Dnr: STYR 2023/92

Annual Report MAX IV Laboratory

2022

1) Executive summary

MAX IV Laboratory is a Swedish national synchrotron laboratory that provides access to 16 modern X-ray beamlines for academia, research institutes, industry, and government agencies worldwide. It employs over 300 staff and welcomes around 1000 users annually.

The scientific output of the laboratory keeps on increasing as more beamlines transition from construction to operation and play an active role in our user science program. This is also supported by the continued growth of our user community that remains strongly engaged with using our growing beamline portfolio for their research needs. For 2022, the MAX IV laboratory publication database indicates 157 peer-reviewed articles, a 21% increase compared to the 134 publications in 2021.

In 2022, MAX IV underwent extensive organisational changes, establishing a Technical Division to improve technical support and development within the Science and Accelerator Divisions. The laboratory appointed an interim director, Olof Karis, and a Deputy Director to strengthen MAX IV management further. The laboratory also developed a ten-year strategy and implementation plan that was validated by the MAX IV Board in December.

MAX IV is the first fourth-generation light source worldwide, creating opportunities for experimental techniques based on brightness and coherence. In 2022, the laboratory opened ForMAX, a beamline financed jointly by the Wallenberg Foundation and Treesearch, focusing on renewable and sustainable materials from forest-based materials. MicroMAX, a flagship beamline for protein structure determination, has also been commissioned in 2022. With these two beamlines entering operation, MAX IV has completed all the construction of all beamlines.

MAX IV has increased collaboration with Swedish universities through PRISMAS, a project within the European COFUND action, recruiting up to 40 doctoral students with research profiles linked to MAX IV. These students will complete a secondment at MAX IV, with co-supervisors based at the laboratory. The laboratory has also seen an increase in industry collaborations, particularly in drug discovery.

In 2023, MAX IV will continue to clarify roles and responsibilities within the Science Division. The process to recruit both a Director and an Administrative director started in early 2023. MAX IV will work on improving forecasting and cost follow-up. It will also focus on strengthening collaborations with higher education institutions, advancing work on the upcoming research bill, and completing a second experiment station at NanoMAX.

Lund, March 2023

Prof Olof Karis, Director MAX IV

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2) Scientific output

All MAX IV laboratory publications are available on our website at https://www.maxiv.lu.se/science/publications-2/. The details of our 2022 publications are also listed in detail in Appendix 5.

In 2022, and at the time of writing this report, the MAX IV laboratory publication database contained 157 peer-reviewed articles, as indicated by the dotted line in Figure 1. This corresponds to a 21% increase compared to 134 publications in 2021.

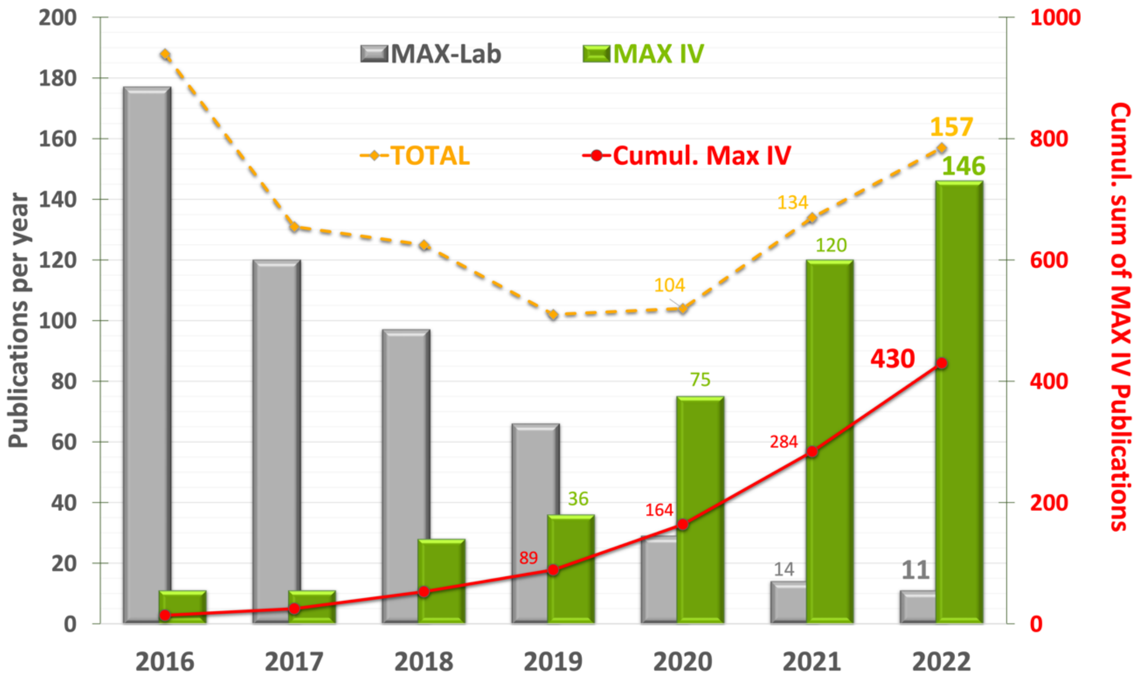


Figure 1: Number of publications per year discussing data measured at MAX-Lab and MAX IV in gray and green, respectively. MAX IV publications also include work performed by MAX IV staff that does not involve our beamlines. The dotted line indicates the total number of publications per year (MAX IV and MAX-Lab). The solid line displays the cumulative number of MAX IV-only publications.

The total number of publications (dotted line) contains articles discussing data measured at MAX-Lab (gray) and MAX IV (green). Publications that use data measured both at MAX-Lab and MAX IV are counted as MAX IV. Publications discussing data measured at MAX-Lab-only continue to decline (gray), i.e., a 21% decrease from 2021. In contrast, MAX IV data (green) continues to increase and shows a 22% increase in comparison to 2021.

Since 2020, the number of publications using data from MAX IV surpasses the one containing data measured at MAX-Lab. This is, for example, highlighted in Figure 2, for which 7% of the publications refer to data measured solely at MAX-Lab. We expect this diminution of MAX-Lab publications to continue.

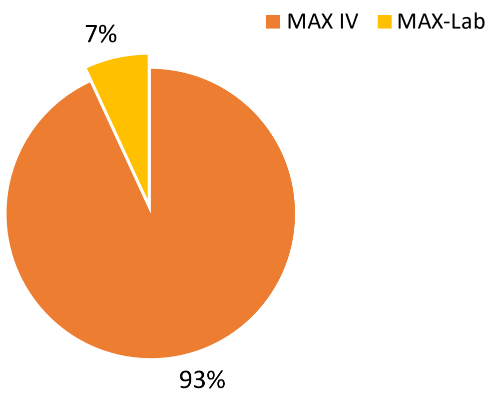


Figure 2: Distribution of 2022 publications involving measurement at MAX IV & MAX-Lab. Data measured both at MAX IV and MAX-Lab are considered MAX IV.

The cumulative number of MAX IV publications, as indicated by the solid red line in Figure 1, increases with 430 publications in 2022, a 51% increase compared to 2021. This is consistent with the increasing number of beamlines transitioning to user operation (i.e., fourteen (14) beamlines by December 2022) and the increased capabilities of each beamline. We expect this trend to continue. We also note that 11 PhD and 4 MSc theses were completed in 2022 using results obtained at MAX IV.

A graphical representation of the scientific impact of the work performed at MAX IV is presented in Figure 3. It displays the histogram (blue) of the 2022 publications frequency as a function of the journal impact factor (Clarivate, 2022).

We note the following:

- The average impact factor of all publications in 2022 is <IF> = 7.8, as indicated by the dash-dotted line in Figure 3.
- The average impact factor remains large and equivalent to <IF> = 7.9 for 2021, as displayed by the dash-dotted line.
- Nearly 30% of 2022 publications are in journals with an impact factor larger than the average impact factor <IF>.
- We note that four (4) publications are in journals with an impact factor above 30: Nature (1), Nature Materials (1), and Advanced Materials (2).

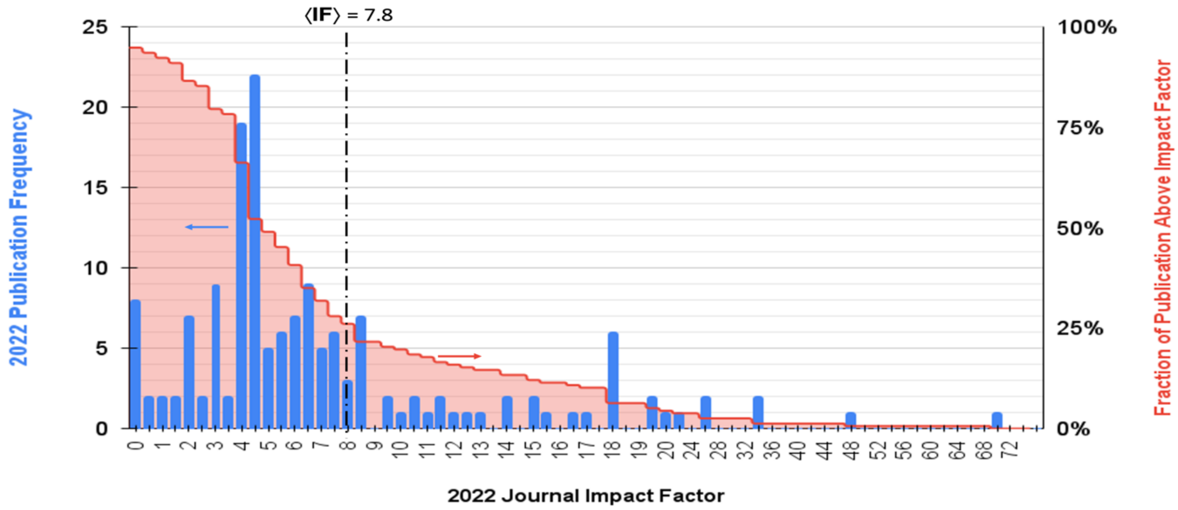


Figure 2: Histogram and left axis: 2022 Publications frequency as a function of the 2022 journals impact factor (IF). Solid line and right axis: Fraction of 2022 publications above a specific journal impact factor IF. The dash-dotted line indicates the average impact factor <IF> = 7.8.

Figure 4 presents the distribution of 2022 peer-reviewed publications related to data measured before 2016 at MAX Lab (gray), with any of our MAX IV beamlines (green), and the ones associated with the development of our accelerator complex (orange). Publications connected to data measured both at MAX-Lab and MAX IV are credited to the respective MAX IV beamline. Beamlines are ordered vertically from top to bottom by the time by which they were introduced to user operation. We note the following:

- BioMAX, our high-throughput macromolecular crystallography beamline, contributes to 24% of the 157 MAX IV publications for 2022.
- The scientific productivity of the earliest beamlines (NanoMAX, HIPPIE, FinEstBeAMS, BLOCH, and FlexPES) continue to increase. All exceed the threshold of 12 publications per beamline. We expect BALDER, MAXPEEM, and SPECIES to reach this milestone over the next few years.
- Veritas, our high-resolution Resonant Inelastic Scattering instrument, has addressed continuous technical challenges over the past few years. Expert commissioning users performed early experiments in 2022, and we expect the User Science Programme to ramp up while the technical performance of the RIXS instrument matures.
- The science productivity from FemtoMAX remains low and of concern. FemtoMAX will be evaluated in the framework of our periodic beamline reviews mid-2023.
- SoftiMAX, ForMAX & DanMAX just entered user operation in 2022. We expect the scientific productivity of these beamlines to grow rapidly over the coming years. We note that DanMAX is already generating a significant number (5) of publications in 2022, even at this very early stage.
- We did not expect any publication from MicroMAX yet, as it will only accept users in 2023.

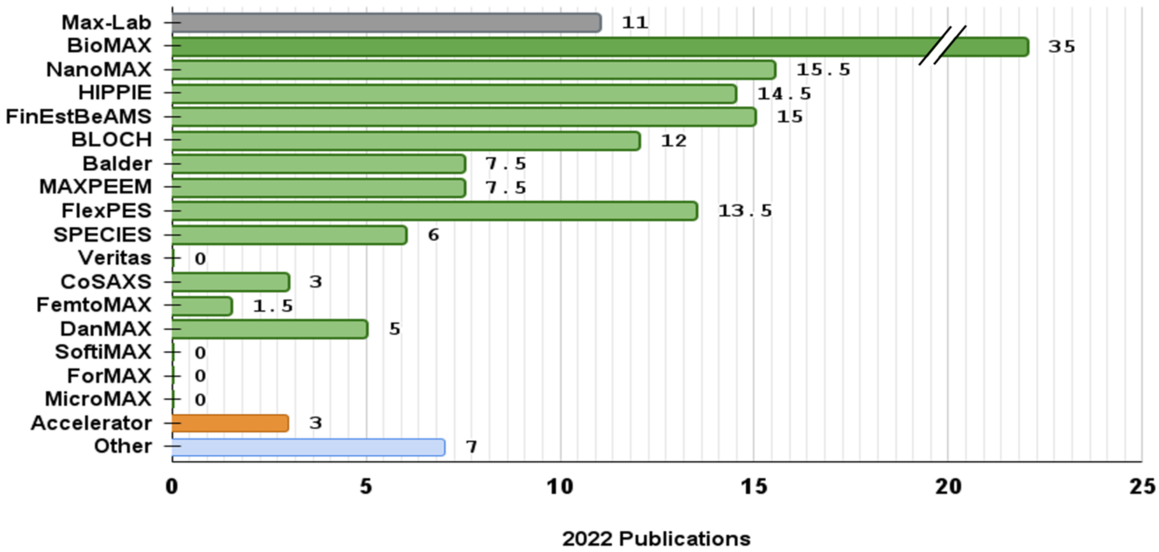


Figure 3: Number of 2022 publications discussing data from MAX-Lab (gray) or the MAX IV beamlines (green). Note that BioMAX is not plotted to scale. Publications related to both MAX IV and MAX-Lab measurements are credited to the respective MAX IV beamline. Also, beamlines are ordered by when they were introduced to our User Science Programme from top to bottom. Publications based on data measured at more than one instrument are prorated to the number of beamlines involved. Orange: Number of publications related to the MAX IV Accelerator Division. Blue: Number of publications from MAX IV staff unrelated to a measurement performed at our beamlines (e.g., engineering or theory article, collaboration with other facilities, etc.)

Some of our many scientific achievements are provided in the MAX IV laboratory's "Highlights 2021" (see Figure 5 - Left). It is available on our website at: https://www.maxiv.lu.se/science/reports/.

We also archive the "science news" that appear on our website. They can be found at https://www.maxiv.lu.se/science/science-news/

Figure 4 (Left) Cover page of our "Highlight 2021" publication discussing science achievements during 2021. It is available on our website at: https://www.maxiv.lu.se/science/reports/. (Right) Screenshot of our webpage providing regular "science news" that can be found at: https://www.maxiv.lu.se/science/science-news/.

From the many 2022 publications from our user program, we mention the scientific highlights below:

- A pivotal article that shows the advantages of the increase of coherence and stability an MBA-based synchrotron can give is the publication by Li *et al*. on Bragg ptychography experiments performed at NanoMAX[1]. This increase in coherence and stability meant that it was possible to retrieve high-quality images of a crystalline sample, with unprecedented quality, as the information increase was enough to overcome experimental limitations. The high brilliance of MAX IV also made it possible to speed up data acquisition significantly. This kind of Bragg ptychography experiment would not have been possible on a former generation of synchrotrons.
- The work of Barthel *et al.*[2] shows that the BioMAX beamline is a fully mature highly automated beamline where data collection on > 1000 ligand-soaked crystals is possible in very short timespans. This maturity of the beamline makes it possible to use crystallography as a screening method for early steps of drug discovery, such as fragment screening. This work also shows that fragment screening is not only a tool within drug discovery but that it also can identify putative protein-protein interaction sites and give information on complex formation. Using the capabilities of FragMAX, Luttens *et al.*[3] were able to combine virtual screening to find inhibitors against the SARS-CoV-2 main protease with crystallographic studies and further optimization. This resulted in a noncovalent main protease inhibitor with excellent properties for further drug development.
- Biocatalytic upgrading of waste products from food production into multifunctional materials increases the sustainability of materials usage. The waste product corn-fibre contains large amounts of cell wall polysaccharides such as arabinoxylans (AX) that can be used as a building source for new materials. In the paper by Yilmaz-Turan[4] *et al.* it was crosslinked using two different enzymatic systems, laccase/O_2 and peroxidase/H_2O_2. The use of either enzymatic system leads to hydrogel formation, but one process is faster, the other one slower but gives a more elastic product. Data from CoSAXS revealed structural differences in the network organization of the hydrogels produced by the two enzymes. This information can be used to develop hydrogels with specific functionalities so that they can be used for biomedical and nutritional applications in wound healing, cellular repair, and targeted delivery.

- Wang *et al.* investigated the inverse single-site model catalyst Fe1$(OH)_X$/Pt(111) for the preferential oxidation of CO in H_2 by using ambient pressure X-ray photoemission spectroscopy from our FlexPES beamline. The results highlight the high flexibility of the single iron atom catalyst in switching oxidation states, not observed for iron oxide nanoparticles under similar reaction conditions. This may indicate a higher intrinsic activity of such single interfacial sites than the conventional metal-oxide interfaces of nanoparticles.
- Boix *et al.* used the time-resolved ambient pressure X-ray Photoemission Spectroscopy capabilities of the HIPPE beamline to study the kinetics of an undercover catalytic process. This work provides a better understanding of the in-situ picture of H_2 and CO gas delivery, undercover reaction, and product removal from the confined space intercalated between graphene flakes on an Iridium surface. Understanding how gases enter the confined space below graphene and how the form products exit it again were in focus.
- García-Fernández *et al.* used the soft X-ray Photoemission Spectroscopy capabilities of our FlexPES beamlines to provide a better understanding of the surface and interface properties of lead-halide perovskites. This work on $MAPbI_3$ and $Cs_xFA_{1-x}PbI_3$ clean surfaces, focuses on Carbon and Nitrogen 1s and can serve as reference spectra for photoelectron spectroscopy investigations of technologically relevant polycrystalline thin films. The findings can also be utilized to optimize the design of device interfaces further.

Disclaimer

We corrected the number of 2021 publications provided in the 2021 Annual Laboratory report from 138 to 134. This is the result of several publications that were given a 2021 publication date at the time of the writing of the 2021 Annual Report (i.e., March 2021) but later appeared in a 2022 printed edition. This also revises the 2021 average impact factor to <IF> = 7.9 (instead of 7.1).

3) User Science Program

By the end of 2022, MAX IV had all 16 funded beamlines open to general user proposals.

- Fourteen beamlines received general users in 2022.
- ForMAX was taking light and was accepting general user proposals. The first commissioning expert users were scheduled for November 2022.
- MicroMAX was accepting general user proposals.

The details of the extensive capabilities of our beamlines are listed in Appendix 3.

Impact of the Covid-19 pandemic on our User Science Program
From the beginning of 2022 and on, the Covid-19 pandemic did not have any substantial impact on our user operation anymore. All but a few remaining scheduling backlogs were dissolved by the end of 2021, and users largely returned on-site already by the end of 2021.

Impact of sanctions imposed on the Russian Federation in response to the full-scale invasion of Ukraine
In response to the invasion of Ukraine by the Russian Federation, the Swedish government, in agreement with EU decisions, put an immediate and indefinite ban on scientific collaborations with Russian institutions. Consequently, MAX IV is not allowing access to its systems and installations to scientists affiliated with institutions from the Russian Federation. MAX IV also inactivated user accounts belonging to such scientists and also precluded the submission of proposals with co-proposers with such affiliations. As a result of the immediate enforcement of this rule, MAX IV cancelled a small number of previously approved user experiments.

Impact of the energy cost increase and electricity supply uncertainty
At the end of 2022, the change in the energy market resulted in supply uncertainty, with the risk extend the winter shutdown by several months into 2023. To alleviate the impact of such an event on the scheduling of beamtime, a waiting list system was put in place for the proposals from the Autumn 2022 call. When writing this report, this risk appears to be significantly reduced and we do not foresee applying similar measures going forward.

User Science Program Statistics
Table 1 provide statistics about our User Science Program for the period running from 2022-03-01 to 2023-02-20.

Table 1: User visits per beamline during the reporting period (2022-03-02 – 2023-02-20). Please note that each user registered on the proposal was counted as a visitor for those experiments that were conducted as mail-in or remote experiments.

Balder	138	**DanMAX**	165	**ForMAX**	32	**SoftiMAX**	77
BioMAX	219	**FemtoMAX**	27	**HIPPIE**	121	**SPECIES**	90
BLOCH	113	**FinEstBeAMS**	104	**MAXPEEM**	84	**SPM-lab**	11
CoSAXS	155	**FlexPES**	138	**NanoMAX**	163	**Veritas**	49
Total	1399						

In 2022, MAX IV hosted 1399 user visits. We note that this is a net increase from pre-pandemic numbers. The distribution per beamline is indicated in Table 1. We note that we count as user visits users registered on the proposal for which the experiment was conducted as mail-in or remote. The gender distribution of user visits was 33% women and 67% men.

The geographical distribution of our users' home institutions is provided in Table 2 and Figure 6. The majority of our users were from Sweden (47%), followed by Denmark (16%) and Germany (9%). Compared to last year, one can see a slight increase in user visits from outside Northern Europe which clearly reflects the lifting of travel restrictions that impacted user distribution during the pandemic. The Swedish user fraction has stayed stable over the last years to about 50%.

Table 2: Regional geographical distribution of European users.

Region	Users
Sweden	47%
Scandinavia (Sweden, Denmark, Norway)	65%
Nordic (Scandinavia, Finland, Iceland)	69%
Northern Europe (Nordic, Baltic countries)	71%
European	96%

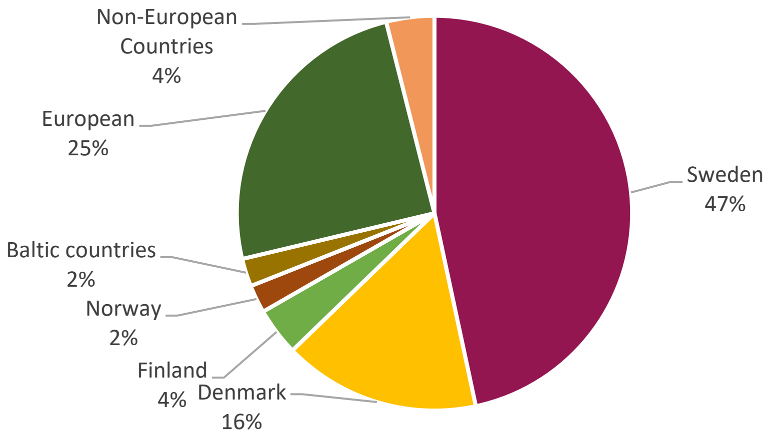


Figure 5: Geographical distribution of the home institution for the recorded users for the reporting period.

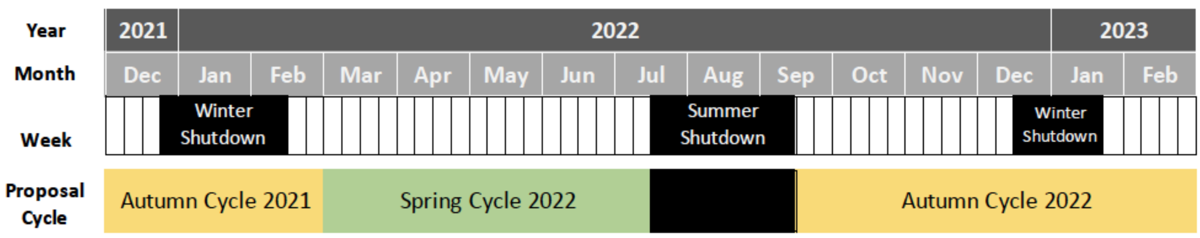


Figure 7: MAX IV opens Calls for proposals twice per year for General User Access program. The calls are named according to their beamtime period and year, not when the call itself opens. The two calls and beamtime cycles are split approximately like this: Spring Cycle call for proposals opens in September (open for ca 3-4 weeks), the beamtime period is approximately March to July/August (including summer shutdown). Fall Cycle call for proposals opens in February (open for ca 4 weeks), the beamtime period is approximately September to February (including winter shutdown). NB: Other access modes are also available, see https://www.maxiv.lu.se/user-access/access-modes/

There were two main proposal calls in 2022:

- The spring call (opened on 14 February; closed on 14 March) accepted proposals that were to be scheduled for the Autumn Cycle September 2022 to February 2023. A total of 335 proposals were submitted, and their distribution per beamline is provided in Table 3. All beamlines were available in this call, with ForMAX and MicroMAX not in the general user program but accepting commissioning expert users.
- The autumn call (opened on September 5th; closed on September 26th) accepted proposals to be scheduled for the Spring Cycle March 2023 to August 2023. A total of 361 proposals were submitted, and their distribution per beamline is provided in Table 3.
- We note that some beamlines lead in the typical number of proposals per cycle. The number of proposals varies considerably from call to call, indicating that the user community is still learning about the available capabilities. Notably, some beamlines (Balder, NanoMAX, DanMAX and BLOCH) have more than 30 proposals, while others see a slight reduction.

Figure 8 presents the distribution of submitted and accepted proposals per Program Advisory Committee (PAC) research areas. The MAX IV PAC typically consists of about 55 international scientists. They evaluate proposals based on scientific merit and participate in the beamtime allocation. The current description of the members of our PAC is available at the following link on our website: https://www.maxiv.lu.se/about-us/governance/advisory-bodies/ Before the PAC evaluation, our beamline staff reviews all proposals for technical feasibility. The proposal evaluation process is described in more detail at: https://www.maxiv.lu.se/user-access/user-guide/proposal-submission/review-process-standard-access/ The distribution of our beamlines per research area is provided in Table 3. We note that the largest number of proposal requests by the user community is for spectroscopy, chemistry, and soft matter and nanoscience. Structural biology is not adequately represented in this plot, as this community self organizes with Beamtime Allocation Group (BAG) proposals.

Table 3: Distribution of proposals per beamline and call in 2022.

PAC Research Area	Beamline	Spring Call	Autumn Call
Chemistry & Soft Matter	Balder	38	45
	CoSAXS	41	36
	ForMAX	12	15
Structural Biology	BioMAX	16	5
	MicroMAX	2	1
	NanoMAX	36	31
Material Science with Hard X-ray	DanMAX	20	30
	BLOCH	33	45
	FinEstBeAMS	21	27
	FlexPES	36	29
	HIPPIE	33	21
	MAXPEEM	16	14
	SoftiMAX	9	14
	VERITAS	13	15
	SPECIES	12	20
Ultrafast Science	FemtoMAX	7	8
Total		335	361

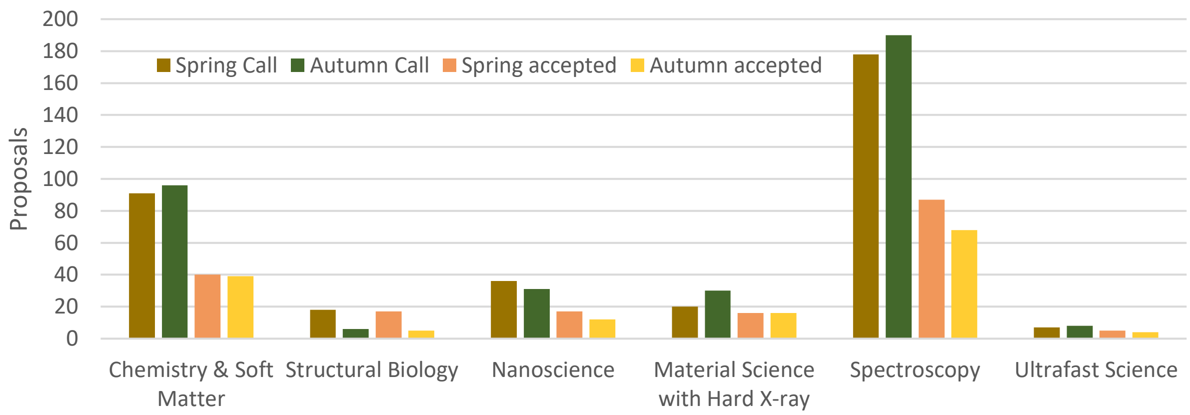


*Figure 8: Submitted and accepted proposals per research area in the 2022 spring and autumn calls. *Structural Biology proposals for the BioMAX beamline include BAG proposals.*

4) Industry engagement

In 2022, the industrial use of MAX IV continued to grow. Ninety proprietary experiments were conducted at our beamlines, an increase of 29% compared to the previous year (70 experiments in 2021). A total of 33 industry users purchased 669 hours of proprietary beamtime, an increase of 20% compared to the previous year (556 hours). This mainly corresponded to industrial demand for macromolecular crystallography at the BioMAX beamline and for fragment screening, now also offered as an all-in-one service at the newly installed fragment screening platform FragMAX. Also this year a larger number of companies used MAX IV through the Vinnova pilot project funding together with mediators from both academia and institute. A third of the proprietary beamtime in 2022 was connected to Vinnova pilot projects. In addition, another twenty-five (25) proprietary hours for 14 experiments were purchased for other MAX IV services, such as access to the optics lab and the microscopy lab. This adds up to a total number of 104 proprietary experiments in 2022.

Table 4: Number of industry users, including technology institutes.

Industry users	2018	2019	2020	2021	2022
Recurring users		3	4	9	16
New users	4	10	7	18	17
Total users	**4**	**13**	**11**	**27**	**33**

Table 5: Number of proprietary beamtime hours per research technique.

Proprietary hours per research technique	2018	2019	2020	2021	2022
MX (BioMAX, MicroMAX)	43	132	218	300	420
Spectroscopy (HIPPIE, Balder, SPECIES, SoftiMAX)		60	34	140	159
Imaging (NanoMAX, MAXPEEM, DanMAX, ForMAX)		24	37	96	61
Scattering (CoSAXS, ForMAX)			24	20	25
Diffraction (DanMAX)					4
Support labs (AFM, Optics)					25
Total hours	**43**	**216**	**313**	**556**	**694**

The industry mainly benefits from MAX IV in the form of collaborative research through open access. Out of 764 proposals submitted to MAX IV through the open access mode during spring and fall cycles of 2022, 16% (119 proposals) declared to have an industry connection. In other words, in addition to the 669 hours of proprietary beamtime purchased in 2022, about a sixth of all proposals submitted through open access had an industry connection. The acceptance rate for industry-connected proposals in 2022 was 51%.

Increased external communication and outreach efforts

The IRO has increased external communication through owned and external channels, targeting strategically relevant industry sectors. A step-by-step guide for industry users has been implemented on the newly launched MAX IV website. More “easy to read” industry cases have also been produced and distributed through the MAXESS Industry Arena project (funded by the Swedish Agency for Economic and Regional Growth and Region Skåne). Most of the cases are based on Vinnova pilot project reports but some new cases are generated in the MAXESS Industry Arena project in collaboration with SmiLe life science incubator.

A closer relationship with the life science industry sector
As a part of the strategic goal to enhance collaboration with the life science and healthcare sector and MAX IV, InfraLife organized a successful two-week course in integrative structural biology techniques for researchers in August 2022[1]. The aim was to increase the general knowledge level among researchers and scientists about the techniques available at MAX IV, ESS, and SciLifeLab. The course was open to scientists from academia, health care, and industry and took place in Lund, Gothenburg, and Stockholm. Students and scientists appreciated it, and the ambition is to make the course a recurring event through national collaboration.

The MAX IV industry office team also participated in the Nordic Life Science Days in Malmö in September 2022 through the VR-funded project InfraLife (Infra Access for Life Science Sweden), a joint hub of MAX IV, ESS, and SciLifeLab. The conference was an important opportunity to meet life science researchers and scientists to discuss how large-scale research infrastructures can be useful in their industrial R&D projects.

To further support startup and growth companies within the life science field in their product development, the IRO has continued collaborating with the life science incubator SmiLe in Lund through the MAXESS Industry Arena project. The joint activities during 2022 have led to more local startups using large-scale research infrastructures to perform life science experiments. For example, the contract development and manufacturing organization Magle Chemoswed, a startup member of SmiLe, conducted an R&D experiment at MAX IV beamline DanMAX where X-ray powder diffraction was used to measure polymorphs in tablets[2].

First industry experiment performed at ForMAX
In November 2022, global food packaging and processing company Tetra Pak performed the first-ever industry experiment at the newest beamline ForMAX. The experiment focused on developing more durable and sustainable paper-based consumer products to replace single-use plastic products. It successfully rendered high-resolution data and brought new, valuable insights that will now guide Tetra Pak's future sustainable product development.

The ForMAX beamline initiative is the result of several market-leading forest and packaging industries joining forces with academia and the Knut and Alice Wallenberg Foundation. The opening of the ForMAX beamline in autumn 2022 gained national and international attention in the mainstream and industry media through a press release coordinated by the IRO in collaboration with Treesearch, Tetra Pak, and the Knut and Alice Wallenberg Foundation.

Fruitful collaborations and strengthening of multipliers
The IRO has continued the close collaboration with Alfa Laval through its full-time team member dedicated to strengthening synchrotron-based R&D activities within the Nordic metal industry. The

[1] Infralife, *Education & Training*, accessed 21 March 2023, https://www.infralife.se/activities/education-and-training/structural-biology-course/

[2] MAXESS, *Investigating Polymorphic Purity of Tablets*, accessed 21 March 2023, https://maxess.se/case/investigating-polymorphic-purity-of-tablets/

two-year assignment has been prolonged for another year. The collaboration has contributed to a closer dialogue with the metal and manufacturing industry. Productive workshops and discussions have been organised with Swedish companies and trade associations, facilitating knowledge transfer and mapping emerging industrial research needs that may inspire the future development of MAX IV.

The VR-funded collaboration between MAX IV, RISE and Swerim, with the mission to strengthen Swedish institutes in their roles of multipliers supporting the industry's use of large-scale research infrastructures, came to an end. The positive collaboration has led to the implementation of new capabilities, including nine new employees at RISE and SWERIM dedicated to assisting companies in using MAX IV.

References

[5)] Infralife, *Education & Training*, accessed 21 March 2023, https://www.infralife.se/activities/education-and-training/structural-biology-course/

[6)] MAXESS, *Investigating Polymorphic Purity of Tablets*, accessed 21 March 2023, https://maxess.se/case/investigating-polymorphic-purity-of-tablets/

5) Beamline development (2022)

In 2022, and for the first time, all 16 beamlines of MAX IV received light to their experimental stations. The year also saw a significant number of development projects being realised throughout the portfolio of MAX IV beamlines. There is, at present, not any new beamline being funded, but the 16 existing beamlines have many ongoing developments. Six main beamline construction projects are still open (MicroMAX, ForMAX, CoSAXS, DanMAX, SoftiMAX and NanoMAX). CoSAXS and NanoMAX will be completed in 2023. In addition, the other beamlines are adding capabilities after securing funding as part of their operation.

The pandemic still affects us in terms of significant delays for many vital components. The worldwide shortage of semiconductors and other components has also caused several project delays. The MicroMAX project has been severely delayed due to late deliveries of their optics.

New beamlines entering operation in 2022

ForMAX and MicroMAX beamlines took light for the first time in 2022.

ForMAX, a beamline for *in situ* multiscale structural characterisation of hierarchical systems such as plant fibres by combining full-field tomographic imaging, small- and wide-angle X-ray scattering (SWAXS), and scanning SWAXS imaging, succeeded to get their first light on the experimental station just before the summer shutdown in 2022. In the autumn, several expert user groups, including one from industry have performed experiments at ForMAX, and the beamline has now had its first call for external users.

MicroMAX is a microfocus beamline for macromolecular crystallography aiming to provide flexibility in terms of X-ray performance and experimental setup for serial and time-resolved crystallography. The beamline also took the first light in spring 2022, but due to late deliveries and other issues with its optics, the first beam on a sample took place in late autumn 2022, and the first experimental data was obtained late December. The beamline is now open for both normal proposals on standard rotational crystallography and for commissioning experts to help develop serial crystallography and time-resolved experiments.

New capabilities on existing beamlines

In addition, many new capabilities were added and/ or offered to external users for the first time in 2022. The most important being:

- **Balder**, the X-ray absorption and emission spectroscopy (XAS & XES) beamline for medium- and hard energy X-rays, now offers a unique and internally developed X-ray emission spectrometer (Scania) to external users. In addition, thanks to upgrades in the control system, the beamline can now offer the capability to collect full EXAFS spectra in a second.
- **BioMAX** is an X-ray macromolecular crystallography beamline. Added capabilities in 2022 include grid scans for X-ray diffraction-based sample centering and fast (1 second) flying energy scans.
- **Bloch** beamline is dedicated to high-resolution angle-resolved photoelectron spectroscopy (ARPES), and in 2022, the spin-ARPES station on the B-branch of the beamline received its first commissioning users. The technique is now available also for external users.

- **CoSAXS** is a multipurpose Small Angle X-ray Scattering (SAXS) instrument with opportunities for X-ray Photon Correlation Spectroscopy (XPCS) experiments. Added user capabilities in 2022 include a rheometer and the possibility to perform experiments with high magnetic field.
- **DanMAX** is a materials science beamline dedicated to *in situ* and operando experiments on real materials. In 2022, the powder diffraction station come into full operation and can now offer data collection speeds up to 250 Hz.
- **FemtoMAX**, the femtosecond X-ray beamline at the MAX IV short-pulse facility (SPF) is tailored for ultrafast X-ray techniques. New features in 2022 include the incorporation of a completely new experimental chamber enabling diffraction geometries up to 2theta=120deg (in-vacuum).
- **FinEstBeAMS** is a materials and atmospheric science beamline providing ultraviolet and soft X-ray radiation on two branches: one is dedicated to ultra-high vacuum studies of surfaces and interfaces, while the other to gas-phase experiments and photoluminescence in solids. In 2022, the beamline had their first external users on the solid-state end station and a new aerosol sample delivery system was successfully tested and will now be available for external users.
- **FlexPES** offers a variety of photoemission and soft X-ray absorption experiments for the Surface/Material Science and Low-Density Matter user communities. New capabilities in 2022, include continuous (fast) scanning mode delivered to users; -> time of scanning (NEXAFS) is shortened on average by a factor of 10 (from 20 min to 2 min/spectrum) and a new grating increasing the flux 2 – 7 times at lower photon energies.
- **HIPPIE** is a beamline for Ambient Pressure X-ray Photoelectron Spectroscopy (APXPS), a technique also offered at Species beamline on the 1.5 GeV ring. In 2022 a High-Pressure Reactor was successfully tested and will be offered to the users in the 2023-II call. PM-IRRAS (an infrared spectroscopy technique) has successfully been implemented, and the capability is now offered to 2023 users. Another new capability is the event-averaged time-resolved APXPS that is now available for general users at both SPECIES and HIPPIE.
- **MAXPEEM** beamline is equipped with an aberration-corrected Spectroscopic PhotoEmission and Low Energy Electron Microscope (SPELEEM). The microscope has been upgraded on several occasions. In 2022, the new energy analyser was installed, improving the energy resolution in all modes of operation. Now, along with high spatial resolution, photoelectron spectra and the electronic band structure can be acquired with twice better energy resolution.
- **NanoMAX**, the hard X-ray nanoprobe of MAX IV had its first external commissioning users on their 2nd end station, an X-ray microscope based on zone plate optics. The commissioning of the instrument will continue in 2023.
- **SoftiMAX** is a soft X-ray beamline dedicated to spectromicroscopy and coherent imaging. In 2022 the beamline had its first general users on the STXM and Ptychography branch line and can now offer both techniques to general users.
- **SPECIES** is a soft X-ray beamline with two branches: one for Ambient Pressure XPS (APXPS) experiments and one for Resonant Inelastic X-ray Scattering (RIXS) experiments. New capabilities offered in 2022 include a set up for photo catalysis experiments incorporating an external light source (solar simulator).
- **Veritas** beamline is a Resonant Inelastic X-ray Scattering (RIXS) beamline on the 3 GeV ring. Progress in 2022 includes the successful incorporation of a Helium cryostat and a load-lock/ in vacuum sample storage enabling experiments on air-sensitive samples.

- **Low Density Matter (LDM)** is a cross-beamline initiative for research on gas phase molecules, liquids, and free clusters. In 2022, the ICE (Ions in Coincidence with Electrons) mobile end station had its first regular users. It is designed to be compatible with several of our LDM-relevant beamlines and has now been used in both single and multibunch modes. In addition, and in collaboration with XFEL in Hamburg, new 3D-printed nozzles and equipment producing very thin (< 1 µm) liquid jets have been successfully tested on FlexPES. The jet that can be used on several beamlines becomes transparent for soft X-rays and enables e.g., XAS in transmission for light elements.

MAX IV has two main processes for orchestrating the beamlines developments when these require internal resources. The primary process is through the Central Project Office (CPO), which coordinates all large-scale projects at MAX IV on beamlines, infrastructure, and accelerator systems. On the beamline side, the For- and MicroMAX projects have dominated the CPO activities. Still, many of the above-listed new capabilities on beamlines result from one or several CPO projects. In total, some 12 beamline-related CPO projects were completed during 2022, and 6 new ones were started. The most important new projects are Imaging detectors for DanMAX and ForMAX, the DanMAX high-resolution powder diffraction set-up (HERDi) and the CXI end station on SoftiMAX.

Beamline projects of smaller scale are managed through the Beamline Advisory Group (BPAG) process by the Beamline Office (BO). In 2022, 26 BPAG projects were completed. These varied significantly in scope but generally aimed to provide an extra feature or improvement regarding, e.g., user-friendliness, safety or more complex fixes that need immediate attention. Two typical examples are introducing an emergency stop for all movements of mechanical parts inside the NanoMAX experimental hutch and installing a separate water-cooling circuit for internally cooled mirrors on Bloch to minimise the risk of corrosion.

Beamline reviews

MAX IV organises periodic reviews of our beamlines to ensure their instrumentation and scientific programs' adequacy and relevance for the user community and competitiveness compared to similar instruments. These beamline reviews typically occur every three to five years and aim at assessing scientific productivity and associated medium- and long-term technical and strategic development plans. In 2022, the activities on the Finest and FlexPES beamlines were evaluated in a joint review and the Bloch beamline in an independent review during the spring. The outcome of these reviews was presented and discussed with our Science Advisory Committee.

New beamlines

There is space for 10-15 more beamlines situated at either storage ring or the Short Pulse Facility. New beamlines concepts can be proposed through so-called Expressions of Interest (EoIs). In 2021, MAX IV invited internal and external stakeholders for a first round of EoIs and received six related to new beamlines. In spring 2022, these were evaluated by an external committee of experts and divided into three categories: A – Clear pass, B- Question remains, and C – No pass this time. The following beamline proposals received an A – clear pass (no priority order):

- **SXL** – A Soft X-Ray free-electron laser beamline driven by the MAX IV 3 GeV linac
- **GTiMAX** – Tomographic imaging beamline at MAX IV
- **MedMAX** – Bio/medical imaging beamline for tomography of soft materials
- **MIRARI** – IR for everyone

- **Tender and Hard X-ray beamline for X-ray Spectroscopies**

The following beamline proposal received a B – questions remain.

- **OPERA** – A hard X-ray operando diffraction beamline

MAX IV will, in collaboration with corresponding communities, continue to further develop the design and budget for these proposals and actively seek funding opportunities for top-ranked proposals.

6) Accelerator Operations and Development

Accelerator Operations in 2022

The year 2022 was marked by a nearly full recovery in delivered beam hours compared to the previous year, which was severely affected by the COVID-19 pandemic. The recovery was not yet up to the levels of 2020, when accelerator operations achieved the international golden standard of roughly 5000 hours of delivery. This was partly due to remaining side effects of the pandemic, in particular, the installation of two new beamline insertion devices in the 3 GeV ring, which was postponed from summer 2021 to winter 2022. Moreover, additional time in the summer 2022 shutdown was planned to allow for an investigation of potentially serious arcing in the linac RF system.

Finally, the last operations week of the year in the 3 GeV ring was converted to a maintenance week, originally upon request from two beamlines who needed to replace leaking fixed masks in their front ends and later used to remove a leaking harmonic cavity. The resulting scheduled beamline hours for 2022 were 4464, 4848, and 4272 for the 3 GeV ring, 1.5 GeV ring, and Short Pulse Facility (SPF), respectively. These figures fall short of the planned goals for the year by roughly 20% for the storage rings and about 30% for the short pulse facility. Figure 9 shows the development of scheduled beamline hours since the start of user operation in 2017.

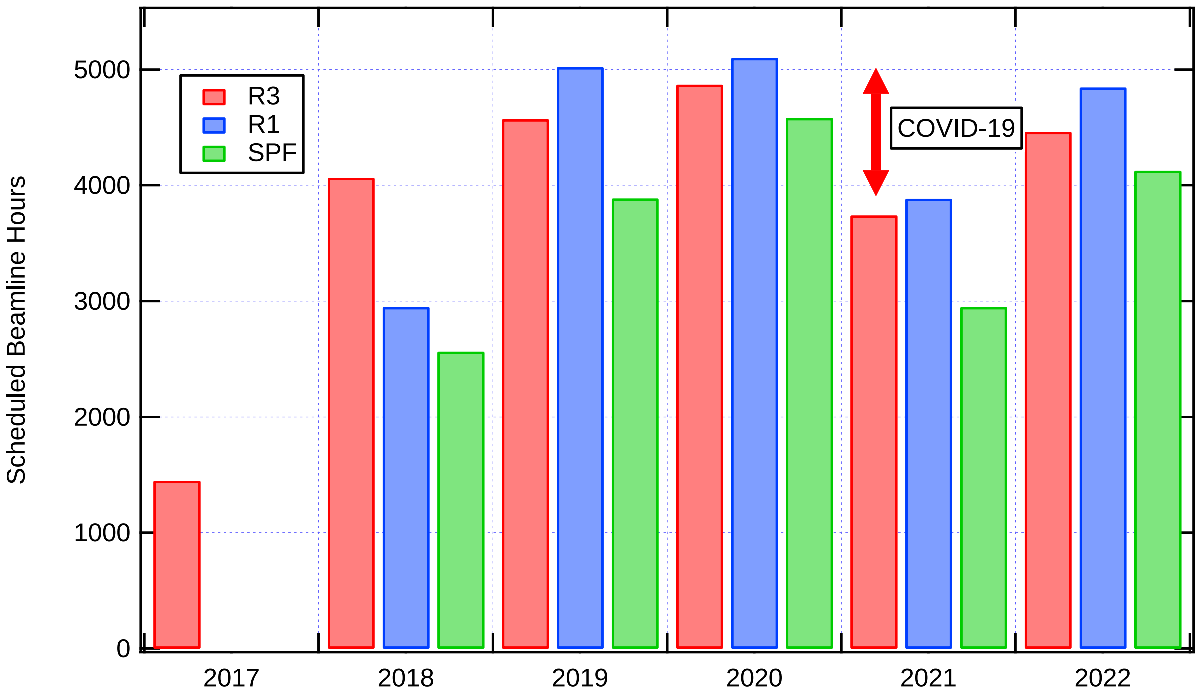


Figure 9: Number of scheduled beamline hours per year since the start of user operations in 2017. By 2020, all accelerators were approaching 5000 hours. The significant reduction in 2021 is a direct result of the COVID-19 pandemic and 2022 shows a welcome recovery towards the 2020 levels.

The accelerator uptime in 2022 (Figure 11) was the best in both storage rings since the start of user operations, achieving 98.2% in the 3 GeV ring and 98.4% in the 1.5 GeV ring. The SPF (Figure 12) shows a much-improved uptime (97%) compared to the past two years, a welcome result of the linac reliability improvement programme launched in 2022.

At the same time the mean time between failures (MTBF) continued at excellent levels for the storage rings: The goal of 72 hours MTBF was met for the 3 GeV ring and exceeded for the 1.5 GeV ring, which achieved 97 hours. The MTBF for the SPF in 2021 (13 hours) was slightly better than for the previous year, but still below our 24-hour goal. However, the programme launched in 2022 to automate the recovery of modulator/klystron trips did provide a very significant reduction in the frequency of long-duration downtimes, as can be seen in Figure 12.

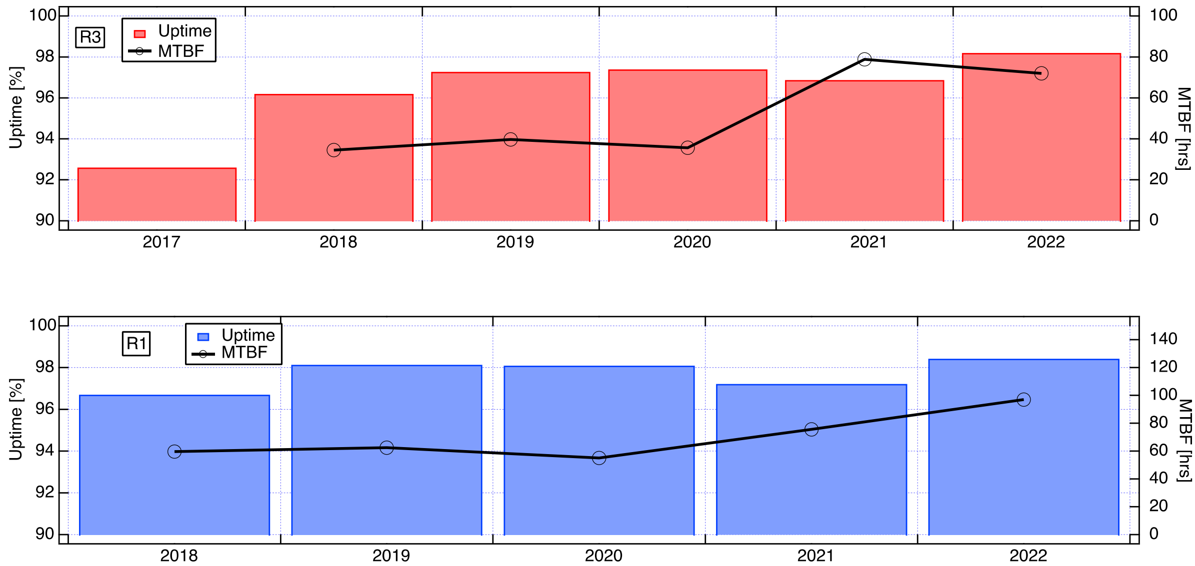


Figure 10: Uptime and Mean Time Between Failures (MTBF) for the 3 GeV (Red) and 1.5 GeV (Blue) storage rings since the start of user operations.

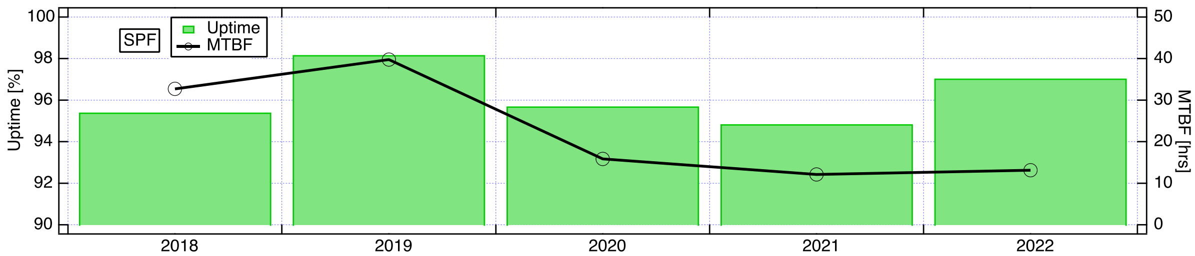


Figure 11: Uptime and MTBF for the Short Pulse Facility.

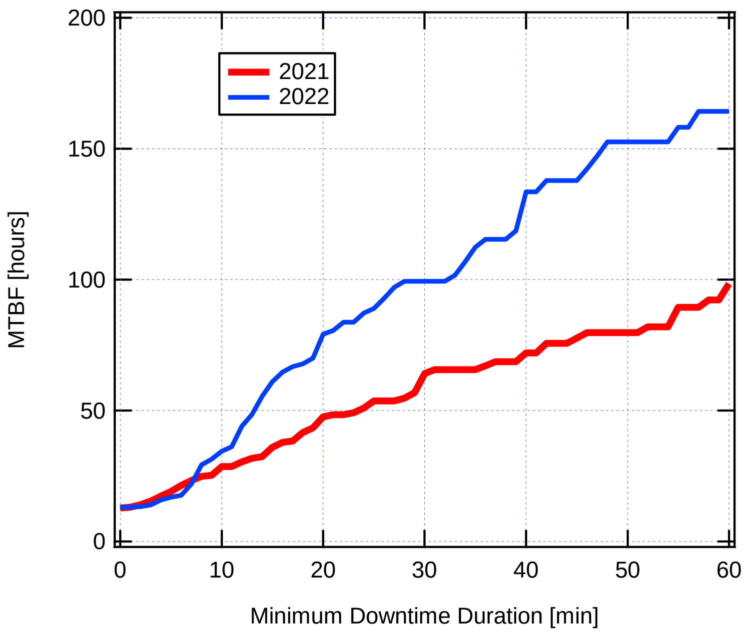


Figure 12: MTBF for the Short Pulse Facility as a function of downtime duration – only the downtimes with a duration larger than a given value are counted. A significant reduction in long downtimes is clear from 2021 to 2022.

Accelerator Division Highlights

Transparent Injection into the 1.5 GeV Ring

A multipole injection kicker (MIK) system was built, installed, and successfully commissioned in the 1.5 GeV ring. This device follows the same design principles of a similar system already in operation in the 3 GeV ring since several years, and which has provided world-record low perturbations to the stored beam during top-ups. The original system was developed within the scope of a collaboration with Synchrotron SOLEIL in France and was based on a concept proposed at BESSY in Berlin. It consists of eight current-carrying wires arranged in such a geometry that a deflecting magnetic field is produced at the position of the injected beam, while the field seen by the stored beam is ideally zero.

Commissioning of the new system in the 1.5 GeV ring was extremely fast and once installation was completed in late November, high-efficiency injection could be achieved within the first 15 minutes of operation (Figure 12). The outstanding reduction in perturbations to the stored beam as compared to the previously used conventional injection system is illustrated in Figure 14. While the dipole kicker remains as a fallback, the MIK has become the standard mechanism for injection during beam delivery to beamlines already the day following its first operation.

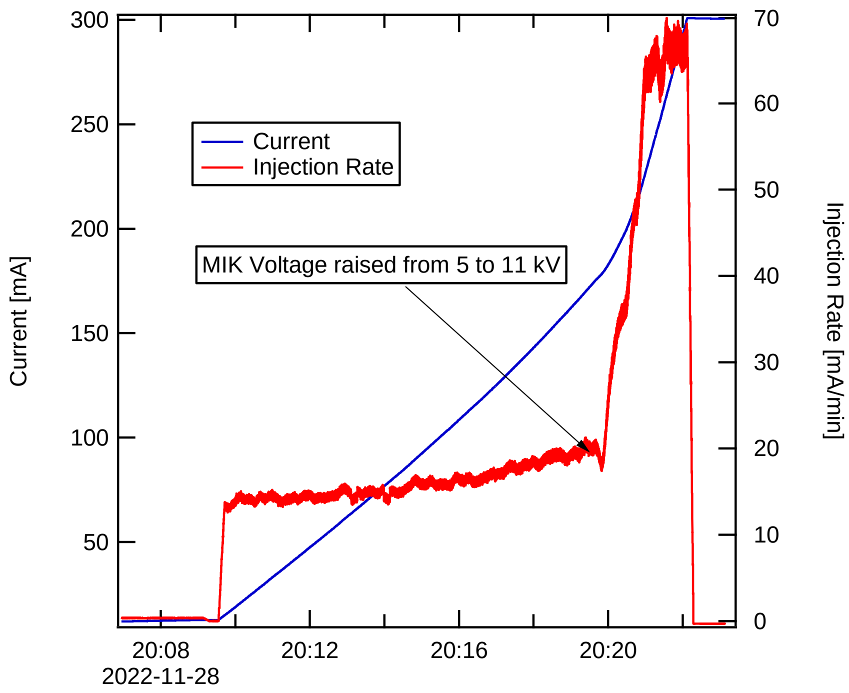


Figure 13: First injection realized with Multipole Injection Kicker in the 1,5 GeV ring.

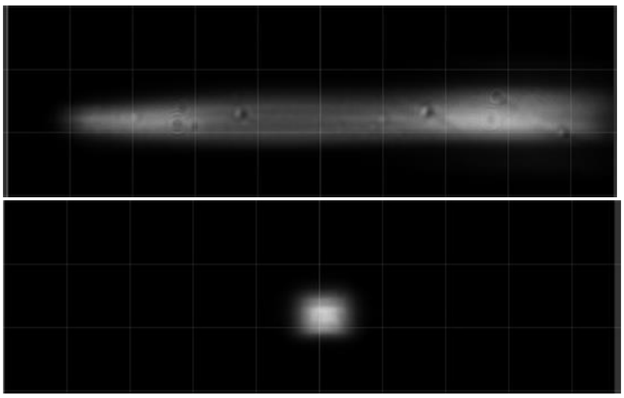


Figure 14: Transverse profile of the electron beam in the 1.5 GeV as observed at a diagnostic beamline during a top-up injection. Top: injection with the conventional injection system. Bottom: injection with the new Multipole Injection Kicker

Transverse Deflecting Cavity System at the Linear Accelerator

The suite of diagnostic systems used to characterize the properties of the electron beam produced by the linear accelerator received a major boost with the assembly of a transverse deflecting cavity (TDC) line. The TDC will allow the measurement of various properties of the very short electron bunches (nominally down to 100 fs): in particular, the first direct measurement of the bunch lengths as well as knowledge of thee variation of beam properties along the bunches (so called “slice parameters”) will be possible with down to 1 fs time resolution. This will give an important insight into the complex dynamics of the short bunches with benefits, for example an understanding of the causes of emittance growth along the linear accelerator. All of this will provide a more robust delivery of short X-Ray pulses to the FemtoMAX beamline and pave the way to the future production of even shorter pulses and to the operation of the linac as a driver to a soft X-Ray free-electron laser.

Once a radiation safety permit is obtained over the next months, the structures will be conditioned at high power. Commissioning with beam is expected to start early in autumn.

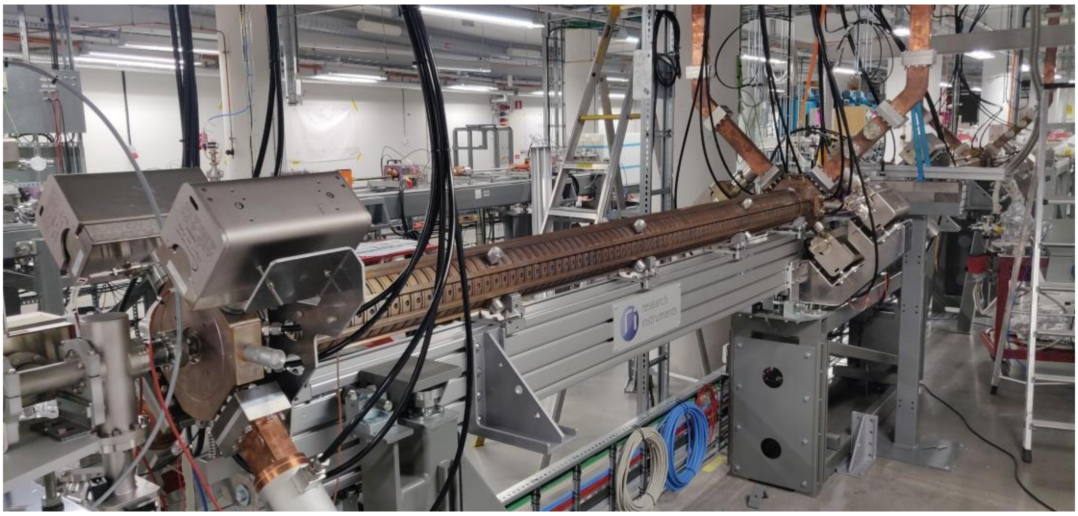


Figure 15: One of the two transverse deflecting cavity structures installed in the Short Pulse Facility hall in autumn 2022.

Transverse Resonant Island Buckets (TRIBs) in the 1.5 GeV ring

To satisfy the needs of scientific experiments requiring customized time structures of the synchrotron radiation, the 1.5 GeV ring is today run in “single-bunch” mode for a few weeks every year. While this mode enables outstanding science, it also reduces total intensity to the detriment of other experiments, which are typically impossible under those circumstances. One scheme that could potentially allow the simultaneous use of the source by both communities thus increasing the availability of the source for time-resolved science, was pioneered at BESSY – transverse resonant island buckets (TRIBs). In this operation mode, the optics in the storage ring is brought close to a third-order resonance causing transverse phase space to split into several “islands” which constitute spatially separated source of light.

The population of these islands can be controlled on a bunch-by-bunch basis so that beamlines that select only light from the islands can effectively observe a light pulse repetition rate that is different from that observed by beamlines that select the light from the core of the beam. In this way, multi-bunch and single-bunch experiments could be run simultaneously. In 2022, the scheme was tested successfully in demonstration experiments at the 1.5 GeV ring at currents up to 450 mA. Tests in which beamlines could select the light from the islands and undulator gaps were moved while top-up injection was carried out were also successful (Figure 16). These allowed us to start addressing several critical challenges, including storing enough charge in the islands and, in particular, maintaining stable transverse tunes while insertion device gaps and phases change.

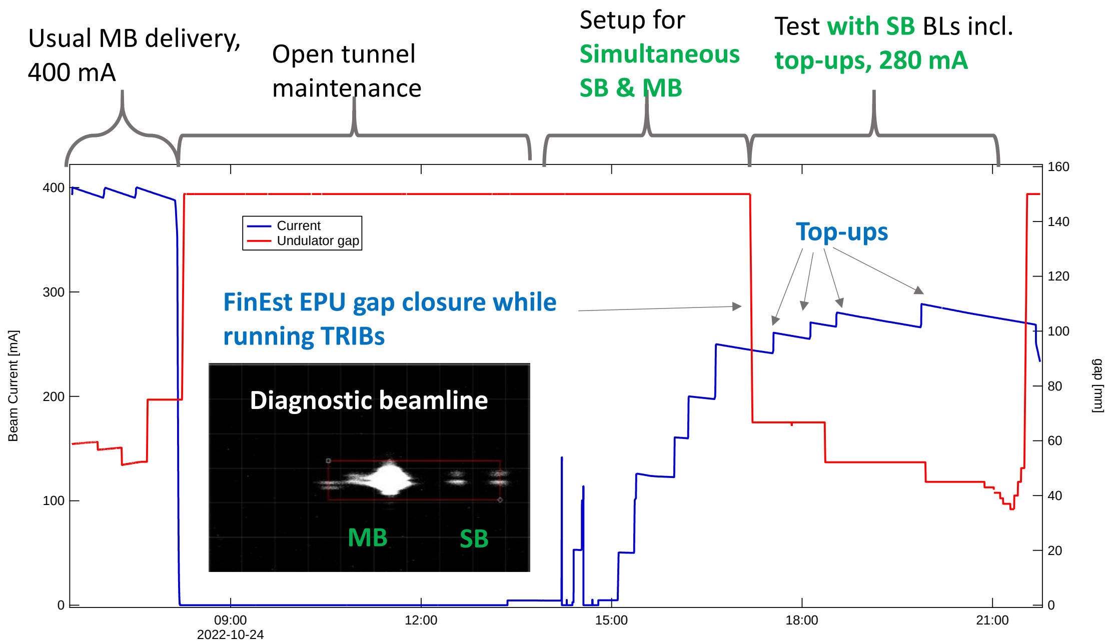


Figure 16: Beam current and FinEST beamline Undulator gap during tests with TRIBs. Once the Undulator gap was closed while in TRIBs mode, the undulator gap was closed at 280 mA, light from the islands was selected at the beamline and top-ups were realized. The insert shows the transverse profile of the electron beam as observed at a diagnostic beamline with both the core (multibunch) beam and the island (single-bunch) beam.

Lower Emittance Optics in the 3 GeV ring

Theoretical and experimental studies aimed at reducing the electron beam emittance and thereby increasing the photon beam brightness in the 3 GeV ring proceeded in 2022. This is the first step towards the ultimate goal of achieving the diffraction limit at hard x-ray photon wavelengths. In 2022, a stronger focusing optics was implemented that can be achieved without any hardware changes to the ring, i. e. maintaining the same magnets and power supplies, but simply readjusting their excitations. This optics is designed to provide a bare-lattice emittance of 270 pmrad, i. e. a 20% reduction with respect to the 328 pmrad of the nominal lattice (Figure 17). Beam threading algorithms were implemented to realize the first few turns in the new lattice and capture of a low current could be successfully demonstrated. This allowed verification and correction of linear optics parameters such as the dispersion function and beta beats. Achieving enough dynamic aperture to allow for beam accumulation is still to be demonstrated.

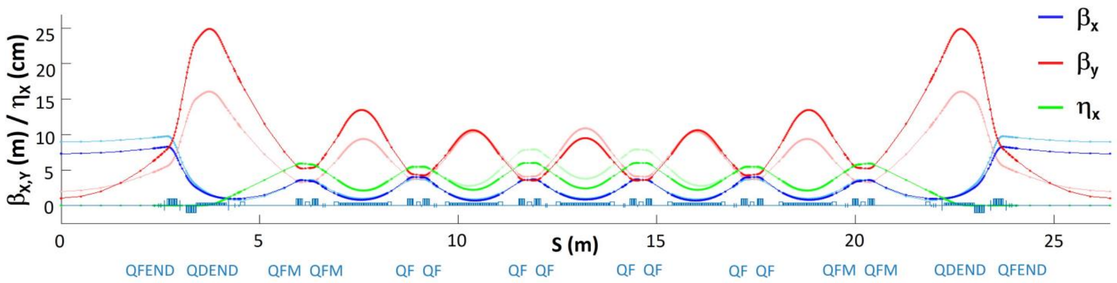


Figure 17: Twiss parameters along one achromat of the MAX IV 3 GeV ring. Light colours - present lattice at 328 pmrad, Dark colours (new lattice at 270 pmrad).

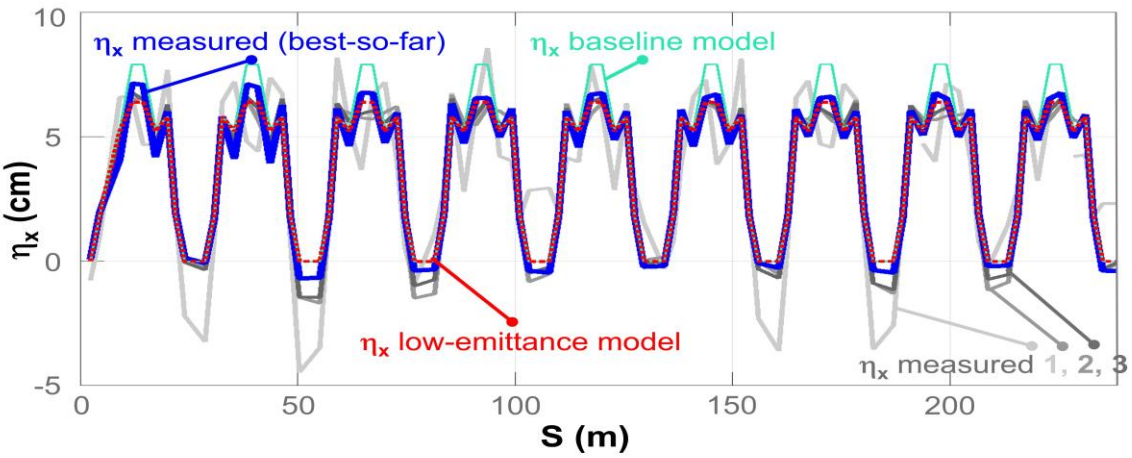


Figure 18: Dispersion function measurement for the new lower emittance lattice.

HarmonLIP 2022 Workshop

On 10-12 October, a workshop on the use of Harmonic Cavity Systems at fourth and future generation light sources was organized at MAX IV. The workshop was sponsored by LEAPS (League of European Accelerator-Based Light Sources) and had 50 registered participants from 13 Institutions and 10 countries, see Figure 19. This is the first in a series of events that result from the Leaps Internal project HarmonLIP initially proposed by MAX IV to the Leaps Working Group 2 in autumn 2021. Bringing such an event to MAX IV highlights the fact that even though harmonic RF systems have been successfully in use at third generation sources since many years, they were often added to those sources as part of upgrade programs while they are part of the baseline design on most fourth-generation sources, particularly in the intermediate energy range of a few GeV where intrabeam scattering (IBS) is most severe.

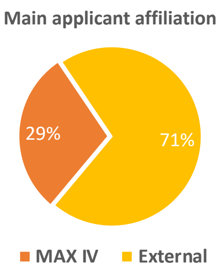
For future light sources aiming to achieve even lower emittances than the present suite of existing and planned sources, good control of the bunch length will be even more critical, and one may envisage the need to achieve considerably larger lengthening ratios than those achieved today (which vary from 2 to 5). Combining different harmonic systems may be a mechanism to provide such extremely long bunches, but its feasibility remains to be demonstrated experimentally.

Figure 19: Some of the HarmonLIP participants during a tour of the MAX IV Facility.

7) Collaborations and Partnerships

Project Applications

In 2022, MAX IV was involved in 34 individual grant applications to national and international funding organizations. In about 30% of the cases, the project's main applicant was a MAX IV staff member (with or without project partners). The remaining 70% of the applications were led by external collaborators as displayed in Figure 20. This shows that MAX IV staff is proactively searching for external funding to support further facility development both as leaders of funding applications and as project partners with collaborators from academia and industry.



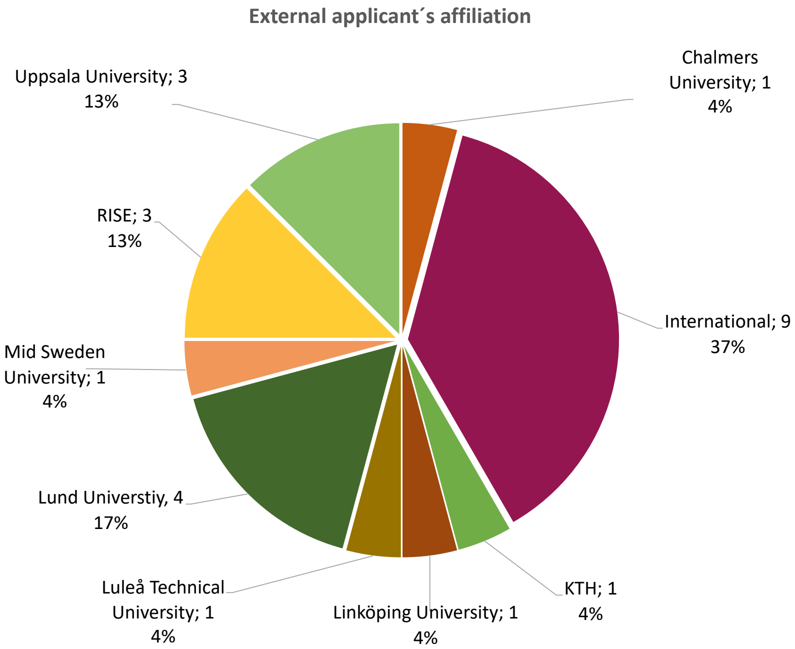


Figure 20: (Top) Graphical distribution of the affiliation of the main applicant of each project application. (Bottom) Number of project applications per main applicant affiliation involving MAX IV as partner.

The 34 project applications were submitted to 10 different funding agencies, the majority of which are from Scandinavian countries, as displayed in Figure 21. We also note the following:

- Of the submitted applications, eleven have been approved, thus showing a success rate of 32%.
- Sixteen applications have been submitted to the Swedish Research Council (VR) with MAX IV involvement; 15 of those were submitted to the Call for accessibility to infrastructure (two of

those were approved, having MAX IV as project partner contributing in-kind to project development).

- Five applications were submitted to Calls from Scandinavian institutions (Finnish, Danish and NordForsk).
- Ten applications were seeking funding from European Commission Programmes, mostly from calls belonging to Pillar 1 of Horizon Europe (Infrastructure Calls and Marie Sklodowska Curie Actions).

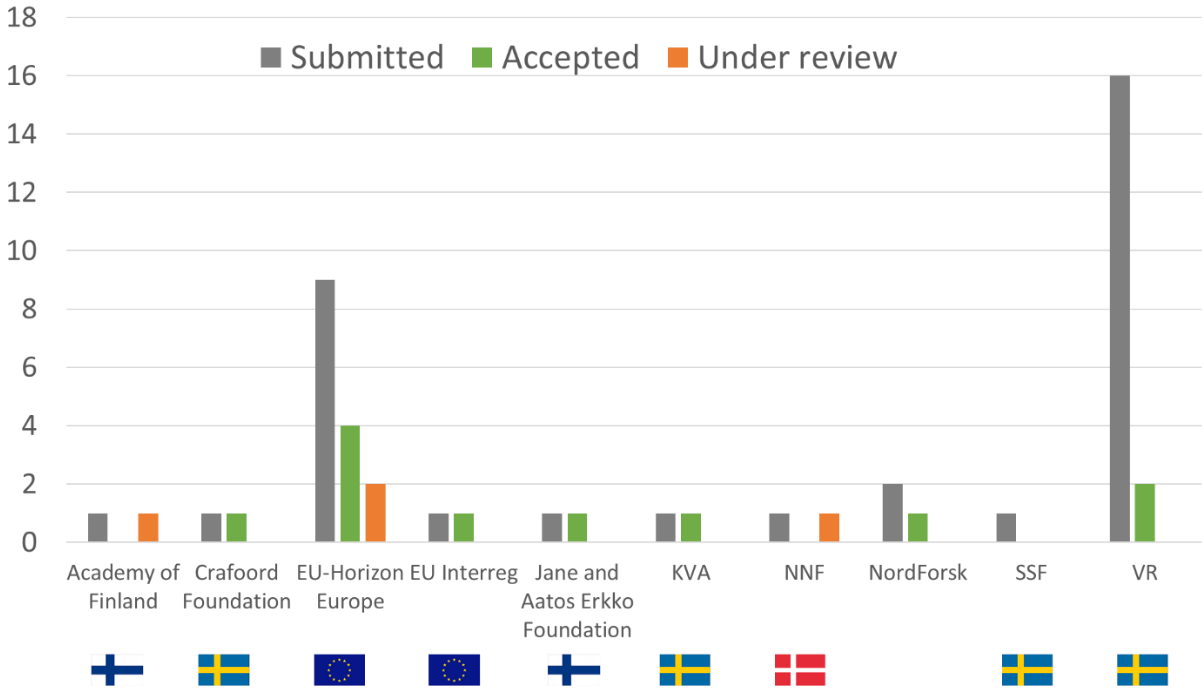


Figure 21: Total number of applications submitted, accepted, or currently under review per funding agency in 2022 (known as of February 2023). Funders are listed alphabetically.

Among the applications with a positive outcome, the PRISMAS[3] project (funded by EU through the MSCA COFUND programme) is of special value for MAX IV and the Swedish Universities involved. It is the first European project coordinated by the facility and it is the result of a strong collaborative effort aiming to train the next generation of synchrotron science experts through an ambitious PhD programme tackling six research areas. Preparatory work started in 2022, to start the project in 2023.

Funded External Research Projects

The following two paragraphs outline a summary of (A) currently ongoing projects (started before 2022) and those (B) started in 2022 (approved towards the end of 2021 and during 2022).

[3] https://www.maxiv.lu.se/education-outreach/programs-and-activities/prismas/

Ongoing Projects

By the end of 2022, MAX IV was involved in 52 externally funded projects from 17 funding agencies and for a total contract amount of 199,747 MSEK. Details are provided in Figure 22.

MAX IV is the project leader in 22 of these external projects and received funds for 23 additional projects as a collaborator. In 7 of the external projects, there are no funds for MAX IV, and the facility´s participation is in-kind.

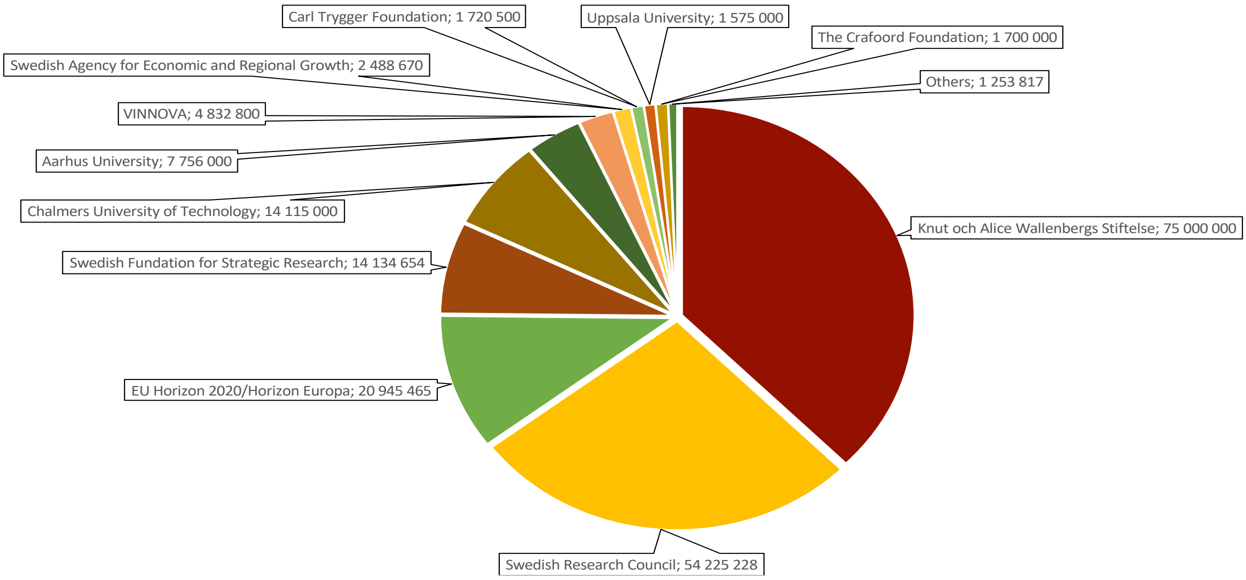


Figure 22: Contract amount in SEK per Funding Agency in 2022 for a total amount 199 747 134 SEK. The indicated values do not include projects that ended during 2022. The grant values relate only to research projects and do not include funding for beamline construction projects.

New projects in 2022

Seven new external projects started in 2022, some of which received a funding decision in 2021. In two of those projects, MAX IV is the project leader. MAX IV also receives funds for three additional projects as a collaborator and is involved in two more projects for where no funds are transferred to MAX IV.

Among the projects started in 2022, we would like to highlight the following:

ReMade@ARI **–** The project, funded under the Horizon Europe Call HORIZON-INFRA-2021-SERV-01 and coordinated by HZDR (total budget 13,7 M€), deals with innovative materials for key components in areas such as electronics, packaging or textiles. The goal is to develop new materials with high recyclability and at the same time competitive functionalities. To this end, the institutions involved want to harness the potential of more than 50 analytical research infrastructures throughout Europe. MAX IV coordinates the central user office for the consortium and provides an expert hub for cellulose based materials. MAX IV also offers limited access to two of its 16 beamlines to contribute to Circular Economy motivated scientific cases, making available techniques such as absorption/emission, diffraction, scattering as well as imaging techniques.

Combining multiscale spectromicroscopy to investigate the global health of fossil seed fern *Lepidopteris ottonis* – This research project led by MAX IV and supported by KVA (Anna-Greta and Holger Crafoord's foundation) integrates multiscale spectromicroscopy to reveal a wealth of spatially resolved biochemical detail through investigation of an important fossil seed fern *Lepidopteris ottonis*, which went extinct at the end-Triassic period. This novel approach combines synchrotron imaging and chemical spectroscopy to construct a chemical hierarchy so that chemical information measured in one field of view may be abstracted in the context of other biological levels to gain a global perspective on the overall health of specimens. The collaboration involves the Swedish Museum of Natural History.

Ongoing collaborations – MAX IV continues to actively interact with several national and international networks. On the international level, the facility actively collaborates with partners such as the League of European Accelerator-based Photon Sources (LEAPS), lightsources.org, and the Analytical Research Infrastructures in Europe (ARIE). These networks are arenas of promotion of the exchange of information and knowledge, which is often the trigger of project applications that creates consortia applying for funding at the EU level (e g ReMade@ARI project mentioned above).

On a national level, MAX IV is involved with various networks such as Treesearch, Northern Lights on Food, Metalbeams. This contributes to strong collaboration with Swedish academia and industry that allows us to guide the development of our facility further while ensuring Swedish research remains at the forefront of science.

8) Communication and Outreach

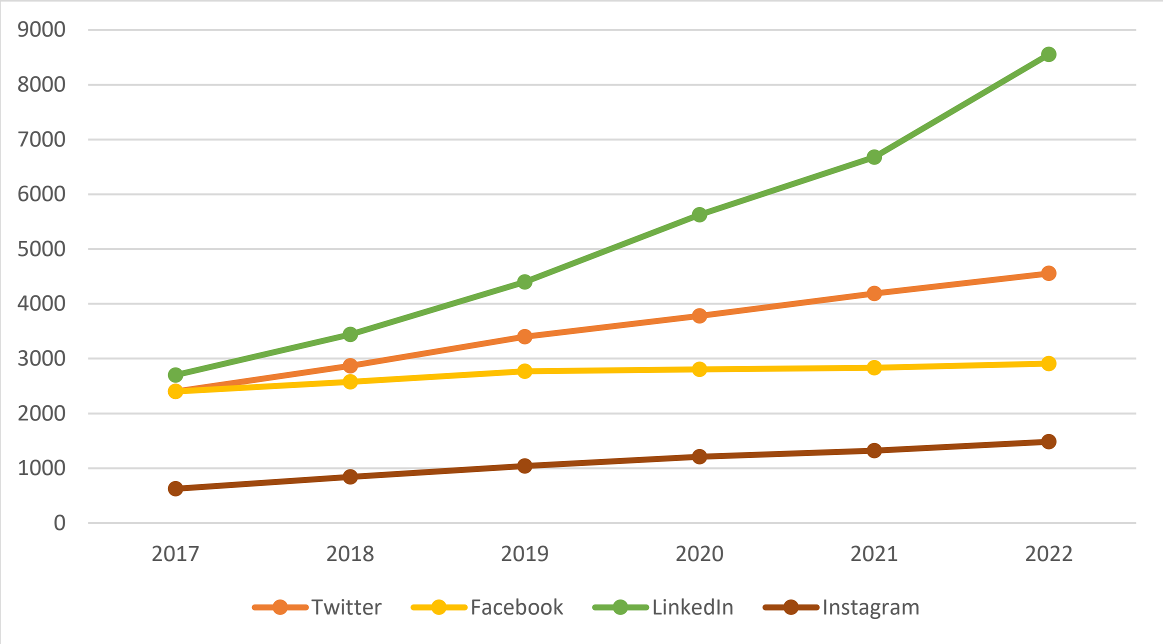


Figure 23: The graphic illustrates MAX IV's different social media channels from 2017 to 2022. The trends show that the number of followers on social media channels have increased significantly.

The MAX IV communication team supports the organization in external and internal communication by, for example, managing the website, producing news stories and reports, conveying internal information, and arranging interaction opportunities with schools and the general public. We also arrange a significant part of the visits to MAX IV. Currently, MAX IV welcomes around 3000 visitors per year. This does not include users.

New website

In September 2022, before the user call, the new MAX IV website was launched. One main feature of the new website is that central information about, for example, the capabilities of the beamlines or safety is generated from one single input point to avoid confusion. Much analysis has been going into making the website as valuable and clear as possible to our main target group, MAX IV users. However, a new website is always just a starting point. Statistics gathered using our new tool, Matomo, will become essential input to optimize its structure further. The new website complies with the EU website accessibility directive.

Outreach Officer

A dedicated Outreach Officer was appointed for the first time at MAX IV in the summer of 2022. One task of the Outreach Officer is to lead and develop efforts directed towards schools and the public, such as MAX IV Open Day, school visits programmes, and teacher programmes. Another task is to oversee educational exhibitions at MAX IV. At present, we have an exhibition overviewing the development of accelerators from the 1970s until the 4th generation facility of today.

MAX4MINT School Outreach

MAX IV’s programme for school outreach, MAX4MINT, is financed by the Swedish Research Council, and the target group are students in grade eight, who are around 15 years old. The programme includes a half day at MAX IV with hands-on experiments and a tour. It also includes financial support for transport from the school to MAX IV. So far, MAX IV has welcomed 411 visitors through the MAX4MINT programme.

Internal Communication

Internal communication has continued to increase and develop. MAX IV now has monthly staff meetings emphasizing dialogue between management and staff. A newsletter, SMT News, is sent out to the staff after the Senior Management Team meetings with information about decisions and ongoing discussions that are currently taking place in the management.

Science Highlights

The MAX IV Scientific Highlights report, containing the most impactful papers of 2021, was finished in October 2022. It can be downloaded from https://www.maxiv.lu.se/science/reports/.

News and Social Media

The communications group has also continued to write news stories for the web and social media. A few examples of stories from 2022 are on anti-viral drugs, steels, forest-based materials, supercomputers, and the climate change impact on the Arctic. MAX IV are active on Twitter, Linkedin, Facebook, Instagram and YouTube. We measure impact using the service Agorapulse.

9) Organisation and staffing

The details of the MAX IV organization by year-end 2022 are shown in Figure 24. Details on the MAX IV governance, including the descriptions of the MAX IV board and the various Machine, Scientific and Program Advisory Committee's (MAC, SAC, PAC) are provided on our website at the following link: https://www.maxiv.lu.se/governance/

By the end of 2022, MAX IV had 300 full-time employees (FTE), as displayed in Figure 25. MAX IV continued to grow in 2022 as an organization while constructing, commissioning, and operating an increasing number of beamlines. Our open positions are advertised internationally in targeted networks to seek the strongest talents, resulting in MAX IV being a diverse and multicultural workplace. Because of several new challenges, the electricity price being one, that arose during the year the Senior Management Team in August 2022 decided on a temporary hiring freeze. Exemptions to the hiring freeze are made for critical posts to ensure the operation of the MAX IV facility after discussion and decision by the Senior Management Team.

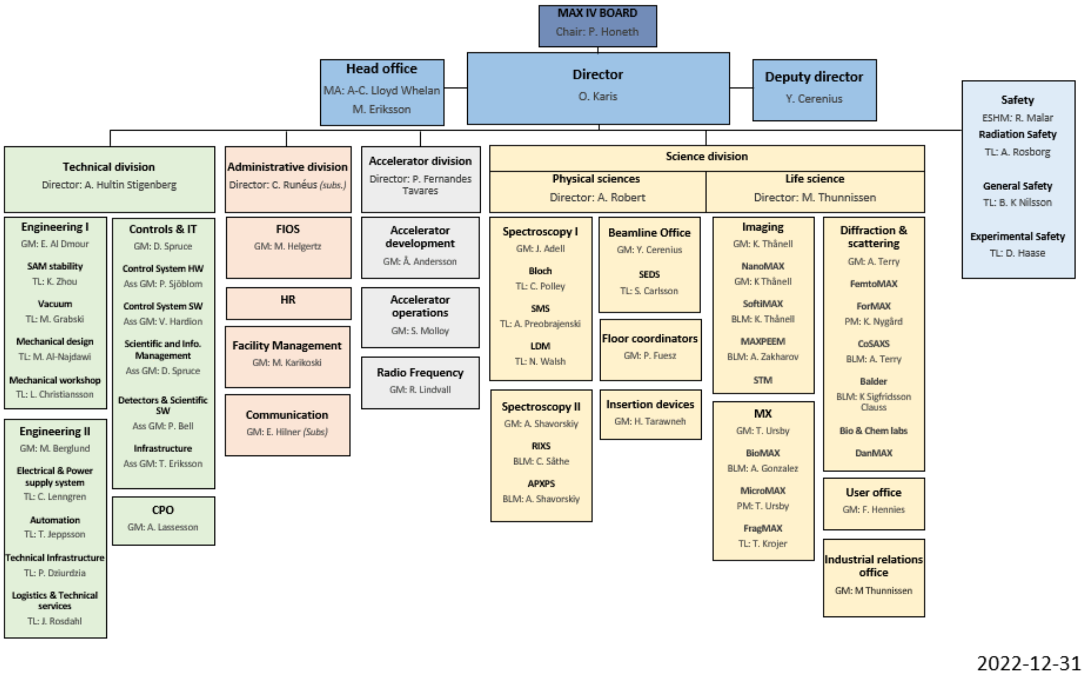


Figure 24: MAX IV organization chart as per December 2022 that details the Technical, Administrative, Accelerator and Science Divisions and their groups and central functions such as Safety, Deputy Director, and Head Office.

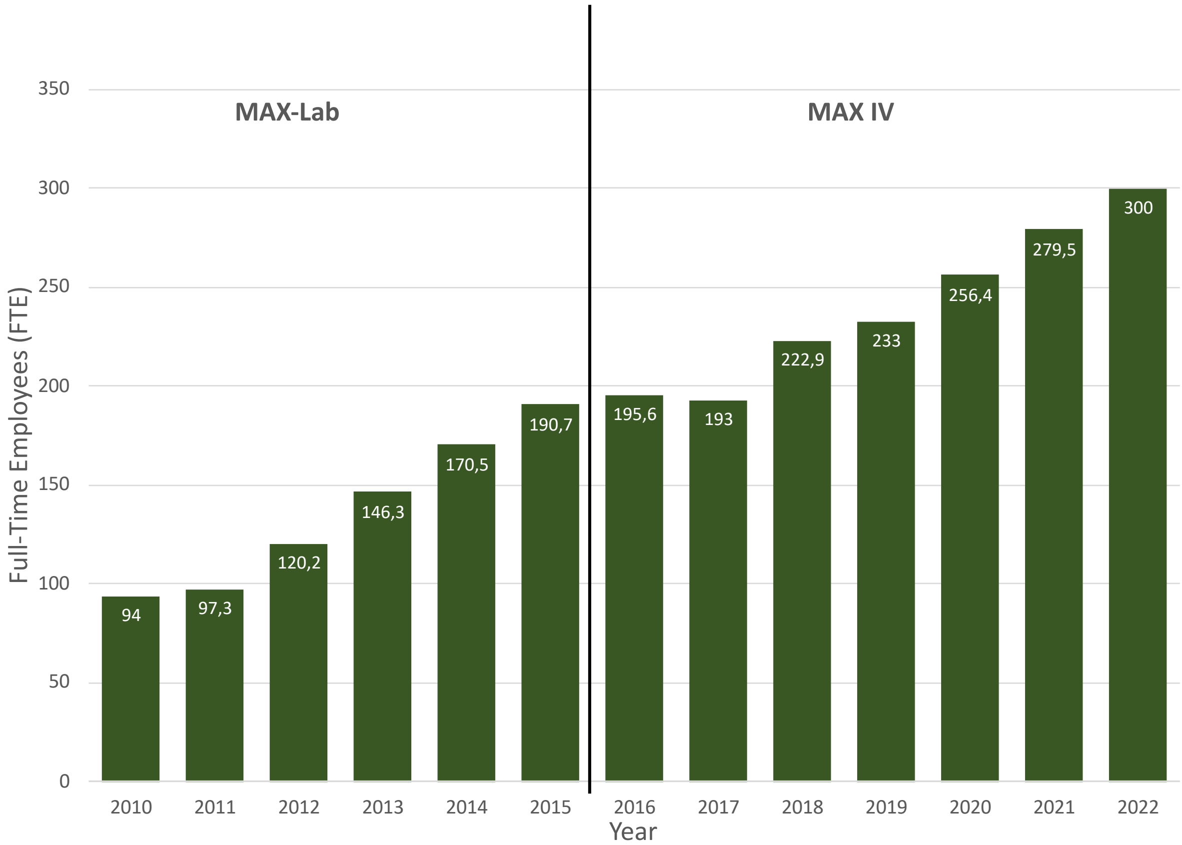


Figure 25: Number of Full-Time Employees (FTE) since 2010. MAX IV Laboratory opened its doors to staff in January 2016. Before this date, the laboratory was called MAX Lab.

After a review of the organization, conducted by the MAX IV Board in 2021, the recommendation was to establish a Technical Division. This followed a preceding recommendation in the same direction made by a review committee established by Vetenskapsrådet (the Swedish Research Council). After negotiation with the Unions, the department of Controls & IT was moved into the new Technical Division mid-year with an interim director for the division. The search for a permanent Technical Director was initiated in summer 2022 and was concluded by the end of August. The appointed Technical Director started full-time employment on 14 October. By the end of 2022, the departments of Engineering and the Central Project Office were also moved into the Technical Division, as shown in Figure 24.

An internal project to review the organization within the Science Division was initiated and concluded during the second quarter of 2022. As a step in the implementation of the internal review's conclusion, it was decided to appoint a Deputy Director. The aim of this new supporting role is to ease and improve the workflow within the Scientific Division and was an internal recruitment for a three-year assignment. The Deputy Director was in place on 1 October.

Other organizational changes have included the move of Communications to the Administrative Division and several minor changes have been made to improve the work and flow within the organization.
With a growing organization, MAX IV has had the need to tackle the problem of an increasing lack of office space, resulting in a temporary satellite office located one km away from MAX IV. The first employees moved to the Cube on 14 November. Risk assessments were made prior to decisions of placement.

The division into two offices, as well as remote work, has required MAX IV to continue to adapt to a hybrid workplace. Following the remote agreements made during the pandemic, employees can continue to work up to 40% remote if the individual's work tasks allow for remote work. This follows the guidelines from Lund University for technical and administrative staff and needs to be agreed upon between the employee and their manager.

To continue the leadership development program, a training matrix with mandatory training courses has been presented by HR and decided upon by the management team. Work remains in implementation and availability for some of these courses.

10) Financial report

In 2022, the MAX IV operating budget was funded by the Swedish Research Council (VR), Lund University, Swedish universities[4], the Swedish Governmental Agency for Innovation Systems (Vinnova) and Formas. In addition, there were contributions from both Finland and Estonia to our operation budget, thus reflecting their continued strong commitment to their collaboration with our facility. As a condition for these grants, MAX IV submits an annual report with emphasis on the activities at the facility.

The 2022 funding, costs, and financial result for operations of MAX IV are shown in Appendix 4.

Comments on the outcome of the 2022 MAX IV Operating Budget
Unforeseen increased costs for electricity and premises, the latter connected to the STIBOR rent, have made the financial situation of MAX IV extra challenging. To address this the management at MAX IV has decided on a partial hiring freeze and any new positions can only be approved after careful evaluation and a formal decision in the Senior Management team, decreased investments in maintenance and upgrades, 50% reduction of the Admin OH accounts for all divisions and carefully investigate the number of consultants as part of a competence inventory. In addition to achieving financial stability and transparency, more frequent financial follow-ups and an increased monitoring of world events must prevail.

MAX IV delivered a result of 0 MSEK. This is because part of the remaining VR grant was accrued after the disposal period had expired. In fact, the financial result should have been positive.

The total unused funds at the end of 2022 amounted to 1 031 MSEK. The unused funds are divided into two parts, see table x below. The larger part of 753 MSEK is already tied up in investments made when MAX IV was built and for the construction of the 16 beamlines. When the depreciation has been written off, the unused funds (the financial result), will show 0 SEK on that part.

Total unused funds: 1 031 MSEK

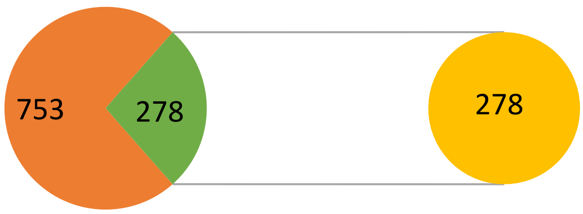


Figure 26: The total amount of unused funds at the end of 2022 is 1 031 MSEK. In orange the unused funds for beamline construction and building development are shown. In green unused operational funds are shown. For more details, see Figure 27 below.

[4] Chalmers University of Technology, Gothenburg University, Karlstad University, Karolinska Institutet, KTH Royal Institute of Technology in Stockholm, Linköping University, Linnæus University, Luleå University of Technology, Lund University, Malmö University, Stockholm University, Swedish University of Agricultural Sciences (SLU), Umeå University and Uppsala University

The remaining 278 MSEK in unused funds are in operations, see table below.

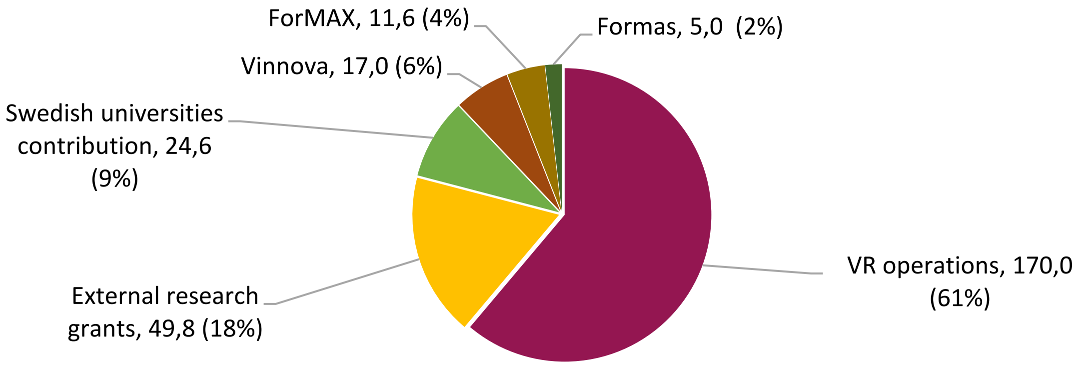


Figure 27: Unused operational funds.

These are mainly due to:

1. VR funds (170 MSEK) are tied up in investments where depreciation runs annually, these amount to 139,5 MSEK. The remaining 30,5 MSEK of VR's unused funds have been approved to be consumed after the disposal period, i. e. during the year 2023.
2. External research grants of 49,8 MSEK are tied up to external projects and do not affect operations.
3. Funds from Swedish universities of 24,6 MSEK will be consumed during the year 2023 because service/maintenance and certain investments have been postponed.
4. Funds from Vinnova and Formas of 17 MSEK and 5 MSEK respectively since the grants were received late in 2022 but will not be used until 2023.
5. Funds of 11,6 MSEK from KTH for the ForMAX project that has already been received but will not be used until 2023.

Budget 2022 - Comments on Funding

Further details about some of the deviations of funding in 2022:

A. Swedish universities such as Uppsala and Malmö contributed with less funds and more in-kind to the MAX IV operation. The in-kind contribution was more significant than budgeted.
B. The decision to receive a grant from Finland was not clear when the budget was approved.
C. The contribution from Estonia was incorrectly budgeted with a higher amount.
D. Other income – MAX IV accounts for revenue from the sale of recycled heat, hosted conferences, etc.; some of which was overestimated with 2,5 MSEK.
E. The contribution from KTH for the ForMAX project of 8,5 MSEK is not included in the budget for 2022 as the contribution is not expected to be paid until 2023.

Budget 2022 - Comments on Costs
Further details about some of the costs and explanations for some of the variances:

A. The deviation is due to MAX IV's lease agreement being based on interest (STIBOR 3M) which rose more than budgeted when the Swedish National Bank (Riksbanken) raised the key interest rate during the year.
B. The facility's cost was lower because budgeted consulting costs were not fully needed as the work could be carried out by existing staff. The costs for service and repairs were lower compared to what was budgeted.
C. Despite soaring electricity prices, MAX IV was only SEK 0.7 million over the budgeted SEK 31.9 million for electricity costs. It is very difficult to make precise forecasts for electricity costs in the next few years as the price that MAX IV pays is affected by a number of factors beyond our control.
D. The deviation on the beamlines is mainly because DanMAX did not need the full budgeted grant due to delays in the project.
E. The contribution to LUNARC, the centre for scientific and technical computing at Lund University, has been less than budgeted.
F. The deviation can be explained by the fact that certain budgeted items were postponed such as a new website, some reduction in support activities to be able to balance up to increased costs in the operations.
G. The large deviation is due, among other things, to an insurance case concerning a component of a beamline and delays in investments that affect depreciation costs.
H. The in-kind contribution from Swedish Universities was more significant than budgeted.
I. The use of management contingency was less than budgeted. The discrepancy is because it was budgeted for the investment amount, while it is the depreciation amount that affects the result.

11) Financial outlook 2023

In November 2022, the Swedish Research Council carried out its sixth review of MAX IV. The review report pointed out the extensive improvement work that has taken place since the last evaluation and the evaluators pointed out that MAX IV now has addressed all the recommendations that the evaluation group had made in previous reviews.

Going forward MAX IV will internally continue the work to clarify roles and responsibilities within the Science Division. The work should enable a more structured way of working with users of MAX IV. The changes should also result in those responsible for individual beamlines a more strategic responsibility to ensure that the beamlines capacity is in the international top class.

Work on changing the relationship between support and core operations is also expected to continue during the coming year. This work aims to establish clear relationships and expectations between clients in core operations and suppliers in support functions. The management will work to improve the organization's ability to forecast and follow up on costs that are not followed up within the framework of larger projects.

During the coming year, both the positions of Director and Administrative Director will be filled as both these positions are currently on an interim basis.

External relations for MAX IV in 2023
During 2022, a large number of meetings have been held with Swedish higher education institutions. Visits to Norway and Denmark has also been carried out. These visits were aimed at trying to re-establish good relations between these stakeholders and MAX IV. The effort was essentially also forward-looking as MAX IV in 2023 will have to spend a lot of time convincing our financiers of the need for a 20% increase in the operating budget to meet increased costs for electricity, rent and personnel. During this period, MAX IV also needs to ensure that the work with inputs to the upcoming research proposal progresses and is coordinated with, above all, large stakeholders such as academia and research financiers. This work has begun but is also complicated by the fact that the political level places great emphasis on raising issues at the EU level during the Swedish presidency.

Operating costs
The planned move of approximately 65 people to new, supplementary office premises in 'Cube' at Brunnshög in Lund began at the end of the business year. By the end of the year, the first group of approximately 36 people had moved their offices to Cube.

MAX IV's rental cost for 2022 was SEK 82 million, a deviation of SEK 9.8 million compared to the budget. MAX IV's lease is based on STIBOR 3M, which rose more than budgeted when the policy rate was raised during the year. The National Audit Office has taken an interest in MAX IV's lease during an examination, whether it is a regular lease for authorities or can be defined as financial leasing. The matter is currently being investigated.

Despite escalating electricity prices, MAX IV was only SEK 0.7 million over the budgeted SEK 31.9 million for electricity costs. It is very difficult to make precise forecasts for electricity costs in the next few years as the price that MAX IV pays is affected by several factors beyond our control.

Relationship with funders

MAX IV's operating grant from the Swedish Research Council for the period 2019 - 2022 is now being finalized. SEK 170 million will be reported as unspent grants, of which SEK 139,5 million are reserved for future depreciation costs. As a result, SEK 30,5 million must be allocated during 2023 before the allocation period for the grant expires.

For the next operating period 2023–2026, an application was submitted in 2022. The levels of VR's contribution to operations had already been decided by the Council for Research Infrastructure's (RFI) at its September meeting in 2021. In line with the RFI recommendation to develop a more transparent model for MAX IV's application for operations funding to VR 2023-2026, the financial review committee, under the lead of Prof Dag Hanstorp (University of Gothenburg) worked together with MAX IV in the spring to develop the new model. The new application format was sent to VR in the summer.

MAX IV is allocated SEK 380 million in 2023 and SEK 390 million per year until 2026. Contributions have also been received from Vinnova and Formas for the period 2023–2026. Vinnova decided to increase its financing by 2 million SEK to 17 million SEK/year. Formas contributes SEK 5 million in 2023 and then a further 2 million SEK from 2024 to SEK 7 million/year, also an increase in relation to previous agreements. During 2023, the agreement with Swedish higher education institutions that contribute to the operation will be renegotiated. MAX IV's ambition is to get a 20% increase in this operating grant to SEK 60 million.

Appendix 1 – List of Abbreviations

APXPS	ambient pressure x-ray photoemission spectroscopy
ARIE	Analytical Research Infrastructures in Europe
ARPES	angle resolved photoelectron spectroscopy
BAG	block allocation group
CPO	Central Project Office
ESS	European Spallation Source
EXAFS	extended x-ray absorption fine structure
FTE	full-time employees
HERDi	high-resolution powder diffraction set-up
IRO	Industrial Relations Office
KAW	Knut and Alice Wallenberg Foundation
KTH	KTH Royal Institute of Technology, Stockholm
linac	linear accelerator
LU	Lund University
MIK	multipole injection kicker
MTBF	mean time between failures
PAC	Programme Allocation Committee
RF	radio frequency
RFI	Council for Research Infrastructure
RISE	Swedish Research Institutes of Sweden
RIXS	resonant inelastic X-ray scattering
SAXS	small angle x-ray scattering
SPELEEM	spectroscopic photoemission and low energy electron microscope
SPF	Short Pulse Facility
SU	Stockholm University
SWAXS	small- and wide-angle x-ray scattering
SXL	soft x-ray laser
TRIBs	Transverse Resonant Island Buckets
Vinnova	Swedish Governmental Agency for Innovation

	Systems
VR	Swedish Research Council
WAXS	wide angle x-ray scattering
XANES	X-ray absorption near edge structure
XMCD	X-ray magnetic circular dichroism
XPCS	X-ray photon correlation spectroscopy

Appendix 2 – Beamline capabilities available to users

Baseline specifications and experimental capabilities of all MAX IV beamlines as planned and delivered, including upgrades, if any, during the next two-three years for the operational beamlines.

Green: full user operations with >70% of beamtime offered to users

Blue: completion of full-scope delivery and commissioning together with partial user operation with at least >40% of beamtime offered to external users

Off white: Construction and initial commissioning of the instrument. User operations will start in 2023

Beamline	Experimental Capabilities	Techniques currently available to users
Balder	Balder is a multimodal beamline dedicated to hard X-ray spectroscopy (XAS; XES), with XRD and XRF as secondary techniques (XAS must be included in all proposals). Interchangeable sample environments; in operando cells with gases, liquid cells, cryostat, furnaces, etc.	Primary: XAS (XANES/EXAFS), XES Secondary: XRD, XRF
BioMAX	BioMAX is optimised for Macromolecular Crystallography experiments. The beamline is highly automated, in terms of both sample handling hardware and data analysis, including feedback on the data collection.	X-RAY crystallography, MAD, SAD, Serial Crystallography, XRF
Bloch	The Bloch beamline is dedicated to high resolution angle-resolved photoelectron spectroscopy (ARPES) for studying the electronic structure of surfaces and 2D materials. The A-branch endstation is in regular operation, and the B-branch (featuring spin-resolved ARPES) is currently in commissioning.	ARPES, STM, XPS
CoSAXS	CoSAXS is a state-of-the-art Small Angle X-ray Scattering (SAXS) instrument, which also uses MAX IV's high coherence 3 GeV ring for X-ray Photon Correlation (XPCS). The performance is complemented by an exceptional pool of sample environments.	SAXS/WAXS, BioSAXS, liquid SAXS
DanMAX	DanMAX is a materials science beamline, dedicated to in situ and operando experiments on real materials. The beamline currently offers a flexible PXRD instrument and an X-ray beam energy from 15–35 keV. Two additional instruments are under construction; a full field imaging instrument and high-resolution powder X-ray diffraction instrument.	PDF, PXRD, Total Scattering, XRD-CT, XRF, MXRD
ForMAX	ForMAX allows *in-situ* multiscale structural characterization from nm to mm length scales by combining full-field tomographic imaging, small- and wide-angle x-ray scattering (SWAXS), and scanning SWAXS imaging in a single instrument.	SAXS/WAXS Tomography,

	ForMAX is currently under commissioning, with first commissioning experiments expected late 2022.	
FemtoMAX	FemtoMAX is a beamline designed for ultrafast laser pump/x-ray probe experiments with a 200 fs time resolution. The beamline offers GIXS, WAXS and SAXS scattering geometries and cryocooling/heating in vacuum between 20K-500 K. Equipped with a Pilatus time-over threshold photon counting detector. Laser pump wavelengths 266-2000 nm and THz excitation generated in organic crystals is available.	Laser pump/X-ray probe in GIXS, SAXS, WAXS
FinEstBeAMS	FinEstBeAMS is an UV and soft X-ray beamline enabling research in (i) photoluminescence spectroscopy of inorganic materials, (ii) photoelectron and X-ray absorption spectroscopy of surfaces and interfaces, and (iii) electron and ion spectroscopy of gaseous samples.	ARPES, XAS, XPS
FlexPES	The FlexPES (Flexible PhotoElectron Spectroscopy) beamline caters for the experimental needs of both Surface/Material Science and Low Density Matter user communities by enabling a variety of photoemission and soft X-ray absorption experiments. With the two-branch configuration and twin refocusing mirrors up to four end stations can be accommodated, with different focusing conditions.	ARPES, Coincidence spectroscopy, NEXAFS, XPS
HIPPIE	HIPPIE is a state-of-the-art beamline for Ambient pressure X-ray photoelectron spectroscopy (APXPS).	APXAS, APXPS
MAXPEEM	MAXPEEM is a photoelectron microscopy beamline equipped with the aberration correction spectroscopic photoemission and low energy electron microscope (AC-SPELEEM). It offers unique possibilities for extracting simultaneously elemental, chemical, magnetic and electronic information at single digit nanometer spatial resolution to users from a wide area of research fields.	LEEM, Micro XAS, Micro XPS, Nano ARPES, XPEEM
MicroMAX	MicroMAX is a macromolecular crystallography beamline with emphasis on serial crystallography and time-resolved methods. It is flexible both in terms of X-ray beam properties and experiment setup. Automated crystallography with a high-capacity sample changer will be available when opening for users in spring 2023 with different serial and time-resolved methods becoming available in parallel.	Rotational crystallography.
NanoMAX	NanoMAX is a hard X-ray beamline for imaging and diffraction studies at the nanoscale. The instrument provides coherent and highly focused X-rays at its two end stations.	Coherent Imaging, Nano-tomography, Ptychography, Scanning X-ray diffraction imaging

SoftiMAX	SoftiMAX is a soft X-ray imaging beamline with two branch lines. The first branch line is open for users who want to study the morphology, chemical and/or magnetic states of compounds in their samples on a microscopic level (<100 nm). The branchline is set up for transmission measurements, requiring thin (0.1-2 micron) samples.	Forward ptychography, LE-XRF, STXM
SPECIES	SPECIES is a soft X-ray beamline for ambient pressure XPS (APXPS) and resonance inelastic X-ray scattering (RIXS) experiments. The beamline offers a wide photon energy range (30-1500 eV) with different polarizations reaching even to the VUV range. For both endstations, multiple sample environments are offered.	APXPS, RIXS
Veritas	Veritas is a high resolution Resonant Inelastic X-ray Scattering beamline for the soft X-ray region (250 - 1500 eV). The end-station is designed for high versatility with planned sample environments ranging from solids, in-situ and in-operandi conditions to gas-phase and liquids. The beamline also features an open port branch.	RIXS

Appendix 3 – Beamline completion and availability for users

Beamline	Functionality	Available to users	Comment	Beamline construction phase/funding source
Balder	X-ray absorption spectroscopy (XANES and EXAFS) in transmission and fluorescence modes	Yes		Phase I, KAW
	X-ray Emission Spectroscopy (XES)			
	X-ray Diffraction (XRD)			Chalmers
BioMAX	X-ray macromolecular crystallography with SAD and MAD	Yes		Phase I, KAW
Bloch	Angle resolved photoelectron spectroscopy (ARPES) using linear vertical or horizontal polarised light in the range 10-1000 eV	Yes		Phase I, KAW
	Online scanning tunneling microscopy (STM), 50K - 300K			
	Spin-ARPES			
CoSAXS	Solution/soft matter conventional SAXS & bio SAXS	Yes	While open for users some development of CoSAXS is still ongoing, e.g. on additional sample environments.	Phase IIa, VR
	Time resolved experiments			
	WAXS			
	XPCS			
DanMAX	2D PXRD mapping	Yes		Phase III, DanMAX consortium
	Full field imaging and tomography	Q4 2023 (General users) Q2 2024 (General users)	Delays in the delivery of key components has delayed the date for first users since the last report.	
	High resolution diffractometry (HERDi)	2025		
	Single crystal X-ray diffraction (SINCRYS) endstation	2026	SINCRYS is a newly funded endstation at DanMAX and is currently being designed.	SINCRYS cooperation
FemtoMAX	Scattering set-up (SAXS, WAXS) in vacuum, Air or He sample environments	Yes		Phase I, KAW
	Crystallography and grazing incidence X-ray diffraction.			
	Excitation 400 nm – THz radiation.			
	Time-resolved X-ray induced fluorescence measurements.			
	Time resolution 500 fs for scanning measurements, <200 fs for single-shot.			
FinEstBeAMS	Gas-Phase Endstation: Photoelectron and Auger electron spectroscopy Ion time-of-flight mass spectrometry Photoelectron-photon coincidence (PEPICO) and negative-ion/positive-ion coincidence (NIPICO) X-ray absorption	Yes		Phase I, FinEstBeams consortium
	Photoluminescence endstation: Photoluminescence spectroscopy of solid samples			
	Solid state endstation: X-ray photoelectron spectroscopy Angle-resolved photoelectron spectroscopy (ARPES) Near edge X-ray absorption fine structure (NEXAFS)			
FlexPES	High-resolution photoelectron spectroscopy (PES) and X-ray absorption spectroscopy (XAS or NEXAFS) on solid samples	Yes		Phase IIa, VR
	High-resolution PES and COLTRIMS/Multi-coincidence spectroscopy on low density matter (LDM) samples			
ForMAX	Full-field microtomography	Available for commissioning users Q3 2023 (General users)		Phase III, KAW & Treesearch
	Small- and/or wide-angle x-ray scattering (SWAXS)			
	Combined full-field microtomography and SWAXS			
HIPPIE	APXPS of solid-gas, solid-liquid and gas-liquid interfaces for catalysis, electrochemistry, energy, environmental, and atmospheric science	Yes		Phase I, KAW
	HIPPIE B branch	Q4 2023 (Commissioning experts) Q1 2024 (General users)		VR
MAXPEEM	Soft X-ray SPELEEM (micro-LEED, PED, micro ARPES, XMCD microscopy)	Yes		Phase IIa, VR
MicroMAX	Fixed target serial crystallography	Q2 2023 (Commissioning experts) Q3 2023 (General users)	Delays in the delivery of key components has delayed the date for first users since the last report.	Phase III, Novo Nordisk Foundation
NanoMAX	Scanning X-ray diffraction and coherent imaging in Bragg geometry	Yes		Phase I, KAW
	Forward ptychography and CDI			
	X-ray fluorescence mapping in 2D			
	Forward and fluorescence ptycho-tomography			
	Fourier Zoneplate (FZP) endstation	Available for commissioning users Q2 2023 (General users)	Delays in the delivery of key components has delayed the date for first users since the last report.	
SoftiMAX	STXM	Yes		Phase IIa, VR
	Forward ptychography			
	XMCD Microscopy (basic)			
	Coherent X-ray imaging (CXI)	2024	The second branchline optics is under construction and will be completed during early 2023. The design of the CXI endstation is nearing completion.	
SPECIES	APXPS and in-situ ALD experiments up to 20 mbar	Yes		Phase IIa, VR
	RIXS experiments		The Grace spectrometer is available for users. The installation of the Plane Grating Spectrometer is on hold due to technical issues.	
Veritas	NEXAFS experiments	Yes		Phase I, KAW
	Open port experiments			
	RIXS experiments			

Appendix 4 – MAX IV Operating Budget (comments: please see page 40)

2022 MAX IV Operating Budget

Final accounts by 2022-12-31

	(MSEK)			
FUNDING	**Actuals**	**Budget**	**Diff**	**Comment**
Research council	365,0	365,0	,0	
Vinnova	15,0	15,0	,0	
Formas	5,0	5,0	,0	
Swe universities cash contribution	37,5	42,0	-4,5	A
Swe universities in-kind contribution	12,5	8,0	4,5	A
Lund University	62,3	58,0	4,3	
Finland's contribution to Ops	3,9	,0	3,9	B
Estonia's contribution to Ops	,7	2,8	-2,2	C
Industrial beamtime and services	4,6	4,0	,6	
Other income	2,5	5,0	-2,5	D
Operations - MicroMAX	,0	,0	,0	
Operations - ForMAX	8,5	,0	8,5	E
TOTAL FUNDING	**517,6**	**504,9**	**12,7**	

COST	**Actuals**	**Budget**	**Diff**	**Comment**
Rent	-82,0	-72,2	-9,8	A
Facility cost	-21,3	-25,1	3,7	B
Electricity	-32,6	-31,9	-,7	C
Lund University overhead	-27,7	-27,7	,0	
Decommissioning MAX IV	-1,0	-1,0	,0	
Staff	-239,1	-239,9	,8	
Central Project Office	-2,5	-3,5	1,1	
Accelerators (AFSG, RF, AccDev, Op)	-5,5	-6,8	1,2	
Life Science beamlines	-6,8	-8,3	1,5	D
LP3 - Lund Protein Production Platform	-,5	-,5	,0	
Physical science beamlines	-4,5	-5,0	,5	D
DanMAX	-,3	-3,1	2,8	D
IT & Controls	-9,2	-9,1	-,1	
LUNARC	-1,9	-3,5	1,6	E
Engineering I & II	-20,1	-20,7	,6	
Safety	-8,8	-9,8	1,0	
Admin support (FIOS, HR, Procur, Legal)	-6,5	-9,0	2,5	F
User Office, IRO, COM, HO	-3,0	-4,2	1,2	F
Accelerator upkeep and dev.	-14,7	-15,1	,4	
Beamline upkeep and dev	-3,9	-4,6	,7	
Building infrastructure upkeep and dev.	-11,3	-18,1	6,8	G
Beamline office & Insertion Device	-2,8	-3,6	,8	
Swedish universities in-kind contribution	-12,5	-8,0	-4,5	H
DM Ex contingency	-1,6	-7,7	6,1	I
Beamline Operations MicroMAX/ForMAX	,0	,0	,0	
MAX IV co-funding research grants	-,2	-1,3	1,1	
TOTAL COST	**-520,2**	**-539,6**	**19,4**	
Result (Funding-Cost)	**-2,6**	**-34,7**	**32,1**	
Upkeep - use of VR allocated grant	,0	4,6	-4,6	
Change in undepreciated funds	2,5	30,1	-27,6	
TOTAL RESULT	**,0**	**,0**	**,0**	

First Author	AUTHORLIST	TITLE	YEAR	JOURNAL	DOI	BEAMLINE	FACILITY
Anker, A S	Anker Andy S., Kjaer Emil T. S., Juelsholt Mikkel, Chr	Extracting structural motifs	2022	NPJ COMPUTATIONAL MATERIALS	10.1038/s41524-022-00896-3	DanMAX	MAX IV
Armillotta, F	Armillotta F, Bidoggia D, Baronio S, Biasin P, Annese	Single Metal Atom Catalysts	2022	ACS CATALYSIS	10.1021/acscatal.2c02029	HIPPIE	MAX IV
Assylbayev, R.	Assylbayev R., Akilbekov A., Baubekova G., Chernen	Defect-related luminescenc	2022	OPTICAL MATERIALS	10.1016/j.optmat.2022.112308	FinEstBeAMS	MAX IV
Athle, R	Athle Robin, Persson Anton E. O., Troian Andrea, Bc	Top Electrode Engineering f	2022	ACS APPLIED ELECTRONIC MATERIALS	10.1021/acsaelm.1c01181	FlexPES	MAX IV
Athle, R	Athle Robin, Blom Theodor, Irish Austin, Persson Ar	Improved Endurance of Ferı	2022	ADVANCED MATERIALS INTERFACES	10.1002/admi.202201038	FlexPES	MAX IV
Banerjee, S	Banerjee S, Muderspach SJ, Tandrup T, Frandsen KE	Protonation State of an Imp	2022	BIOMOLECULES	10.3390/biom12020194	BioMAX	MAX IV
Barbari, S R	Barbari Stephanie R., Beach Annette K., Markgren Jı	Enhanced polymerase activi	2022	NUCLEIC ACIDS RESEARCH	10.1093/nar/gkac602	BioMAX	MAX IV
Barthel, T	Barthel Tatjana, Wollenhaupt Jan, Lima Gustavo M.	Large-Scale Crystallographic	2022	JOURNAL OF MEDICINAL CHEMISTRY	10.1021/acs.jmedchem.2c01165	BioMAX	MAX IV
Begnini, F	Begnini F, Geschwindner S, Johansson P, Wissler L, I	Importance of Binding Site I	2022	JOURNAL OF MEDICINAL CHEMISTRY	10.1021/acs.jmedchem.1c01975	BioMAX	MAX IV
Belopolski, I	Belopolski Ilya, Chang Guoqing, Cochran Tyler A., Cł	Observation of a linked-looj	2022	NATURE	10.1038/s41586-022-04512-8	BLOCH	MAX IV
Berkowicz, S	Berkowicz S, Das S, Reiser M, Filianina M, Bin M, Cr	Nanofocused x-ray photon (	2022	PHYSICAL REVIEW RESEARCH	10.1103/PhysRevResearch.4.L03201	NanoMAX	MAX IV
Berntsson, O	Berntsson Oskar, Terry Ann E., Plivelic Tomas S.	A setup for millisecond time	2022	JOURNAL OF SYNCHROTRON RADIATION	10.1107/S1600577522000996	CoSAXS	MAX IV
Björklund Svensson, J	Andersson J, Ferri J, Charles T K, Ekerfelt H, Manstei	Start-to-end simulations of	2022	NUCLEAR INSTRUMENTS & METHODS IN	10.1016/j.nima.2022.166591	Accelerators-FEL	MAX IV
Bjorneholm, O	Bjorneholm Olle, Ohrwall Gunnar, de Brito Arnaldo	Superficial Tale of Two Func	2022	ACCOUNTS OF CHEMICAL RESEARCH	10.1021/acs.accounts.2c00494	I411	MAX-Lab
Boix de la Cruz, V	Boix de la Cruz V, Scardamaglia M, Gallo T, D'Acunt(	Following the Kinetics of Un	2022	ACS CATALYSIS	10.1021/acscatal.2c00803	HIPPIE	MAX IV
Boix de la Cruz, V	Boix de la Cruz V, Xu W, D'Acunto G, Stubbe J, Gallo	Graphene as an Adsorption	2022	JOURNAL OF PHYSICAL CHEMISTRY C	10.1021/acs.jpcc.2c02293	HIPPIE	MAX IV
Brumboiu, I E	Brumboiu IE, Ericsson LKE, Blazinic V, Hansson R, Oı	Photooxidation of PC60BM:	2022	PHYSICAL CHEMISTRY CHEMICAL PHYSIC	10.1039/d2cp03514f	D1011	MAX-Lab
Carbone, D	Carbone D, Kalbfleisch S, Johansson U, Bjorling A, K	Design and performance of	2022	JOURNAL OF SYNCHROTRON RADIATION	10.1107/S1600577522001333	NanoMAX	MAX IV
Carravetta, V	Carravetta C, Anderson Herbert de Abreu Gome C,	An atomistic explanation of	2022	PHYSICAL CHEMISTRY CHEMICAL PHYSIC	10.1039/d2cp03145k	FlexPES	MAX IV
Cernooka, E	Cernooka E, Rumnieks J, Zrelovs N, Tars K, Kazaks A	Diversity of the lysozyme fo	2022	SCIENTIFIC REPORTS	10.1038/s41598-022-08765-1	BioMAX	MAX IV
Chakraborty, D	Chakraborty D, Lyck Smitshuysen TE, Kakekhani A, F	Reversible Atomization and	2022	JOURNAL OF PHYSICAL CHEMISTRY C	10.1021/acs.jpcc.2c05213	Balder	MAX IV
Cheng, Z J	Cheng ZJ, Belopolski I, Tien HJ, Cochran TA, Yang XP	Visualization of Tunable We	2022	ADVANCED MATERIALS	10.1002/adma.202205927	BLOCH	MAX IV
Christensen, S	Christensen S, Groth L, Leiva-Eriksson N, Nyblom M	Oxidative Implications of Su	2022	Antioxidants	10.3390/antiox11081615	BioMAX	MAX IV
Cullinan, F J	Cullinan FJ, Andersson Å, Tavares PF	Quadrupole stability in non-	2022	PHYSICAL REVIEW ACCELERATORS AND E	10.1103/PhysRevAccelBeams.25.04	Accelerators-FEL	MAX IV
D'Acunto, G	D'Acunto Giulio, Jones Rosemary, Ramirez Lucia Pei	Role of Temperature, Pressı	2022	JOURNAL OF PHYSICAL CHEMISTRY C	10.1021/acs.jpcc.2c02683	HIPPIE	MAX IV
D'Acunto, G	D'Acunto Giulio, Kokkonen Esko, Shayesteh Payam,	Oxygen relocation during H	2022	FARADAY DISCUSSIONS	10.1039/d1fd00116g	SPECIES	MAX IV
Del Giudice, R	Del Giudice Rita, Putkaradze Natalia, dos Santos Brı	Structure-guided engineerir	2022	PLANT JOURNAL	10.1111/tpj.15904	BioMAX	MAX IV
Ekstrom, F	Ekstrom Fredrik, Gottinger Andrea, Forsgren Nina, (	Dual Reversible Coumarin Ir	2022	ACS MEDICINAL CHEMISTRY LETTERS	10.1021/acsmedchemlett.2c00001	BioMAX	MAX IV
Fatemeh Mousavi, S F	Mousavi S. Fatemeh, Liu Yen-Po, D'Acunto Giulio, Tı	Atomic Hydrogen Annealing	2022	ACS APPLIED NANO MATERIALS	10.1021/acsanm.2c03891	MAXPEEM	MAX IV
Ganguly, S	Ganguly Smita, Barreiro-Lage Dario, Walsh Noelle, (	The origin of enhanced O-2(	2022	COMMUNICATIONS CHEMISTRY	10.1038/s42004-022-00629-z	I411	MAX-Lab
Garcia-Fernandez, A	Garcia-Fernandez Alberto, Svanstrom Sebastian, Ste	Experimental and Theoretic	2022	SMALL	10.1002/smll.202106450	FlexPES	MAX IV
Garmysheva, T A	Garmysheva Tatiana, Nepomnyashchikh Alexander	Luminescence of ODC(II) in	2022	JOURNAL OF NON-CRYSTALLINE SOLIDS	10.1016/j.jnoncrysol.2021.121199	FinEstBeAMS	MAX IV
Gericke, S M	Gericke SM, Rissler J, Bermeo M, Wallander H, Karls	In Situ H2 Reduction of Al2C	2022	CATALYSTS	10.3390/catal12070755	Balder	MAX IV
Gericke, S M	Gericke SM, Rissler J, Bermeo M, Wallander H, Karls	In Situ H2 Reduction of Al2C	2022	CATALYSTS	10.3390/catal12070755	HIPPIE	MAX IV
Goebel, E J	Goebel Erich J., Kattamuri Chandramohan, Gipson (	Structures of activin ligand t	2022	ISCIENCE	10.1016/j.isci.2021.103590	BioMAX	MAX IV
Gopakumar, G	Gopakumar G, Unger I, Saak CM, Öhrwall G, Brito A	The surface composition of	2022	ENVIRONMENTAL SCIENCE : ATMOSPHEI	10.1039/d1ea00104c	FlexPES	MAX IV
Grinderslev, J B	Grinderslev Jakob B., Skov Lasse N., Sorensen Danie	Polymorphism and solid sol	2022	DALTON TRANSACTIONS	10.1039/d2dt02513b	DanMAX	MAX IV
Gytz Olesen, H	Gytz Olesen H, Michailidou I, Zelek W, M, Vreijling J	Development, Characterizat	2022	Journal of Innate Immunity	10.1159/000524587	BioMAX	MAX IV
Haataja, T	Haataja T, Gado JE, Nutt A, Anderson NT, Nilsson M	Enzyme kinetics by GH7 cell	2022	FEBS JOURNAL	10.1111/febs.16602	BioMAX	MAX IV
Htet C, S	Htet C S, Nayak S, Manjón-Sanz A, Liu J, Kong J, Søre	Atomic structural mechanis	2022	PHYSICAL REVIEW B	10.1103/PhysRevB.105.174113	DanMAX	MAX IV
Huss-Hansen, M K	Huss-Hansen MK, Hedlund EG, Davydok A, Hanstee	Local structure mapping of (	2022	POLYMER	10.1016/j.polymer.2021.124420	NanoMAX	MAX IV
Ioannou, E	Ioannou E, Papageorgiou AC, Labrou NE	Directed Evolution of Phi Cl	2022	INTERNATIONAL JOURNAL OF MOLECUL	10.3390/ijms23137469	BioMAX	MAX IV
Irish, A	Irish A, Zou X, Barrigon E, D'acunto G, Timm R, T Boı	Nitrogen plasma passivatior	2022	Nano Express	10.1088/2632-959x/acb1cc	HIPPIE	MAX IV
Jäger, F	Jäger F, Lamy A, Sun WS, Guerini N, Berntsson RPA	Structure of the enterococc	2022	STRUCTURE	10.1016/j.str.2022.03.013	BioMAX	MAX IV
Jensen, A B	Jensen Alexander Bernthz, Christensen Thorbjorn E	Very large-scale diffraction	2022	JOURNAL OF SYNCHROTRON RADIATION	10.1107/S1600577522008232	DanMAX	MAX IV
Jensen, R K	Jensen RK, Pedersen H, Lorentzen J, Laursen NS, Vo	Structural insights into the f	2022	JOURNAL OF BIOLOGICAL CHEMISTRY	10.1016/j.jbc.2022.102168	BioMAX	MAX IV

Jin, Y	Jin Y, Jin Y, Li K, Yan M, Guo Y, Zhou Y, Preobrajensk	Mixed insulating state for va	2022	JOURNAL OF PHYSICAL CHEMISTRY LETTI	10.1021/acs.jpclett.2c02992	FlexPES	MAX IV
Jones, R	Jones R, D'Acunto G, Shayesteh P, Rehman F, Schna	AP-XPS Study of Ethanol Ads	2022	JOURNAL OF PHYSICAL CHEMISTRY C	10.1021/acs.jpcc.2c05389	SPECIES	MAX IV
Kahnt, M	Kahnt M, Kalbfleisch S, Björling A, Malm E, Pickwort	Complete alignment of a KB	2022	OPTICS EXPRESS	10.1364/OE.470591	NanoMAX	MAX IV
Kalbfleisch, S	Kalbfleisch Sebastian, Zhang Yuhe, Kahnt Maik, Bua	X-ray in-line holography and	2022	JOURNAL OF SYNCHROTRON RADIATION	10.1107/S1600577521012200	NanoMAX	MAX IV
Kallquist, I	Kallquist Ida, Ericson Tove, Lindgren Fredrik, Chen H	Potentials in Li-Ion Batteries	2022	ACS APPLIED MATERIALS & INTERFACES	10.1021/acsami.1c12465	HIPPIE	MAX IV
Kappelhoff, J	Kappelhoff Jan, Keil Jan-Niklas, Kirm Marco, Makho	Spectroscopic studies on Pr	2022	CHEMICAL PHYSICS	10.1016/j.chemphys.2022.111646	FinEstBeAMS	MAX IV
Karakachian, H	Karakachian Hrag, Rosenzweig Philipp, Nguyen T. T.	Periodic Nanoarray of Grapl	2022	ADVANCED FUNCTIONAL MATERIALS	10.1002/adfm.202109839	BLOCH	MAX IV
Kemppainen, J	Kemppainen J, Scales B, Razban Haghighi K, Juusola	Binocular mirror-symmetric	2022	PROCEEDINGS OF THE NATIONAL ACADE	10.1073/pnas.2109717119	OTHER	MAX IV
Kiselev, MD	Kiselev M. D., Reinhardt M., Patanen M., Kivimaki A	An experimental and theore	2022	JOURNAL OF PHYSICS B-ATOMIC MOLEC	10.1088/1361-6455/ac521a	FinEstBeAMS	MAX IV
Kleja, DB	Kleja DB, Gustafsson JP, Kerssler V, Persson I	Bismuth(III) Forms Extraordi	2022	ENVIRONMENTAL SCIENCE & TECHNOLO	10.1021/acs.est.1c06982	I811	MAX-Lab
Klementiev, K	Klementiev K, Tarawneh H, Tavares P F	Wiggler radiation at a low-e	2022	JOURNAL OF SYNCHROTRON RADIATION	10.1107/S1600577521012844	Balder	MAX IV
Klove, Magnus	Klove Magnus, Christensen Rasmus Stubkjaer, Niels	Zr4+ solution structures fro	2022	CHEMICAL SCIENCE	10.1039/d2sc04522b	DanMAX	MAX IV
Koivikko, N	Koivikko N, Ojala S, Laitinen T, Lopes-da-Silva F, Hau	Activity and in situ DRIFT stu	2022	APPLIED CATALYSIS B-ENVIRONMENTAL	10.1016/j.apcatb.2022.121803	HIPPIE	MAX IV
Kojima, Keisuke	Kojima Keisuke, Sunagawa Naoki, Mikkelsen Nils Eg	Comparison of glycoside hy	2022	JOURNAL OF BIOLOGICAL CHEMISTRY	10.1016/j.jbc.2022.101670	MX	MAX-Lab
Kokkonen, E.	Kokkonen E., Kaipio M., Nieminen H. -E, Rehman F.,	Ambient pressure x-ray pho	2022	REVIEW OF SCIENTIFIC INSTRUMENTS	10.1063/5.0076993	SPECIES	MAX IV
Kong, X	Kong X, Zhu S, Shavorskiy A, Li J, Liu W, Corral Arroy	Surface solvation of Martian	2022	ENVIRONMENTAL SCIENCE : ATMOSPHEI	10.1039/D1EA00092F	HIPPIE	MAX IV
Kook, M	Kook M, Kuusik I, Pärna R, Käämbre T, Kikas A, Tonis	Ion fragmentation study of	2022	INTERNATIONAL JOURNAL OF MASS SPE	10.1016/j.ijms.2021.116732	FinEstBeAMS	MAX IV
Koriukina, T	Koriukina T, Kotronia A, Halim J, Hahlin M, Rosen J,	On the Use of Ti3C2Tx MXen	2022	ACS OMEGA	10.1021/acsomega.2c05785	Balder	MAX IV
Košenina, S	Košenina S, Stenmark P	Crystal structure of the OrfX	2022	FEBS LETTERS	10.1002/1873-3468.14542	BioMAX	MAX IV
Kozielski, F	Kozielski F, Sele C, Talibov V O, Lou J, Dong D, \	Identification of fragments l	2022	RSC CHEMICAL BIOLOGY	10.1039/d1cb00135c	BioMAX	MAX IV
Krizek, Filip	Krizek Filip, Reimers Sonka, Kaspar Zdenek, Marmo	Atomically sharp domain wa	2022	SCIENCE ADVANCES	10.1126/sciadv.abn3535	NanoMAX	MAX IV
Kruusma, J	Kruusma Jaanus, Kaambre Tanel, Tonisoo Arvo, Kisa	The electrochemical behavi	2022	JOURNAL OF SOLID STATE ELECTROCHEN	10.1007/s10008-022-05281-0	FinEstBeAMS	MAX IV
Kruusma, J	Kruusma Jaanus, Kaambre Tanel, Tonisoo Arvo, Kisa	The electrochemical behavi	2022	JOURNAL OF SOLID STATE ELECTROCHEN	10.1007/s10008-022-05281-0	FlexPES	MAX IV
Kuzmins, A	Kuzmins A, Pudza I, Klementiev K	In situ study of zinc peroxide	2022	PHYSICA STATUS SOLIDI B-BASIC SOLID S	10.1002/pssb.202200001	Balder	MAX IV
Kwon, J	Kwon J, Soltani S, Polley C, Jung J, Kim M, Kim D, De	Universality of charge dopir	2022	PHYSICAL REVIEW B	10.1103/PhysRevB.106.L241114	BLOCH	MAX IV
Larsson, A	Larsson Alfred, D'Acunto Giulio, Vorobyova Mariya,	Thickness and composition	2022	JOURNAL OF ALLOYS AND COMPOUNDS	10.1016/j.jallcom.2021.162657	FlexPES	MAX IV
Li, C	Li C, Wu X, Liu H, Polley C, Guo Q, Wang Y, Han X, D	Coexistence of two intertwi	2022	PHYSICAL REVIEW RESEARCH	10.1103/PhysRevResearch.4.03307:	BLOCH	MAX IV
Li, P	Li Peng, Allain Marc, Grunewald Tilman A., Rommel	4th generation synchrotron	2022	LIGHT-SCIENCE & APPLICATIONS	10.1038/s41377-022-00758-z	NanoMAX	MAX IV
Li, Xi	Li Xian'e, Zhang Qilun, Yu Jianwei, Xu Ye, Zhang Rui,	Mapping the energy level al	2022	NATURE COMMUNICATIONS	10.1038/s41467-022-29702-w	FlexPES	MAX IV
Li, Y	Li Yaqi, Zatterin Edoardo, Conroy Michele, Pylypets	Electrostatically Driven Pola	2022	ADVANCED MATERIALS	10.1002/adma.202106826	NanoMAX	MAX IV
Lin, W	Lin W, Liang M, Niu Y, Chen Z, Cherasse de M, Meng	Combining two-photon pho	2022	JOURNAL OF MATERIALS CHEMISTRY C	10.1039/D2TC03111F	OTHER	MAX IV
Lindgren, C	Lindgren Cecilia, Forsgren Nina, Hoster Norman, Ak	Broad-Spectrum Antidote D	2022	CHEMISTRY-A EUROPEAN JOURNAL	10.1002/chem.202200678	BioMAX	MAX IV
Liu, Y-P	Liu Yen-Po, Yngman Sofie, Troian Andrea, D'Acunto	Hydrogen plasma enhanced	2022	APPLIED SURFACE SCIENCE	10.1016/j.apsusc.2022.153336	FlexPES	MAX IV
Lorentzen, J	Lorentzen Josefine, Pedersen Dennis Vestergaard, F	Structure determination of	2022	PROTEIN SCIENCE	10.1002/pro.4432	BioMAX	MAX IV
Luttens, A	Luttens Andreas, Gullberg Hjalmar, Abdurakhmano	Ultralarge Virtual Screening	2022	JOURNAL OF THE AMERICAN CHEMICAL	10.1021/jacs.1c08402	BioMAX	MAX IV
Lützenkirchen-Hecht, D	Lützenkirchen-Hecht D, Stötzel J, Just J, Müller O, Bo	Time-Resolved Grazing Incid	2022	PHYSICA STATUS SOLIDI A-APPLICATIONS	10.1002/pssa.202100514	OTHER	MAX IV
Markússon, S M S	Markússon SMS, Hjörleifsson JG, Kursula P, Ásgeirss	Structural Characterization	2022	BIOCHEMISTRY	10.1021/acs.biochem.2c00438	BioMAX	MAX IV
Masternak, M	Masternak Magdalena, Koch Angela, Laulumaa Saa	Differences between the Gl	2022	FEBS JOURNAL	10.1111/febs.16631	BioMAX	MAX IV
Mende, Max	Mende Max, Ali Khadiza, Poelchen Georg, Schulz Su	Strong Rashba Effect and Di	2022	ADVANCED ELECTRONIC MATERIALS	10.1002/aelm.202100768	BLOCH	MAX IV
Merte, L R	Merte Lindsay R., Bisbo Malthe Kjoer, Sokolovic Igo	Structure of an Ultrathin Ox	2022	ANGEWANDTE CHEMIE-INTERNATIONAL	10.1002/anie.202204244	OTHER	MAX IV
Molina, R	Molina R, Garcia-Martin R, López-Méndez B, Jenser	Molecular basis of cyclic tet	2022	NUCLEIC ACIDS RESEARCH	10.1093/nar/gkac923	BioMAX	MAX IV
Mom, K	Mom K, Sixou B, Langer M	Mixed scale dense convolut	2022	APPLIED OPTICS	10.1364/AO.443330	NanoMAX	MAX IV
Mukkattukavil, D J	Mukkattukavil DJ, Hellsvik J, Ghosh A, Chatzigeorgic	Resonant inelastic soft x-ray	2022	JOURNAL OF PHYSICS-CONDENSED MAT	10.1088/1361-648X/ac7500	SPECIES	MAX IV
Narayanan, D	Narayanan Dilip, Tran Kim T., Pallesen Jakob S., Solb	Development of Noncovaler	2022	JOURNAL OF MEDICINAL CHEMISTRY	10.1021/acs.jmedchem.2c00830	BioMAX	MAX IV
Neckel, I T	Neckel Itamar T., da Silva Francisco M. C., Guedes E	Unveiling Center-Type Topo	2022	ANNALEN DER PHYSIK	10.1002/andp.202100219	MAXPEEM	MAX IV
Neckel, I T	Neckel Itamar T., da Silva Francisco M. C., Guedes E	Unveiling Center-Type Topo	2022	ANNALEN DER PHYSIK	10.1002/andp.202100219	NanoMAX	MAX IV
Nickel, A C	Nickel Anne C., Denton Alan R., Houston Judith E., S	Beyond simple self-healing:	2022	JOURNAL OF CHEMICAL PHYSICS	10.1063/5.0119527	CoSAXS	MAX IV

Nicolas, J	Nicolas J, Šics I, Colldelram C, Gonzalez N, Cristol, A,	A Versatile Adaptive Optics	2022	SYNCHROTRON RADIATION NEWS	10.1080/08940886.2022.2066400	OTHER	MAX IV
Nielsen, N S	Nielsen NS, Zarantonello A, Harwood SL, Jensen KT,	Cryo-EM structures of huma	2022	NATURE COMMUNICATIONS	10.1038/s41467-022-30758-x	BioMAX	MAX IV
Nizi, M G	Nizi Maria Giulia, Maksimainen Mirko M., Murthy S	Potent 2,3-dihydrophthalaz	2022	EUROPEAN JOURNAL OF MEDICINAL CHE	10.1016/j.ejmech.2022.114362	BioMAX	MAX IV
Norrild, R K	Norrild RK, Johansson KE, O'shea C, Morth JP, Lindo	Increasing protein stability b	2022	Cell Reports Methods	10.1016/j.crmeth.2022.100333	BioMAX	MAX IV
Ohlin, H	Ohlin H, Frisk T, Åstrand M and Vogt U	Miniaturized Sulfite-Based (	2022	MICROMACHINES	10.3390/mi13030452	NanoMAX	MAX IV
Olovsson, W	Olovsson W, Magnuson M	Rhombohedral and Turbost	2022	JOURNAL OF PHYSICAL CHEMISTRY C	10.1021/acs.jpcc.2c06895	I511-3	MAX-Lab
Omelkov, S	Omelkov S, Chernenko K, Ekström JC, Jurgilaitis A, K	Recent advances in time-res	2022	JOURNAL OF PHYSICS: CONFERENCE SER	10.1088/1742-6596/2380/1/012135	FemtoMAX	MAX IV
Omelkov, S	Omelkov S, Chernenko K, Ekström JC, Jurgilaitis A, K	Recent advances in time-res	2022	JOURNAL OF PHYSICS: CONFERENCE SER	10.1088/1742-6596/2380/1/012135	FinEstBeAMS	MAX IV
Osiecki, J R	Osiecki Jacek R., Suto Shozo, Chutia Arunabhiram	Periodic corner holes on the	2022	NATURE COMMUNICATIONS	10.1038/s41467-022-29768-6	BLOCH	MAX IV
Palmolahti, L	Palmolahti L, Ali-Löytty H, Hannula M, Saari J, Wang	Pinhole-resistant nanocryst	2022	ACTA MATERIALIA	10.1016/j.actamat.2022.118257	FinEstBeAMS	MAX IV
Pan, Y	Pan Yu, Le Congcong, He Bin, Watzman Sarah J., Yao	Giant anomalous Nernst sig	2022	NATURE MATERIALS	10.1038/s41563-021-01149-2	BLOCH	MAX IV
Parenti, M D	Parenti MD, Naldi M, Manoni E, Fabini E, Cederfelt	Discovery of the 4-aminopip	2022	EUROPEAN JOURNAL OF MEDICINAL CHE	10.1016/j.ejmech.2022.114683	BioMAX	MAX IV
Pejchal, J	Pejchal J, Babin V, Buryi M, Laguta V, Hájek F, Páter	Untangling the controversy	2022	Materials Advances	10.1039/d1ma01083b	FinEstBeAMS	MAX IV
Pohl, C	Pohl C, Effantin G, Kandiah E, Meier S, Zeng G, Strei	pH- and concentration-depe	2022	NATURE COMMUNICATIONS	10.1038/s41467-022-30462-w	BioMAX	MAX IV
Polukeev, A V	Polukeev Alexey V, Wallenberg Reine, Uhlig Jens, H	Iridium-Catalyzed Dehydrog	2022	CHEMSUSCHEM	10.1002/cssc.202200085	Balder	MAX IV
Radzhabov, E	Radzhabov Evgeny, Shendrik Roman, Pankratov Vla	Emission of Tm2+in alkaline	2022	JOURNAL OF LUMINESCENCE	10.1016/j.jlumin.2022.119271	FinEstBeAMS	MAX IV
Rani, E	Rani E, K Gupta V, Thasfiquzzaman M, Talebi P, Ma	Unraveling compensation b	2022	JOURNAL OF CATALYSIS	10.1016/j.jcat.2022.09.006	MAXPEEM	MAX IV
Rani, E	Rani Ekta, Singh Harishchandra, Alatarvas Tuomas,	Uncovering temperature-te	2022	JOURNAL OF MATERIALS RESEARCH AND	10.1016/j.jmrt.2022.01.170	MAXPEEM	MAX IV
Rattigan, E	Rattigan Eoghan, Sun Zhaozong, Gallo Tamires, Ang	The cobalt oxidation state in	2022	PHYSICAL CHEMISTRY CHEMICAL PHYSIC	10.1039/d2cp00399f	HIPPIE	MAX IV
Reed, B P	Reed B. P., Bathen M. E., Ash J. W. R., Meara C. J., Z	Diamond (111) surface reco	2022	PHYSICAL REVIEW B	10.1103/PhysRevB.105.205304	I311-PEEM	MAX-Lab
Reimers, S	Reimers Sonka, Kriegner Dominik, Gomonay Olena,	Defect-driven antiferromag	2022	NATURE COMMUNICATIONS	10.1038/s41467-022-28311-x	NanoMAX	MAX IV
Ristinmaa Sorensen, A	Ristinmaa Amanda Sorensen, Coleman Tom, Cesar	Structural diversity and subs	2022	JOURNAL OF BIOLOGICAL CHEMISTRY	10.1016/j.jbc.2022.101758	BioMAX	MAX IV
Rojas-Hernandez, R E	Rojas-Hernandez Rocio Estefania, Rubio-Marcos Fe	Deep-Ultraviolet Emitter: Ra	2022	INORGANIC CHEMISTRY	10.1021/acs.inorgchem.2c01646	FinEstBeAMS	MAX IV
Saadaldin, A	Saadaldin A, Slyamov AM, Stuckelberger ME, Jørge	Multi-modal characterizatio	2022	FARADAY DISCUSSIONS	10.1039/d2fd00044j	NanoMAX	MAX IV
Saaring, J	Saaring Juhan, Vanetsev Alexander, Chernenko Kiril	Time-resolved luminescence	2022	JOURNAL OF LUMINESCENCE	10.1016/j.jlumin.2022.118729	FinEstBeAMS	MAX IV
Sala, S	Sala Simone, Zhang Yuhe, De la Rosa Nathaly, Dreie	Dose-efficient multimodal m	2022	JOURNAL OF SYNCHROTRON RADIATION	10.1107/S1600577522001874	NanoMAX	MAX IV
Sarr, M	Sarr M, Kitoka K, Walsh-White KA, Kaldmäe M, Met	The dimerization mechanism	2022	JOURNAL OF BIOLOGICAL CHEMISTRY	10.1016/j.jbc.2022.101913	BioMAX	MAX IV
Seymour, J	Seymour J, Gousseva E, Large A, Held G, Hein D, Wa	Resonant Electron Spectros	2022	FARADAY DISCUSSIONS	10.1039/D1FD00117E	I311-XPS	MAX-Lab
Shahabi-Ghahfarokhia, S	Shahabi-Ghahfarokhia S, Åström M, Yu C, Lindquisit	Extensive dispersion of met	2022	APPLIED GEOCHEMISTRY	10.1016/j.apgeochem.2021.105170	Balder	MAX IV
Shavorskiy, A	Shavorskiy A, Kokkonen E, Redekop E, D'Acunto G, S	Time-Resolved APXPS with C	2022	SYNCHROTRON RADIATION NEWS	10.1080/08940886.2022.2082166	HIPPIE	MAX IV
Shavorskiy, A	Shavorskiy A, Kokkonen E, Redekop E, D'Acunto G, S	Time-Resolved APXPS with C	2022	SYNCHROTRON RADIATION NEWS	10.1080/08940886.2022.2082166	SPECIES	MAX IV
Shtepliuk, I	Shtepliuk Ivan, Vagin Mikhail, Khan Ziyauddin, Zakh	Understanding of the Electr	2022	NANOMATERIALS	10.3390/nano12132229	MAXPEEM	MAX IV
Shu, R	Shu R, Lundin D, Xin B, Sortica MA, Primetzhofer D,	Influence of Metal Substitut	2022	ACS APPLIED ELECTRONIC MATERIALS	10.1021/acsaelm.1c00311	Balder	MAX IV
Singh, H	Singh H, Xiong Y, ,Rani E, Wang S, Kharbach M, Zhou	Unveiling nano-scaled chem	2022	NPJ MATERIALS DEGRADATION	10.1038/s41529-022-00263-z	MAXPEEM	MAX IV
Sjostedt, C	Sjostedt Carin, Kristofferson Asa, Gustafsson Jon Pe	Evidence of the mineral ZnH	2022	APPLIED GEOCHEMISTRY	10.1016/j.apgeochem.2022.105301	I811	MAX-Lab
Skane, A	Skane Anna, Edvardsen Per Kristian, Cordara Gabrie	Chitinolytic enzymes contrib	2022	BMC MICROBIOLOGY	10.1186/s12866-022-02590-2	BioMAX	MAX IV
Skerlep, M	Skerlep M, Nehzati S, Johansson U, Kleja DB, Persso	Spruce forest afforestation	2022	BIOGEOCHEMISTRY	10.1007/s10533-021-00874-9	OTHER	MAX IV
Spassky, D	Spassky D., Fedyunin F., Rubtsova E., Tarabrina N., M	Structural, optical and lumin	2022	OPTICAL MATERIALS	10.1016/j.optmat.2022.112079	FinEstBeAMS	MAX IV
Sri Gyan, D	Sri Gyan D, Mannix D, Carbone D, Sumpter J L, Gepr	Low-temperature nanoscale	2022	STRUCTURAL DYNAMICS	10.1063/4.0000154	FemtoMAX	MAX IV
Sterling, C M	Sterling Cody M., Kamal Chinnathambi, Garcia-Fern	Electronic Structure and Ch	2022	JOURNAL OF PHYSICAL CHEMISTRY C	10.1021/acs.jpcc.2c06782	FlexPES	MAX IV
Stromsheim, M D	Stromsheim Marie D., Svenum Ingeborg-Helene, Ma	Segregation dynamics of a P	2022	CATALYSIS TODAY	10.1016/j.cattod.2021.02.007	HIPPIE	MAX IV
Svanström, S	Svanström S, García-Fernández A, Jacobsson TJ, Bid	The Complex Degradation M	2022	ACS MATERIALS AU	10.1021/acsmaterialsau.1c00038	SPECIES	MAX IV
Tandrup, T	Tandrup T, Muderspach SJ,Banerjee S, Santoni G, Ip	Changes in active-site geom	2022	IUCRJ	10.1107/S2052252522007175	BioMAX	MAX IV
Tarasov, A V	Tarasov Artem V., Glazkova Daria, Schulz Susanne, F	Crystal electric field and pro	2022	PHYSICAL REVIEW B	10.1103/PhysRevB.106.155136	BLOCH	MAX IV
Tarasov, AV	Tarasov AV, Mende M, Ali K, Poelchen G, Schulz S, V	Structural instability at the I	2022	SURFACES AND INTERFACES	10.1016/j.surfin.2022.102126	BLOCH	MAX IV
Tavares, P F	Tavares P. F., Cullinan F. J., Andersson A., Olsson D.,	Beam-based characterizatio	2022	NUCLEAR INSTRUMENTS & METHODS IN	10.1016/j.nima.2021.165945	Accelerators-FEL	MAX IV
Temperton, R	Temperton R, Kawde A, Eriksson A, Wang W, Kokko	Dip-and-pull ambient pressu	2022	JOURNAL OF CHEMICAL PHYSICS	10.1063/5.0130222	HIPPIE	MAX IV

Thomas, B	Thomas Bony, Geng Shiyu, Wei Jiayuan, Lycksam He	Ice-Templating of Lignin anc	2022	ACS APPLIED NANO MATERIALS	10.1021/acsanm.2c01033	NanoMAX	MAX IV
Travnikova, O	Travnikova O, Kukk E, HOSSEINI F, Granroth S, Itälä	Ultrafast dissociation of am	2022	PHYSICAL CHEMISTRY CHEMICAL PHYSIC	10.1039/D1CP05499F	FinEstBeAMS	MAX IV
Trinkler, L	Trinkler L., Pankratov V., Trukhin A., Berzina B., Cho	Anisotropic photoluminesce	2022	OPTICAL MATERIALS	10.1016/j.optmat.2022.112856	FinEstBeAMS	MAX IV
Usachov, D Y	Usachov DY, Glazkova D, Tarasov AV, Schulz S, Poelc	Estimating the Orientation c	2022	JOURNAL OF PHYSICAL CHEMISTRY LETTI	10.1021/acs.jpclett.2c02203	BLOCH	MAX IV
Verma, A	Verma A, Åberg-Zingmark E, Sparrman T, Mushtaq /	Verma, Apoorv, Emma Åber	2022	SCIENCE ADVANCES	10.1126/sciadv.abm4089	BioMAX	MAX IV
Wallander, H J	Wallander Harald J., Oropeza Freddy E., Hagman Be	Oxidation of a Platinum-Tin	2022	JOURNAL OF PHYSICAL CHEMISTRY C	10.1021/acs.jpcc.2c00786	HIPPIE	MAX IV
Wang, C	Wang C, Kong Y, Soldemo M, Wu Z, Tissot H, Karagc	Stabilization of Cu2O throug	2022	CHEMISTRY OF MATERIALS	10.1021/acs.chemmater.1c04137	HIPPIE	MAX IV
Wang, C	Wang Chunlei, Tissot Heloise, Soldemo Markus, Lu .	Inverse single-site Fe-1(OH)	2022	NANO RESEARCH	10.1007/s12274-021-3551-4	HIPPIE	MAX IV
Wang, C	Wang C, Kong Y, Soldemo M, Wu Z, Tissot H, Karagc	Stabilization of Cu2O throug	2022	CHEMISTRY OF MATERIALS	10.1021/acs.chemmater.1c04137	SPECIES	MAX IV
Wang, W	Wang W, Kivimäki A, Chernenko K, Pärna R, Käämbı	A new user-friendly materia	2022	JOURNAL OF PHYSICS: CONFERENCE SER	10.1088/1742-6596/2380/1/01204ε	FinEstBeAMS	MAX IV
Wang, Yao	Wang Yao, Liu Chaocheng, Duan Hengli, Li Zhi, Wan	Polaronic Trions Induced by	2022	ADVANCED ELECTRONIC MATERIALS	10.1002/aelm.202200852	MAXPEEM	MAX IV
Warlo, M	Warlo M, Bark G, Wanhainen C, Mcelroy I, Björling /	Extreme-resolution synchro	2022	ORE GEOLOGY REVIEWS	10.1016/j.oregeorev.2021.104620	NanoMAX	MAX IV
Weststrate, C J	Weststrate CJ, Niemantsverdriet JW	CO adsorption on Co(0001)	2022	JOURNAL OF CATALYSIS	10.1016/j.jcat.2022.03.005	FlexPES	MAX IV
Weststrate, C J	Weststrate CJ, Sharma D, Gleeson MA and Niemant	Water and Hydroxyl Reactiv	2022	JOURNAL OF PHYSICAL CHEMISTRY C	10.1021/acs.jpcc.2c08425	FlexPES	MAX IV
Wilkens, C	Wilkens C, Vuillemin M, Pilgaard B, Polikarpov I, Mc	GH115 α-glucuronidase stru	2022	ACTA CRYSTALLOGRAPHICA SECTION D-S	10.1107/S2059798322003527	BioMAX	MAX IV
Yang, Xian P.	Yang Xian P., LaBollita Harrison, Cheng Zi-Jia, Bhanc	Visualizing the out-of-plane	2022	PHYSICAL REVIEW B	10.1103/PhysRevB.105.L121107	BLOCH	MAX IV
Yilmaz-Turan, S	Yilmaz-Turan S, Jiang K, Lopez-Sanchez P, Jiménez-C	Hydrogels with protective e	2022	GREEN CHEMISTRY	10.1039/d2gc03331c	CoSAXS	MAX IV
Yilmaz-Turan, S	Yilmaz-Turan S, Lopez-Sanchez P, Jiménez-Quero A,	Revealing the mechanisms c	2022	FOOD HYDROCOLLOIDS	10.1016/j.foodhyd.2022.107575	OTHER	MAX IV
Zhang, C	Zhang C, Wang B, Hellman A, Shipilin M, Schaefer A	Steps and catalytic reaction:	2022	SURFACE SCIENCE	10.1016/j.susc.2021.121928	I311-XPS	MAX-Lab
Zhang, Y	Zhang Y, Towers CG, Singh UK, Liu J, Håkansson M, I	Dusquetide modulates inna	2022	STRUCTURE	10.1016/j.str.2022.05.003	MX	MAX-Lab
Zhu, L	Zhu Lin, Al-Sakeeri Ali, Lenrick Filip, Berg Oskar Dars	Surface chemistry and diffu:	2022	SURFACE AND INTERFACE ANALYSIS	10.1002/sia.7024	MAXPEEM	MAX IV
Zhu, Z	Zhu Zhongyunshen, Jonsson Adam, Liu Yen-Po, Svei	Improved Electrostatics thrc	2022	ACS APPLIED ELECTRONIC MATERIALS	10.1021/acsaelm.1c01134	FlexPES	MAX IV
Zongg, Z	Zongg Zhiyou, Mazurkewich Scott, Pereira Caroline	Mechanism and biomass as	2022	NATURE COMMUNICATIONS	10.1038/s41467-022-28938-w	BioMAX	MAX IV