

MAX IV AND THE INDUSTRY

2023

MAX IV

MAIN FUNDERS AND PARTNERS



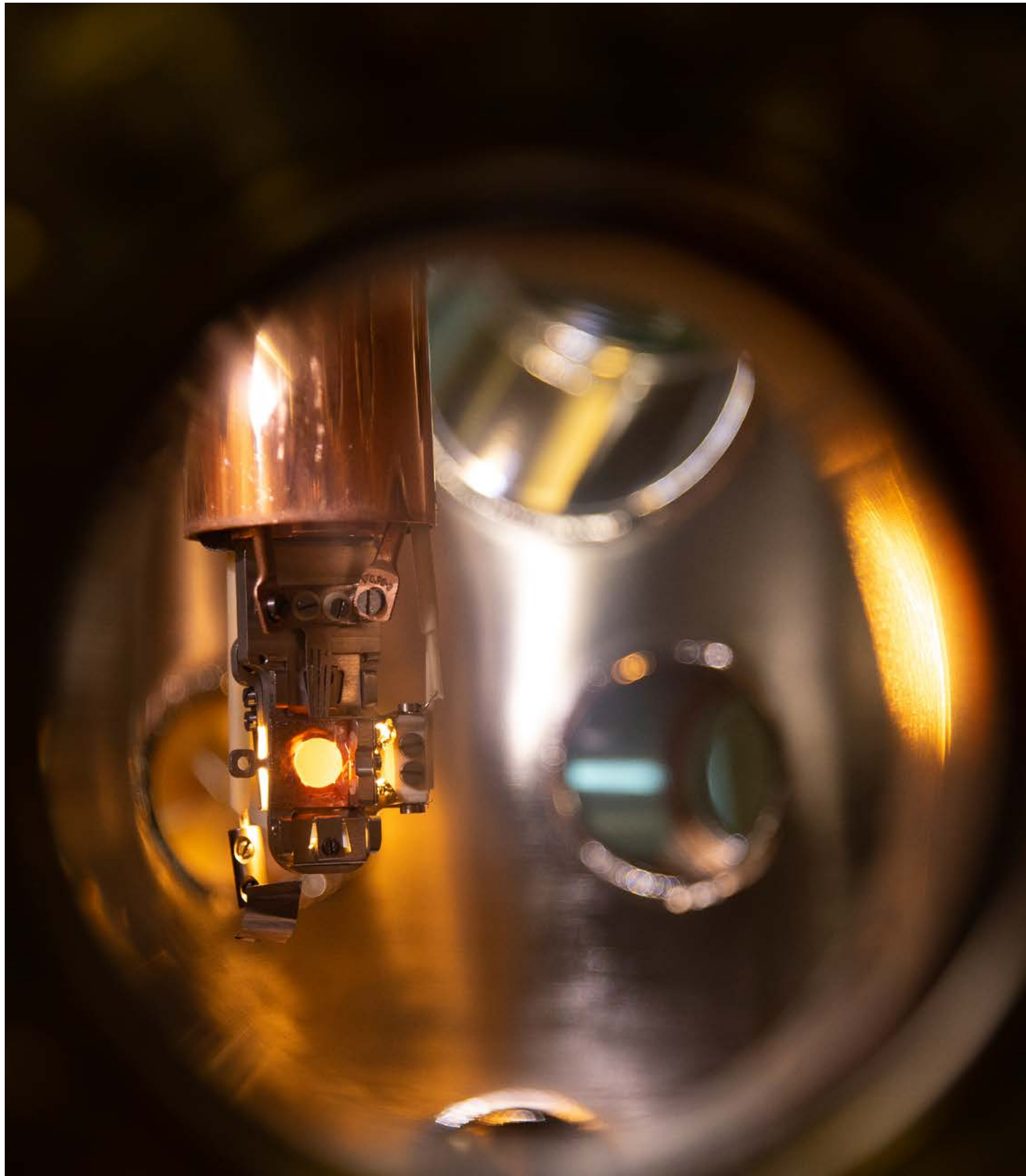
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FOREWORD

Industrial Engagement at MAX IV

I'm pleased to share that another fantastic year of industrial research at MAX IV has come to a close. Our commitment to strengthening industry presence by 2030 remains unwavering. This strategic approach centers on four key ambitions:

1. Broaden the industry user base.
2. Increase industrial use of MAX IV.
3. Develop MAX IV to support industrial needs.
4. Foster a collaborative approach to industry engagement.

The MAX IV Industrial Relations Office collaborates closely with industry partners and a network of stakeholders to achieve these goals. MAX IV offers a diverse array of techniques and capabilities in materials science, targeting the top ten industry sectors in the Nordics to build robust connections. With this publication we wish to highlight some of our efforts and successes on industry engagement at MAX IV.

In 2023, MAX IV continued to make significant progress in our mission to enhance industry engagement and collaboration. This year's standout achievement was the full implementation of the FragMAX platform, dedicated to crystallographic fragment and compound screening. This state-of-the-art facility quickly attracted three industrial users, contributing to nearly a quarter of all proprietary beamtime in 2023. This milestone underscores the increasing value that the industry sees in partnering with MAX IV.

Our journey is deeply intertwined with our industrial collaborators. One of the most illustrative examples is our ongoing partnership with Alfa Laval. We hope that this collaboration will lead to a stronger industrial use of MAX IV within the engineering sector and that Alfa Laval's effort will inspire other companies in other sectors to approach us and learn how they can better use the tools available here. The doors are open!

We are excited to continue this journey, expanding our impact and building on the strong foundations laid in 2023.

Magnus Larsson

Head of Industrial Relations, MAX IV



An aerial, high-angle photograph of a city at night. The image shows a dense grid of streets and buildings. Many windows are illuminated, creating a pattern of warm yellow and orange light. Some buildings have distinct blue or green lights, possibly from signage or specific interior lighting. The overall scene is a vibrant, colorful representation of urban life at night.

INDUSTRY USER CASE

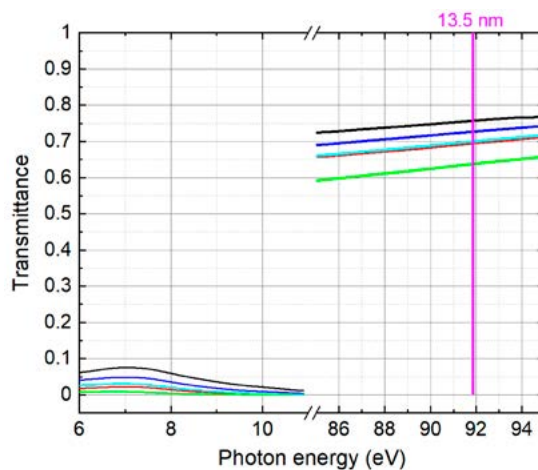


Fine-tuning the next-generation debris filter for industry made from carbon nanotubes

In the semiconductor manufacturing process, a filter is needed to prevent particles and ions from contaminating the silicon wafer and block out undesired wavelengths of light. Finnish carbon nanomaterial development company Canatu Oy develops and tailors such filters in the shape of carbon nanotube membranes for different industrial uses. The membranes should transmit the light used for the lithography process in the extreme ultraviolet (EUV) range while blocking the 100-200 nm wavelength.

Canatu collaborated with the research team at MAX IV beamline FinEstBeAMS to do high accuracy transmission measurements in both deep ultraviolet (DUV) and EUV optical ranges with

precisely controlled parameters. FinEstBeAM's coverage of the entire energy range from 4.5 eV (276 nm wavelength) to well above the EUV range at 92 eV (13.5 nm) offered a unique possibility for testing and optimising the material's properties.



The graph shows the filtering properties of different types of filter designs.

"We highly value the availability, fast turnaround, and the reliability of results in our collaboration with Max IV Laboratory"

Emile van Veldhoven
Senior Development Engineer, Canatu



2023 IN NUMBERS



MAX IV continues to experience a steady increase in industrial utilisation, with a strong emphasis on pharmaceutical development.

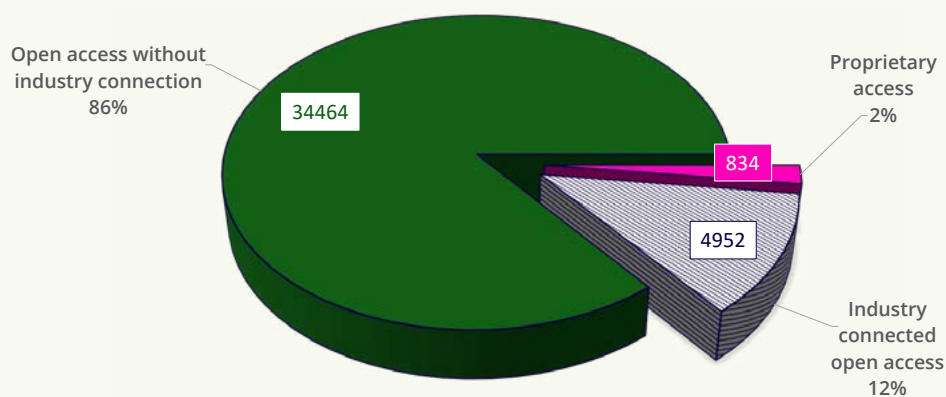
In 2023, 14% of the MAX IV beamtime was utilised by the industry. It was accessed either through collaborative open access or proprietary access; see figure below.

Proprietary industrial use has grown significantly since the first paying user in 2018, reaching 834 hours in 2023. This increase is almost entirely attributed to protein crystallography performed at the BioMAX beamline. Most notably, Frag-MAX, a user facility for crystallographic fragment screening, attracted three new proprietary user groups in 2023, accounting for almost a quarter of the proprietary beamtime.

As synchrotrons worldwide upgrade to 4th generation and enter so-called dark periods, companies look for alternative suppliers of protein crystallography services. With more shutdowns anticipated in the coming years, MAX IV strives to use this opportunity to reach new companies and remain a competitive facility for macromolecular crystallography (MX) services.

See the industry sectors section for a more detailed breakdown of the industry-connected beamtime.

BEAMTIME HOURS EXTERNALLY USED IN 2023 BY TYPE OF ACCESS





INDUSTRY USER CASE

Using fragments to fight neurodegenerative diseases

Neurodegenerative illnesses, such as Alzheimer's disease, urgently require novel therapeutic options. Muna Therapeutics, an international biotech company with offices in Denmark, Belgium, and the United States, is working to produce revolutionary medicines for neurological diseases.

Muna identifies and validates compounds that can be utilised to treat neuronal dysfunction, resolve neuroinflammation, and restore neuroprotection. A gene linked to a heightened risk of neurodegenerative disorders became the focus for developing a potent, selective small-molecule compound aimed at enhancing its function. This could serve as the basis for the discovery of an innovative drug.

Muna carried out an extensive crystallographic fragment screening campaign in partnership with the FragMAX team. More than 1500 fragment molecules were tested for binding at the BioMAX beamline, a process greatly accelerated by recently developed, fully automated data collection routines. The effort produced a significant number of hits that provide a detailed three-dimensional image of the protein's binding landscape and a plethora of starting points for further drug development.

"In our collaborative experience, the FragMAX platform at MAX IV has proven to be a valuable asset, contributing to Muna's progress in fragment screening and providing key starting points for the development of therapies for neurodegenerative diseases."

Joachim Vilstrup, Head Of Protein Chemistry at Muna Therapeutics





FRAGMENT SCREENING





FragMAX is the dedicated user platform for crystal-based fragment and compound screening at MAX IV, open to Swedish and international scientists from academia and industry.

Crystallographic fragment screening is a powerful method for mapping the binding sites of target proteins and for finding new starting points for the discovery of novel pharmaceutical drugs. This technique reveals the three-dimensional structures of protein-ligand complexes and enables the identification of chemical groups that interact with the target.

The service offers an attractive package for industrial users, providing simple workflows for large-scale crystal preparation, data collection and analysis, including access to the facility through a flexible, milestones-based access model. This user-friendly approach account for a significant increase in industrial usage of FragMAX.

Data collection at the FragMAX platform is conducted at BioMAX, one of the macromolecular crystallography beamlines at MAX IV. Procedures at BioMAX are highly automated in terms of sample handling hardware and data analysis, which attracts a lot of industrial users. The addition of the FragMAX experiments has increased the beamline's industrial usage even further, resulting in a high subscription rate of industrial users performing standard macromolecular X-ray crystallography measurements.



MAX IV INTERVIEW

Interview with Tobias Krojer, Project Manager for FragMAX and Beamline Scientist at BioMAX, to learn about what makes the FragMAX platform unique.

How did FragMAX begin?

FragMAX was established through a VR infrastructure accessibility grant during 2019 to 2022 which involved MAX IV, Lund Protein Production Platform (LP3) and industrial partners, SARomics Biostructures and AstraZeneca. MAX IV is now providing the resources to support FragMAX, which is linked to the MX group.

What expertise does FragMAX provide?

FragMAX has two dedicated staff members who can provide expertise in project design, crystal preparation, data collection and data analysis. We have developed automated systems for crystal preparation and data collection and work closely with the in-house engineering group on equipment upgrades. FragMAX has its own software packages and customisable freeware

available to users. Although we have a standard workflow, we are flexible and open to accommodating non-standard requests.

Can you describe the interaction you have with FragMAX users?

I have regular discussions and interactions with the users throughout the whole process, from project planning to summarising the findings. We want the experiment to enable their science and research, therefore the two-way conversations are incredibly important.

What is the future of fragment screening in Drug Discovery?

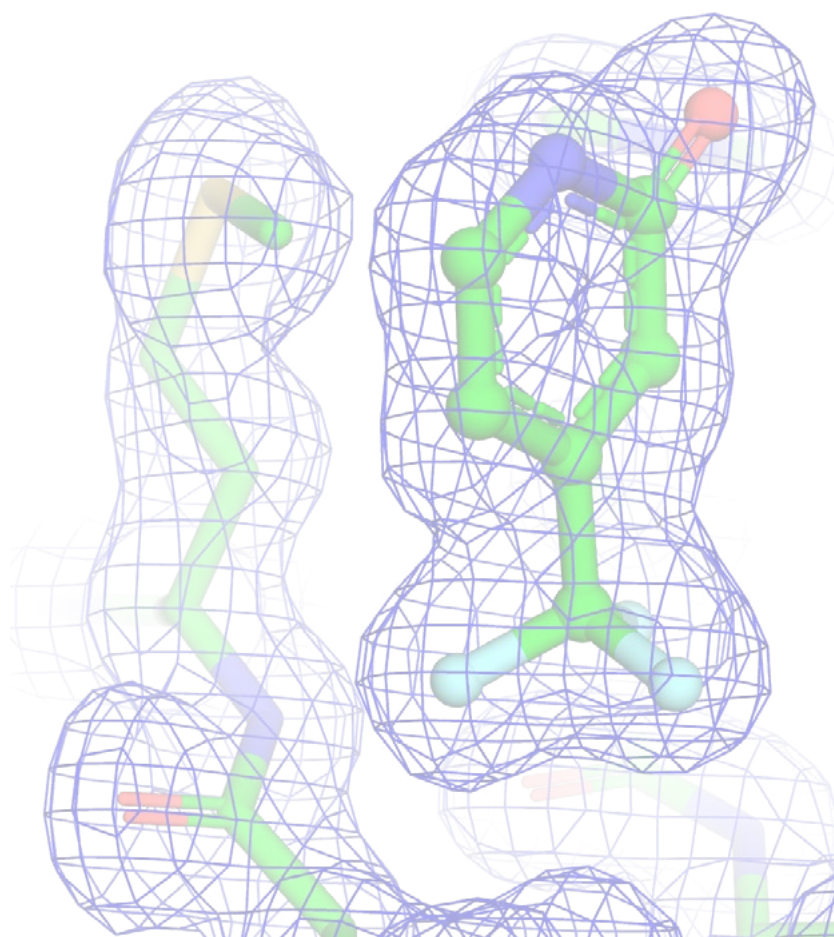
Fragment screening platforms are being established and developed worldwide. They can narrow down the chemical space to a few hundred up to a thousand compounds and using crystals allows for 3D structure interaction too. At FragMAX, we want to expand the fragment libraries but we are a science driven facility where we want to adapt our services to the needs of the users.

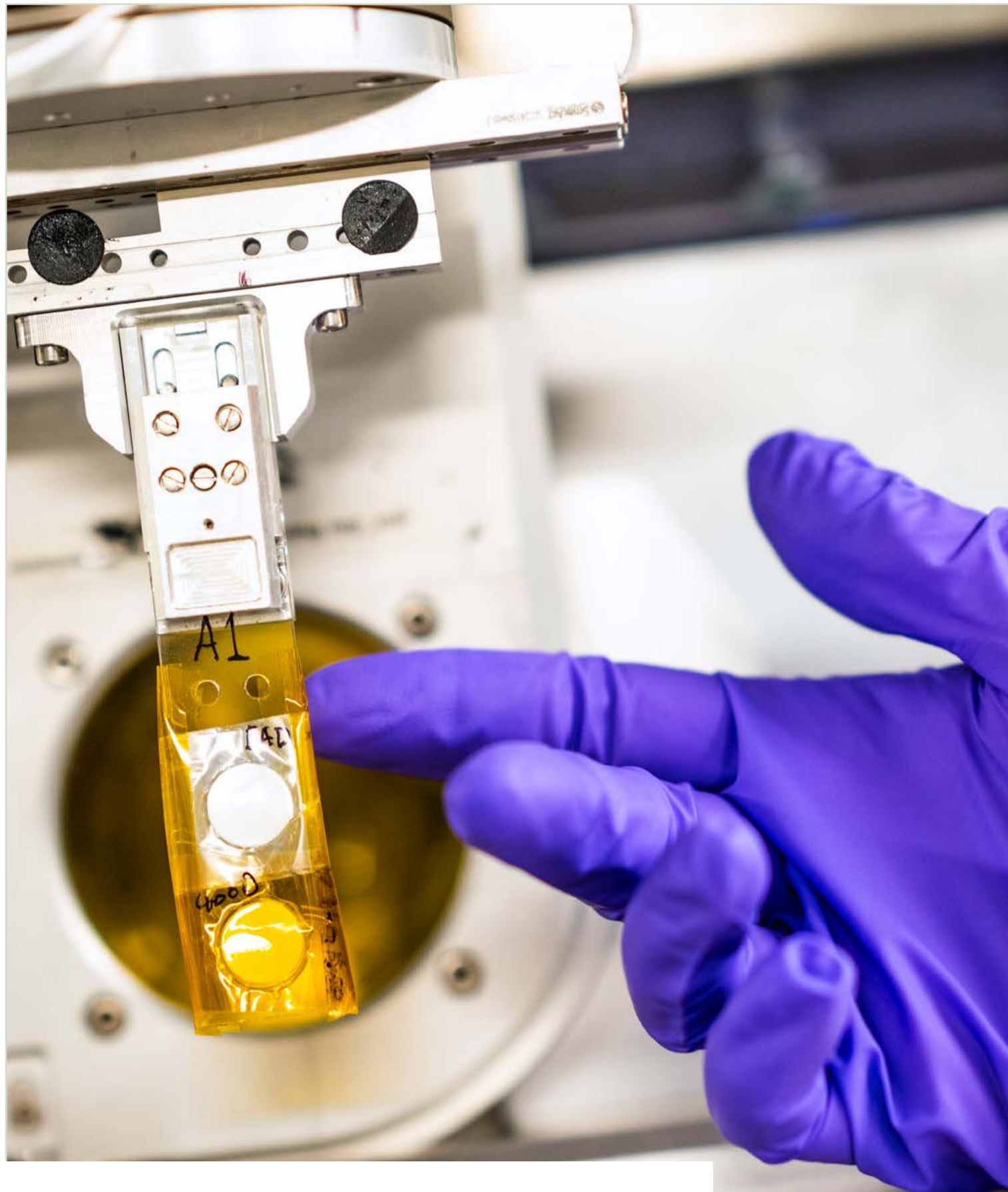
What is unique about FragMAX?

Only a handful of synchrotron based fragment screening platforms are available worldwide. Our approach is to provide a personalised and knowledgeable discussion partner in connection with using the platform.

How does a potential user contact FragMAX?

Simply contact us at FragMAX to discuss your project needs! Academic users can then apply twice a year through the open-access route. Industrial users can access FragMAX anytime by contacting the Industrial Relations Office.





INDUSTRY SECTORS



Accelerating multisectorial research from pharmaceuticals to green energy

In 2023, the Pharma sector still dominated industry use of MAX IV, accounting for 19% of the total beamtime. This sector saw a 72% increase in proprietary access compared to 2022, largely due to the FragMAX crystal-based fragment and compound screening platform.

The energy sector, particularly the battery industry, surged in its use of MAX IV, becoming the second-largest user group with 18% of the industry-connected beamtime, up from 13% in 2022. The shift towards abundant, recyclable battery materials is driving R&D investments and also prompting this sector to exploit MAX IV's capabilities to a larger extent.

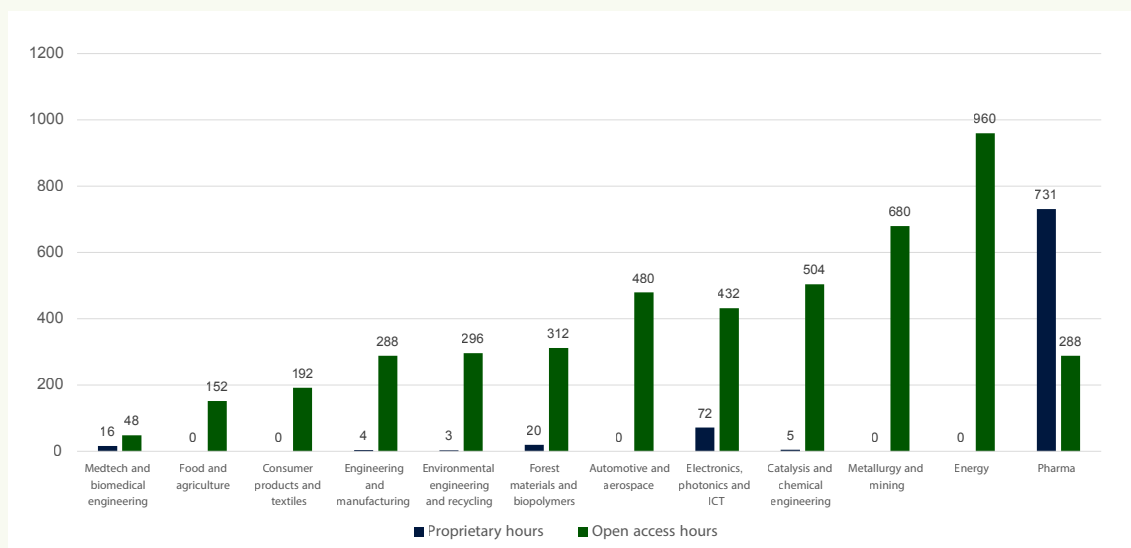
The metal industry, including engineering and automotive sectors, remains a significant user of MAX IV, primarily through open-access. This mature sector, with strong academic and international ties, continues to leverage synchrotron capabilities for its research.

Catalysis and chemical engineering, as well as electronics, photonics, and information and communication technology, were prominent in industry-connected open access. Notably, the electronics industry was the second-largest user group in proprietary access, following the Pharma sector.

The forest materials and biopolymers, alongside environmental engineering and recycling sectors, solidified their presence, representing 12% of industry-connected beamtime.

Emerging sectors like consumer products and textiles, food and agriculture, and medtech and biomedical engineering are steadily increasing their use of MAX IV.

INDUSTRY-CONNECTED BEAMTIME HOURS IN 2023 BY TYPE OF ACCESS AND INDUSTRY SECTOR



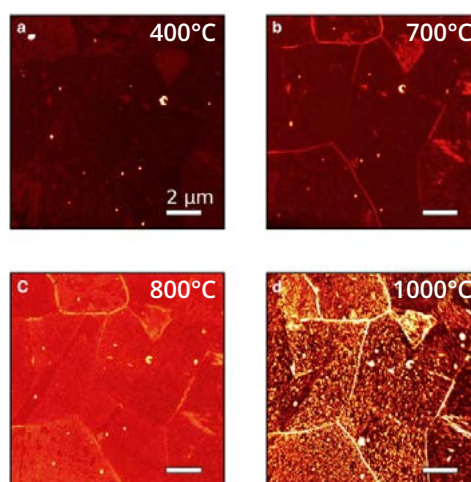
As part of a long-standing working relationship, Alfa Laval and Lund University partnered to investigate and characterise a promising stainless-steel material for heat exchangers.

Alfa Laval is a global company in the area of heat transfer, separation and fluid handling. One of their largest product groups are heat exchangers, which are an essential component within many renewable energy applications. Heat exchangers are manufactured from stacks of plates joined together through a vacuum diffusion bonding process, but not all alloys are suitable for this.

The 321-grade stainless steel was imaged in situ at the MAXPEEM beamline, in collaboration with beamline scientist Alexei Zakharov, at various bonding temperatures to assess the microstructure evolution. Alfa Laval, along with other partners have previously developed a sample environment to mimic the heating settings used during their bonding process. This equipment is now available for all users at MAX IV.

The experiment showed a migration of small amounts of titanium (Ti) from the bulk material at 400°C to large precipitates covering the surface when heated to 1000°C. Such precipitates would lead to poor bonding, resulting in low mechanical properties of the material. The powerful instruments at MAX IV were required to obtain high resolution of these microstructures.

Surface chemistry measurements at the Flex-PES beamline were conducted in collaboration with beamline scientist Alexei Preobrajenski to confirm that the particles were already present in the sample before heating.



X-ray absorption spectroscopy-photoemission electron microscopy (XAS-PEEM) images at the Ti L-edge on a steel surface at four different temperatures using the MAXPEEM beamline.

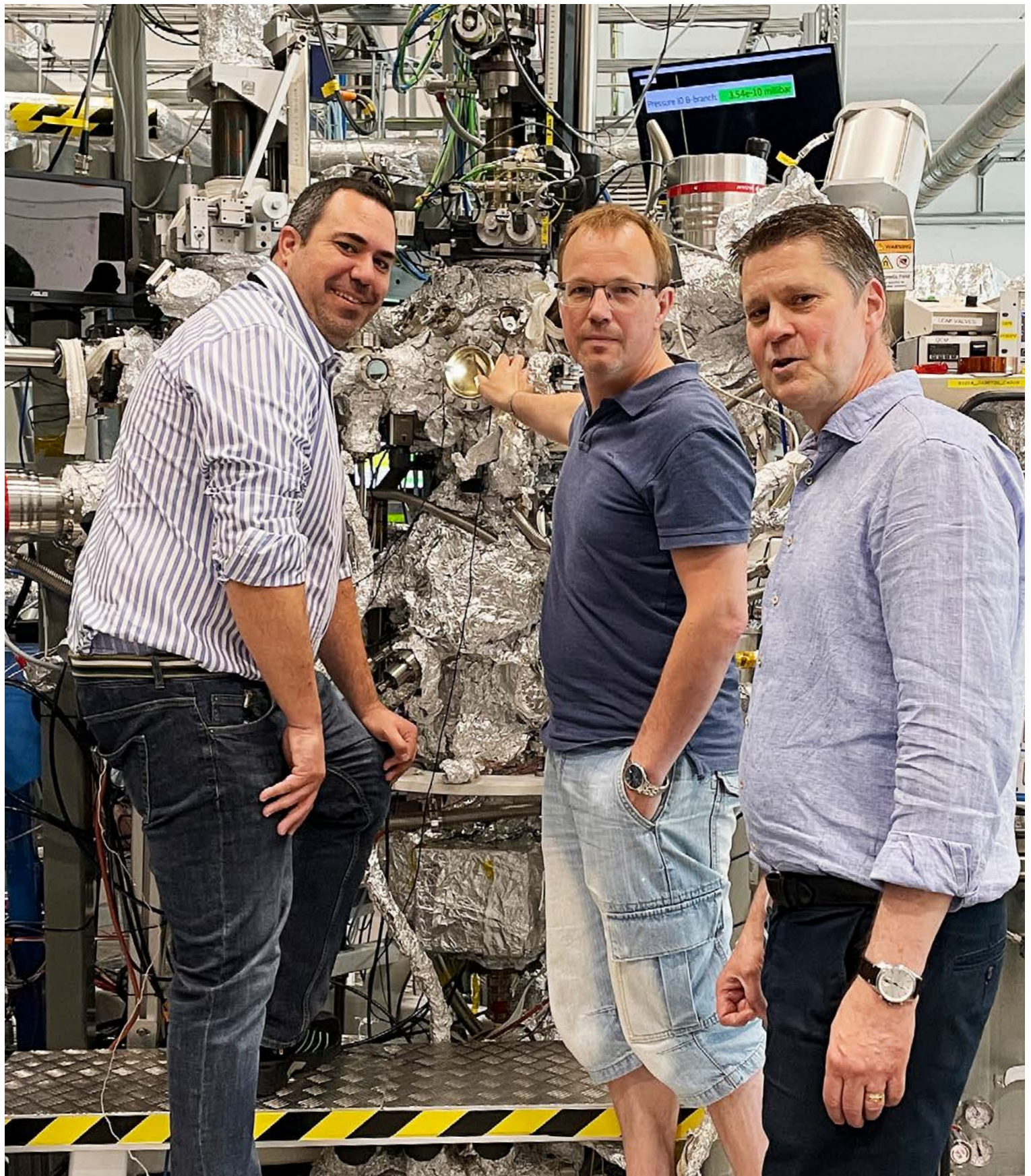
Complimentary measurements were conducted to determine the elemental composition of the material. The findings equipped the academic partners with knowledge about the mechanism of action and the industrial partners with information about changes they would need to employ to use this material in the future.



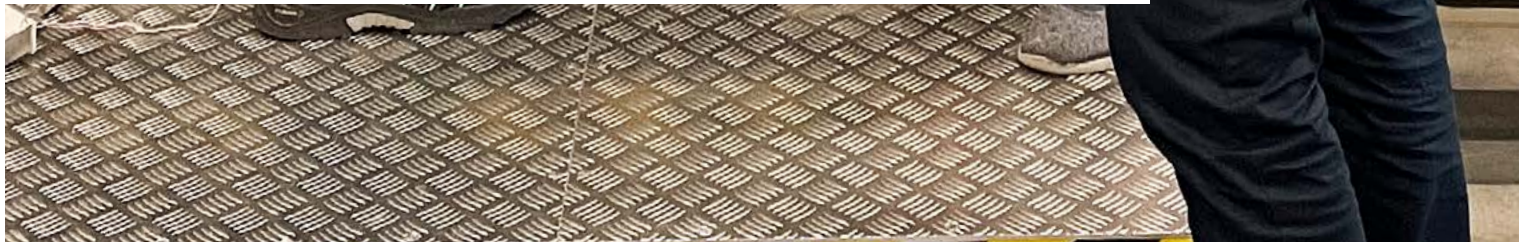
Publication

I. Lazar et al. Diffusion Bonding 321-Grade Stainless Steel: Failure and Multimodal Characterization. *Microscopy and Microanalysis*, Volume 30, Issue 2, April 2024, Pages 192–199.

DOI: [10.1093/mam/ozae019](https://doi.org/10.1093/mam/ozae019)



INDUSTRY USER CASE





INDUSTRY INTERVIEW

Through academic collaborations, the industry can access MAX IV free of charge via a peer-reviewed process and publish their findings. We spoke with Hector Pous Romero and Magnus Fredriksson from Alfa Laval about their experience using this access route.

How did the collaboration between Alfa Laval and Lund University (LU) arise?

HPR: Alfa Laval has a long-standing collaboration with LU, which has involved multiple projects and shared students. Although Alfa Laval can conduct the experiments (along with the academic partners), the academic partners have the time and capabilities required for data analysis.

Were there any hurdles to overcome?

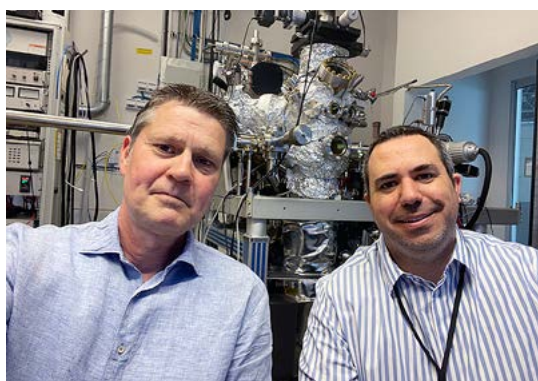
HPR: Having correctly prepared samples required more time and expertise than expected and enough samples for extensive calibration and experimentation.

Were there any unexpected outcomes?

HPR & MF: Unfortunately, the titanium migration means that we cannot use this material unless we change our bonding process or work with less titanium. In the long term, we will save time by avoiding other investigations using material of this composition.

What advice would you give other industries considering this access route?

HPR & MF: It is important to have an open relationship with trust between the parties, where the purpose and goals are clearly defined. Involve the MAX IV beamline staff in your discussions, as they are interested in the scientific challenges and know what is feasible.



Magnus Fredriksson (Program Manager, Alfa Laval and at the Industrial Relations Office, MAX IV) and Hector Pous Romero (Material Specialist, Alfa Laval) at MAX IV.

How does your position at Alfa Laval and the Industrial Relations Office at MAX IV benefit both parties?

MF: Being physically located at both places allows me to learn about the techniques, share knowledge and connect with people. Being part of the MAX IV staff provides a unique position to work closely with the experts, build relations, and, as a result, get connected to the relevant communities – a definite success factor. I can act as an enabler and bridge between not only MAX IV and Alfa Laval but also between other companies and infrastructures, including synchrotron and neutron facilities.

"The more relationships we have, the more trust there is, the easier it is, and the more creative ideas arise"

Hector Pous Romero, Material Specialist, Alfa Laval



ACCESS ROUTES

Several support schemes are available on both European and national levels, and MAX IV actively participates in several projects to further strengthen industry use of the facility.

LEAPS-Innov (The League of European Accelerator-based Photon Sources) is a project dedicated to Industry and Innovation within a consortium of 19 light sources called LEAPS. This project enables technology development between industry and European light sources and provides a dedicated funding scheme for industrial access for Small and Medium-sized Enterprises (SME). To date, LEAPS-Innov has funded 26 SME projects involving beamtime at European facilities, with MAX IV involved in one project last year.

ReMade@ARI (Recyclable Materials Development at Analytical Research Infrastructures) focuses on the circular economy. It is a European hub for materials research, providing access to a wide range of advanced analytical tools, including MAX IV. There are two available access programs for industry: transnational access for SMEs and joint access for Industries of any size with a knowl-

edge provider. MAX IV Industrial Relations Office is part of a network of experts that will guide companies to the right infrastructure.

HALRIC (The Hanseatic Life Science Research Consortium) is a recently established project enabling cross-border collaboration by providing pilot project funding for the project parties, enabling collaborations with life science industry and health care. The focus is on collaboration, which is a great opportunity for the industry to team up with other partners and utilise more than one infrastructure. The calls are ongoing and 2023 saw four approved projects involving MAX IV.

Vinnova (Sweden's Innovation Agency) funds pilot and development projects using large-scale research infrastructures. New calls have been open on various occasions over the last six years.



www.leaps-innov.eu



halric.eu



remade-project.eu



www.vinnova.se



As part of its strategy to engage with industry, MAX IV works with many external partners to boost the industrial use of its facilities.

Metalbeams focuses on increasing the use of MAX IV and other large-scale research infrastructures in the metal and engineering sectors. This year, the industrial relations office arranged a 2-day workshop at MAX IV. Participants from academia, institutes, and eight companies attended lectures and a hands-on experiment on in-situ corrosion at the HIPPIE beamline.

InfraLife aims to maximise the benefits of MAX IV, ESS, and SciLifeLab by increasing knowledge and accessibility for life science researchers. The industry organisations LIF and SwedenBio are partners in the project. In 2023, connections between these infrastructures were strengthened through dialogues on Imaging, Data Management, and Environment. InfraLife's website features industry case stories and presentations on life science capabilities at these large-scale facilities. Through the project we strive to connect people, stimulate collaboration, host seminars, and promote the use of the facilities.



www.metalbeams.se



InfraLife

www.infralife.se





COLLABORATION

The **MAXESS Industry Arena** is a platform where the industry can find more information about possibilities available at synchrotron and neutron facilities. The platform hosts a Find Partner feature consisting of nearly 100 collaboration partners and showcases stories of industrial use of MAX IV. The EU-funded MAXESS-SmiLe project concluded in 2023 with a number of company projects within life science. The MAXESS platform remains active and is an ideal space for industries to find partners for their research and development needs.

MAX IV is one of 18 partners in **NextBioForm**, a centre for the formulation and processing of biologics. The other partners include institutes, academic institutions, hospitals, and industry partners in the biopharmaceutical and biotech sectors. One of the focuses at NextBioForm is using MAX IV to develop new characterisation methods for industrial formulation research.

MAXESS
INDUSTRY ARENA

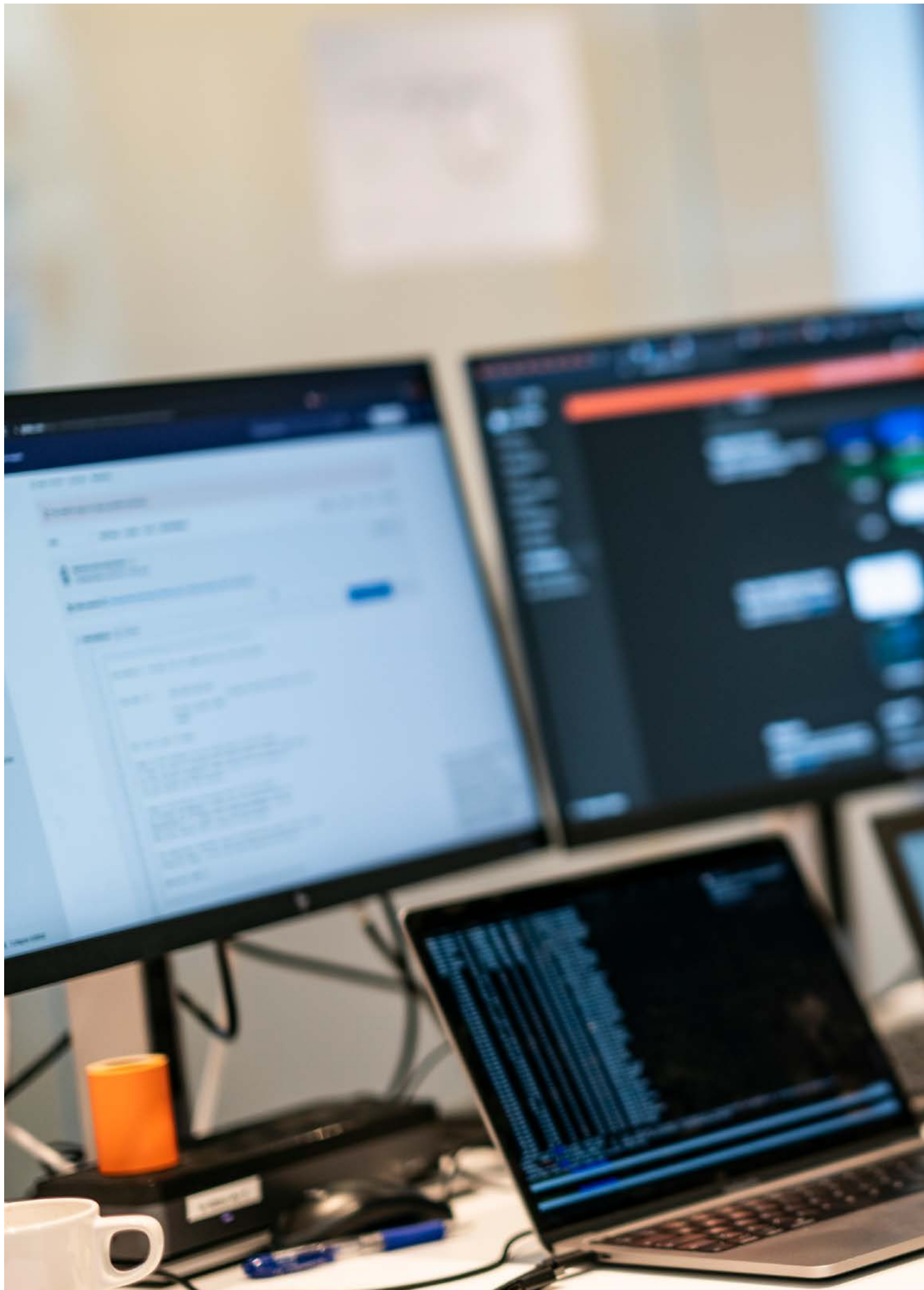
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NextBioForm

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