A/S.

The interactions with Research Institutes of Sweden (RISE) increased during the year and in June a letter of intent (LOI) was signed between RISE and MAX IV. One of the key activities in the LOI is to increase the awareness and competence about synchrotron methods within RISE. The two organisation have, together with ESS, met regularly over the last two years to identify areas of common interest and to set up various initiatives.

Workshops have been arranged to identify and develop case stories that can be used by MAX IV and RISE to illustrate the breath of opportunities towards different industries. A first experiment to create such a user case took place during the autumn when researchers from MAX IV and RISE jointly collected powder diffraction data at ESRF. This will be followed by other experiments in 2017. Towards the end of the year we started a discussion on data storage and computing with Swedish ICT, a RISE resource and competence. MAX IV took active part in the development of the RISE internal roadmap titled "RISE as a key partner to MAX IV and ESS" covering 2016-2030.

7 Financial report with comments

The result and budget for operations at MAX IV Laboratory 2016 can be found in table 1. Some comments to the outcome are found below the table.

Table 1. Result and budget for 2016

(KSEK)	2016	BUDGET
Lund University	53 000	53 000
VR	295 000	295 000
Academy of Finland	0	2 200
TOTAL REVENUES	348 000	350 200
DIRECTOR	-167 873	-173 098
Staff cost	-144 983	-150 175
Director's reserve	-107	-750
Director's groups	-4 486	-4 964
Phase 1 NLF deficit	-4 395	-3 307
MAX IV satellites	-1 000	-1 000
Lund University OH	-12 902	-12 902
ADMINISTRATIVE DIVISION	-124 329	-121 281
Administrative director	-2 462	-2 500
Decommissioning	-27 001	-13 500
MAX-lab rent & facility	-7 995	-7 000
MAX IV rent (incl maintenance rent)	-59 665	-67 415
Building services	-24 577	-27 622
Finance, HR & Office Services	-2 629	-3 244
MACHINE DIVISION	-20 137	-20 761
Machine director	-281	-388
Accelerators operation	-13 751	-14 744
Engineering	-5 150	-4 565
RF	-955	-1 064
SCIENCE DIVISION	-19 703	-19 559
Science director	-790	-1 150
DanMAX co-funding	0	-500
FinEstBeams co-funding	-2 315	-350
Beamline operation	-7 356	-9 031
Beamline Office	-2 303	-2 825
IT & Controls	-6 986	-5 587
ILO/User office	-208	-116
Beamtime sales	255	0
TOTAL COST	-332 042	-334 699
RESULT 2016	15 958	14 500

The agreement with the Finnish Academy was not finalised 2016.

DIRECTOR:

- Staff: staff costs are 5 MSEK below budget due to postponement of employment
- Phase 1 NLF deficit due to costs related to D-building extension

ADMINISTRATIVE DIVISION:

- Decommissioning of MAX-lab was re-estimated to 30 MSEK mid-2016. The outcome for 2016 was 27 MSEK
- MAX-lab rent & facility: Higher cost due to delayed return of part of the MAX-lab premises to LU Byggnad
- MAX IV rent: STIBOR significantly below the budgeted 0 %
- HR: Lower recruitment cost than was budgeted for

SCIENCE DIVISION

- FinEstBeams co-funding: Change in accounting principle has been made. Project deficit accounted for as cost during 2016-2018 instead of long-term depreciation

RESULT

The positive result for 2016 (+16 MSEK) reduced the negative agency capital closing balance for 2015 as planned. Closing balance 2016-12-31 (+10.8 MSEK) is a rental cost reserve. The purpose of this reserve is to mitigate the interest rate risk.

The budgeted result 2017 will create a planned rental reserve of 24 MSEK.

8 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. 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.

The DanMAX agreement, in which the Danish universities Aarhus University, the Technical University of Denmark and University of Copenhagen come together to fund the DanMAX beamline at MAX IV was finalised in the beginning of summer.

MAX IV continues to receive visits from other light source facilities interested mainly in the new multiband achromat (MBA) accelerator technology, either for upgrading existing accelerators or for building new facilities. In 2016 delegations inspecting this MBA technology came from among others Japan (Tohoku University, SPring-8, and Photon Factory), China (Beijing Light Source), USA (Advanced Photon Source) and Canada (Canadian Light Source).

A list of international agreements and collaborations put in place during 2016 is found in the Appendix.

MAX IV Laboratory and Chalmers University of Technology have entered a formal collaboration in which Chalmers will take an active part in development and use of MAX IV Laboratory.

Appendix

International agreements and collaborations entered 2016

Aarhus University	Research Cooperation Agreement
EMBLEM, EMBL	Collaboration Agreement between EMBLEM/EMBL and MAX IV Laboratory
Jagiellonian University, SOLARIS National Synchrotron Radiation Centre	Research Cooperation Agreement
Danmarks Tekniske Universitet DTU, Aarhus University AU, University of Copenhagen	Cooperation Agreement - DanMAX
Laboratory of Physical Chemistry, Dept. Of Chemistry, University of Helsinki	Regarding "Design, construction, and utilization of the jet-stirred reactor coupled with the PEPICO setup at the FinEst beamline of the MAX IV synchrotron"
ESRF, DIAMOND, SOLEIL, CELLS, DESY, MAX IV, HZB, Global Phasing and EMBL	ISPyB Collaboration Agreement
European Synchrotron Radiation Facility (ESRF), Synchrotron SOLEIL, Elettra - Sincrotrone Trieste, Consortium for the Construction, Equipping and Exploitation of the Synchrotron Light Source (CELLS), MAX IV, Deutsches Elektronen-Synchrotron (DESY), National Synchrotron Radiation Centre SOLARIS, Istituto Nazionale di Astrofisica (INAF)	TANGO Controls Collaboration