

WISE DIALOGUE – MARCH 2025

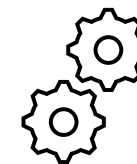
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# MAX IV – Facilitating innovation for sustainability

Olof “Charlie” Karis, MAX IV Director



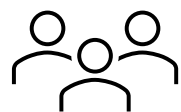
Industry opportunities and needs



Method development



Successful experiments –  
knowledge to develop product



Inspiring new  
industry users

# Materials research is a team sport!

## This is MAX IV

- A Swedish, national laboratory for X-ray research with Lund University as host
- A fourth-generation light source – up to 100 times brighter than the earlier generation and highly coherent
- Available for academic and industrial users worldwide

MAX IV

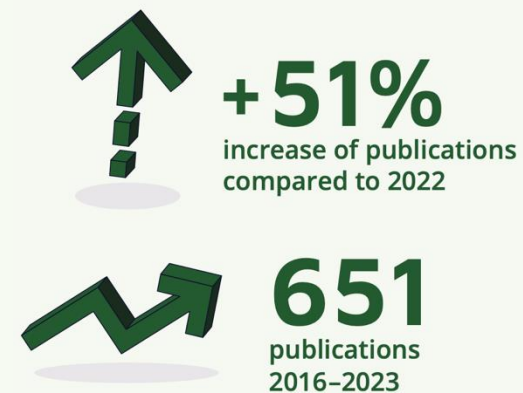
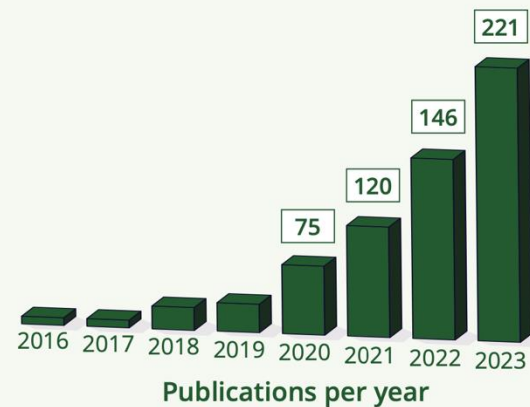


# 2024 beats 2023 and is the best year so far for MAX IV

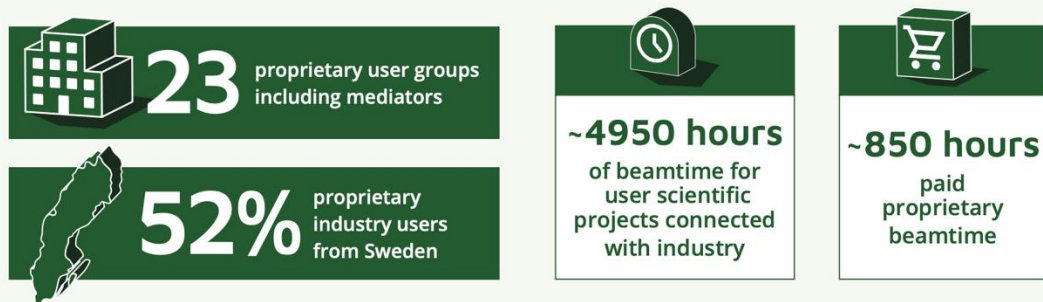
## USERS



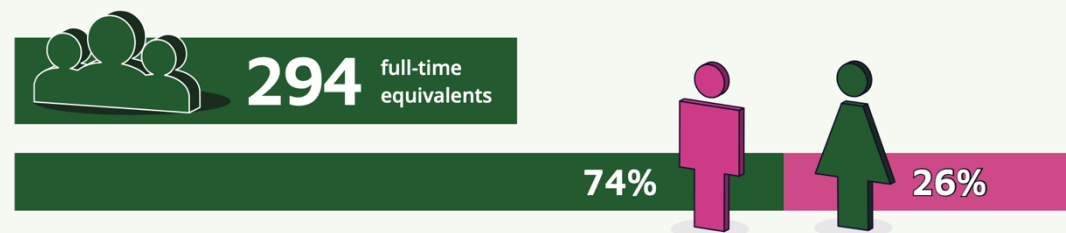
## PUBLICATIONS



## INDUSTRY



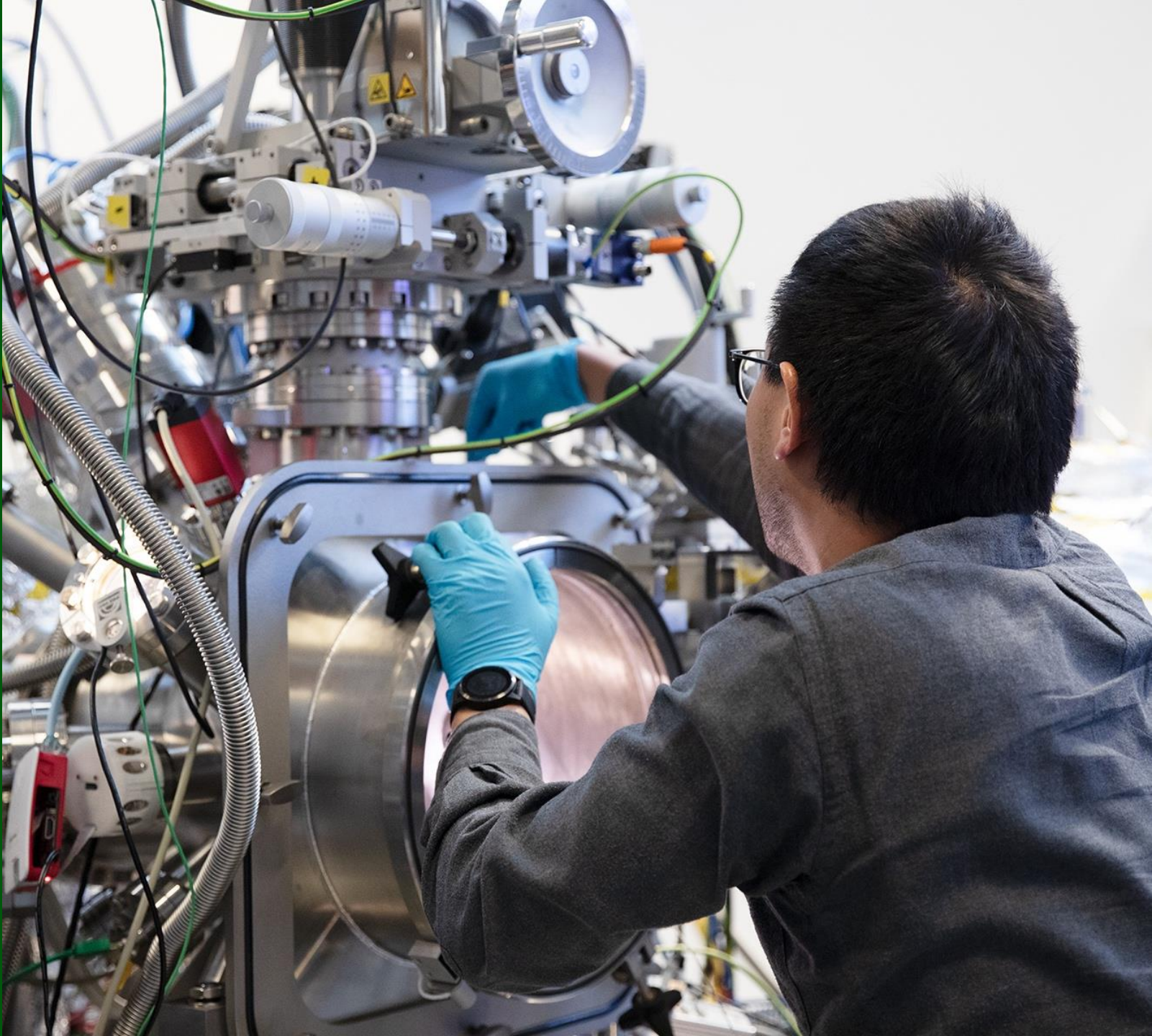
## EMPLOYEES



## 16 beamlines

- Specialised techniques for studies of material properties – structure, chemistry, electronic, magnetic
- The intense MAX IV light allows for experiments under more realistic conditions – better time resolution, dynamics, realistic gas pressures, etc.
- Focus on in-situ/operando experiments and combining methods (multi-modal)

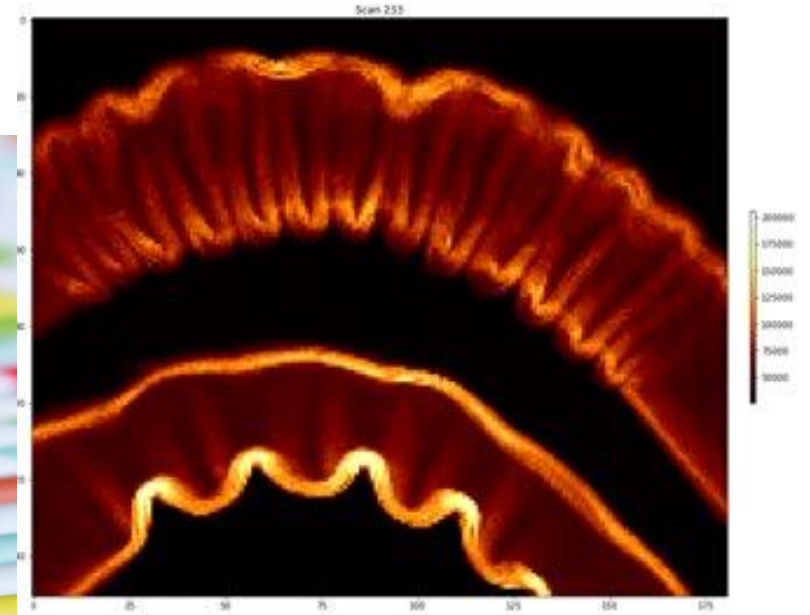
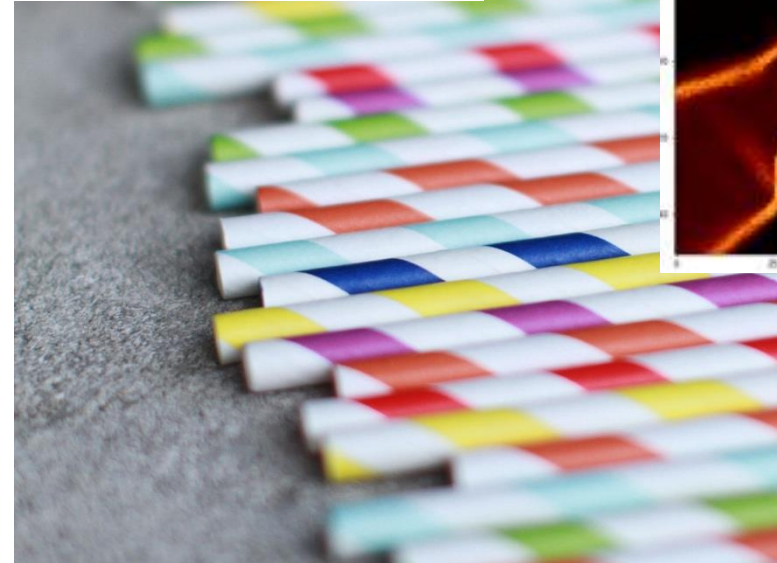
MAX IV



# Circular and sustainable materials – Tetra Pak

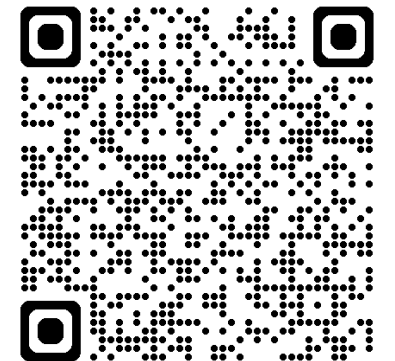


Image: Elin Persson Jutemar and Eskil Andreasson, Tetra Pak, in the ForMAX sample preparation lab at MAX IV. Credit: Anna Sandahl/MAX IV



- Tetra Pak investigating the properties of paper straws
- Fast study to product turnover

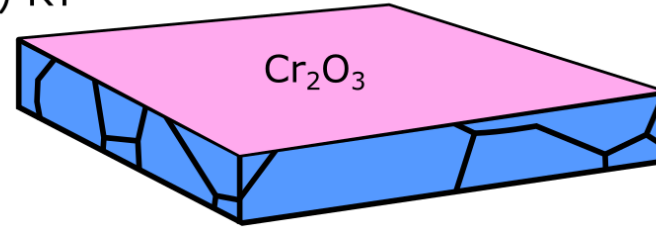
Read the science highlight at [maxiv.se](https://maxiv.se)



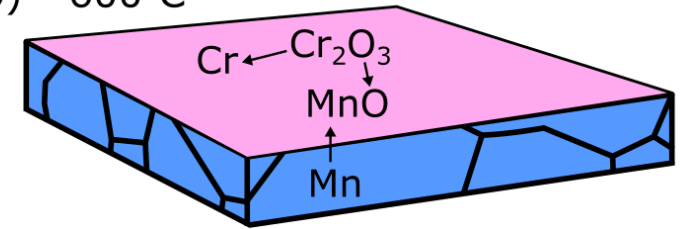
# Properties of stainless steel – Alfa Laval

Protective surface oxide layer of Stainless Steel

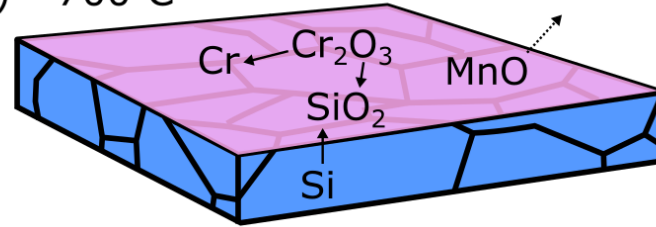
a) RT



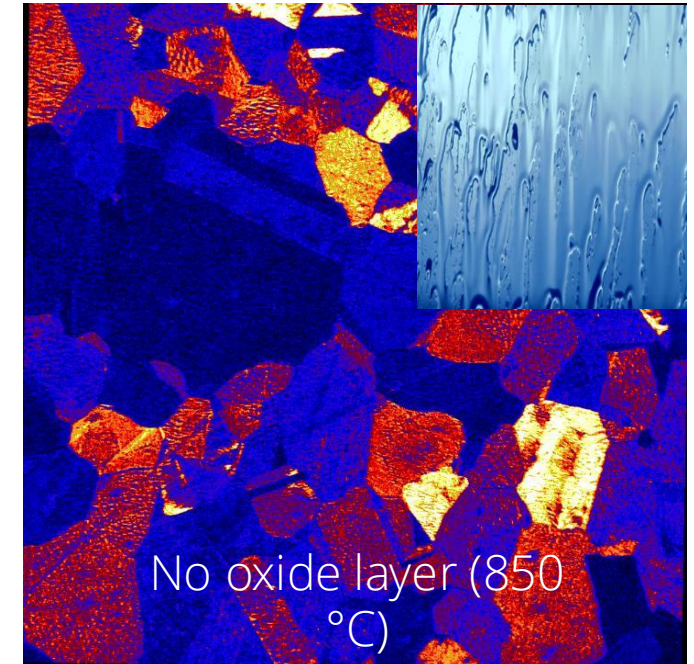
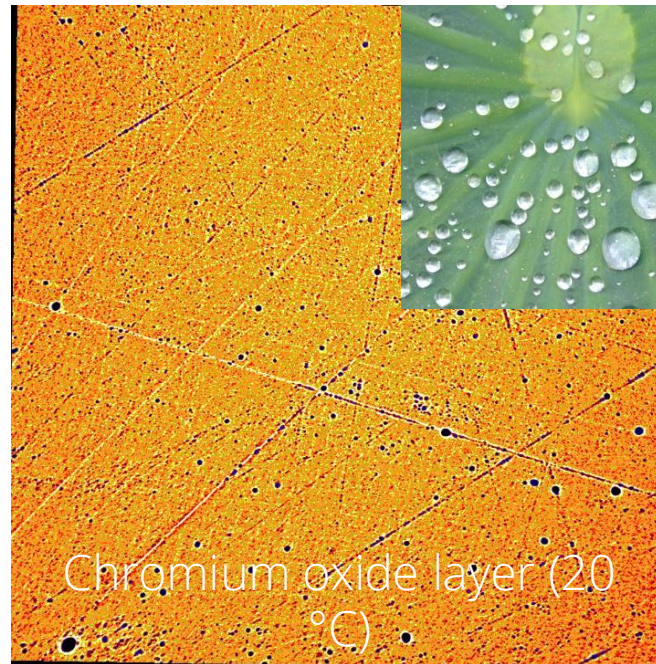
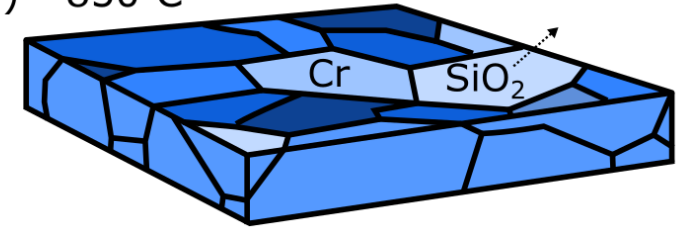
b)  $\sim 600^\circ\text{C}$



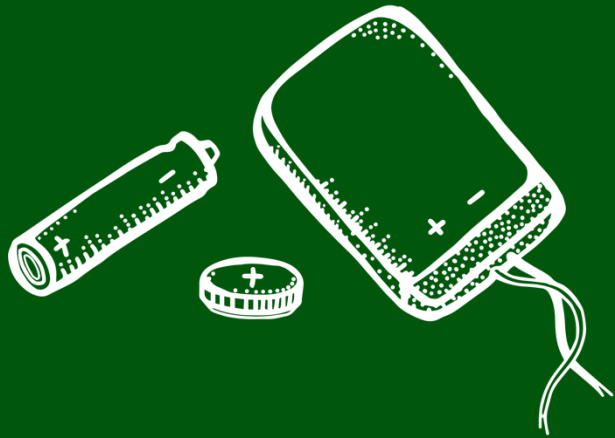
c)  $\sim 700^\circ\text{C}$



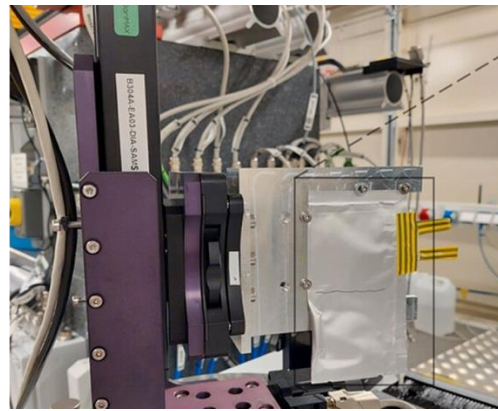
d)  $\sim 850^\circ\text{C}$



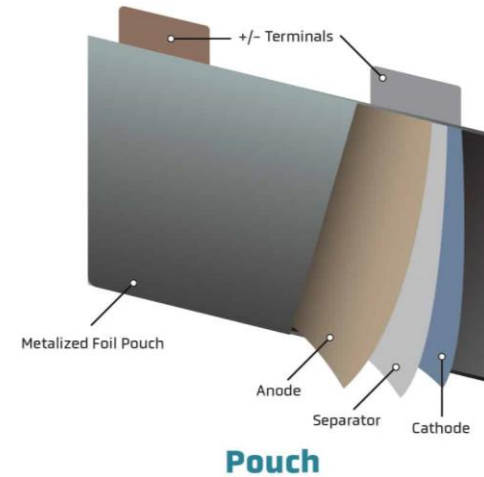
# Revealing the challenges of fast charging batteries



MAXIV

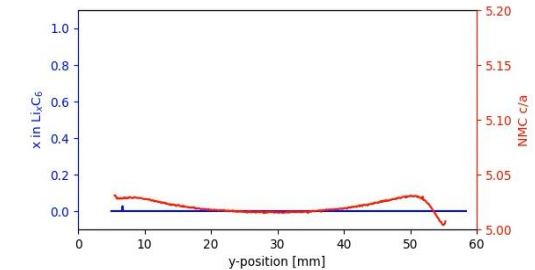
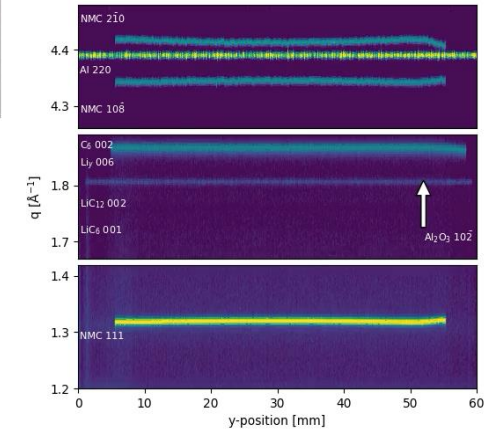
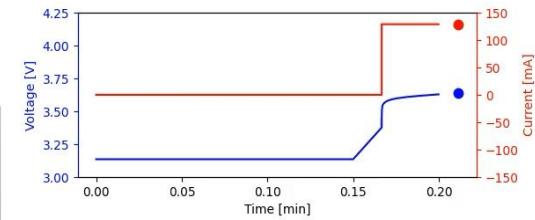


Cathode: NMC  
=  $\text{LiNi}_{1/3}\text{Mn}_{1/3}\text{Co}_{1/3}\text{O}_2$   
Anode: Graphite  
Separator: CC-PET fabric  
+ electrolyte



- Fast charging (3C) leads to inhomogenities during charge/discharge-cycling → not all the cell is utilized properly.
- Application of method to commercial cells:
  - check at what charge rate does the inhomogenities become unacceptable.
  - evaluate local increased resistance can lead to heating.

Fast charging  
(3C = three times faster):



Read the article  
D. R. Sørensen, R. Gordon, A. Smith, I. Kantor, M. Ry Vogel Jørgensen, Chem. Mater. 36 (2024) 1 0871

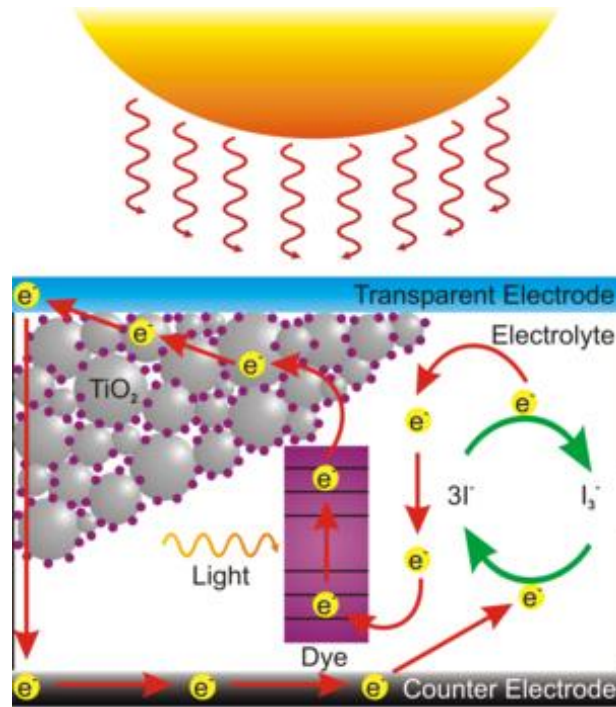




# Flexible solar cells – Exeger

***“To use analysis equipment compatible with industrial samples is key in developing manufacturing techniques”***  
*/Sven Södergren, EXEGER*

MAXIV



Follow and optimise the dye sensitization method

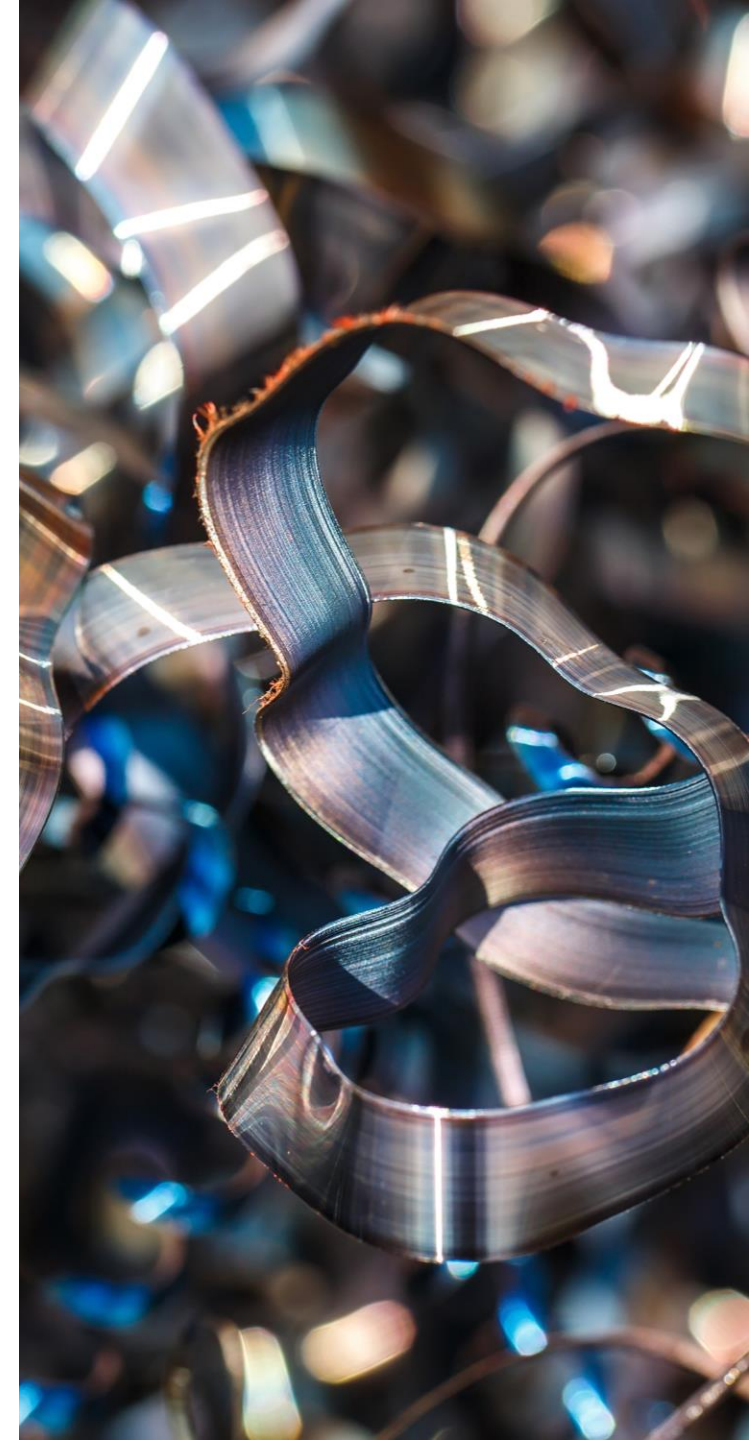
Effect of contact with electrolyte



# The future

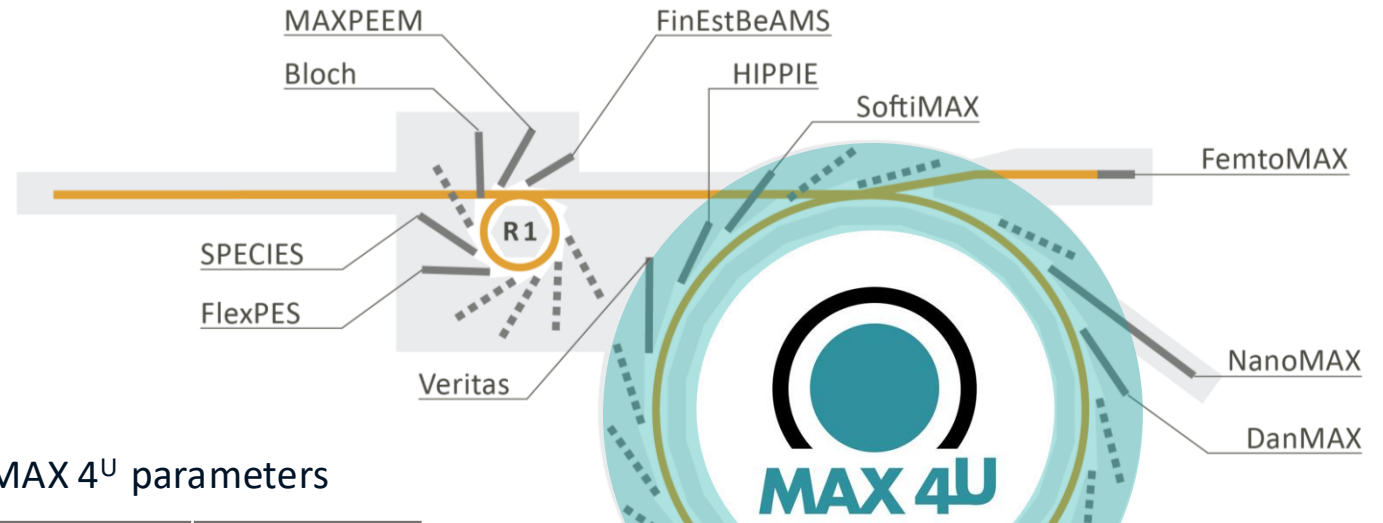
## Towards a circular flow

- How can we maintain the high value of recycled materials?
- By understanding potential value lowering processes!
- Knowledge from X-ray analysis of structure, chemistry etc.
- Change the parameters of the recycling process



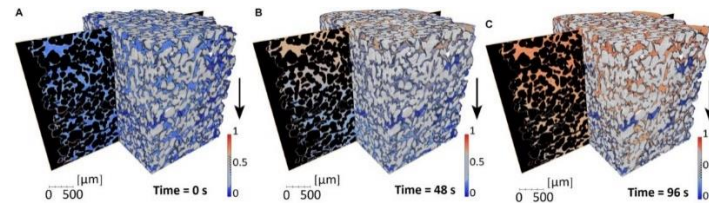
# Looking forward

- MAX 4U accelerator upgrade
- Materials science beamlines in partnership with WISE
  - An imaging beamline supporting materials science for sustainability
  - A spectroscopy beamline supporting materials science for sustainability
- A medical imaging beamline

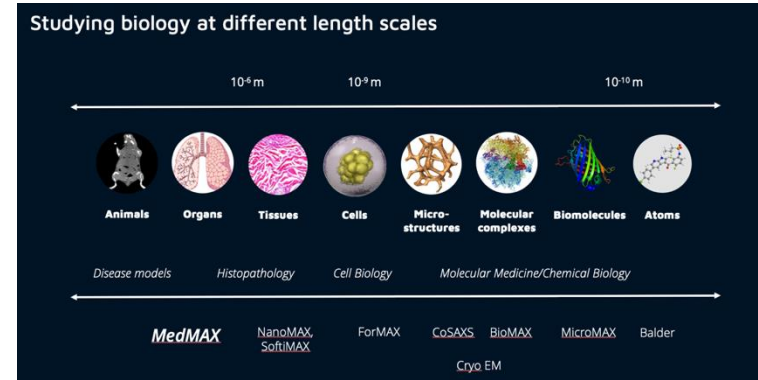


MAX 4U parameters

Parameter	Value
Energy	3 GeV
Circumference	528 m
Bare Lattice Emittance	<b>&lt; 100 pmrad</b>

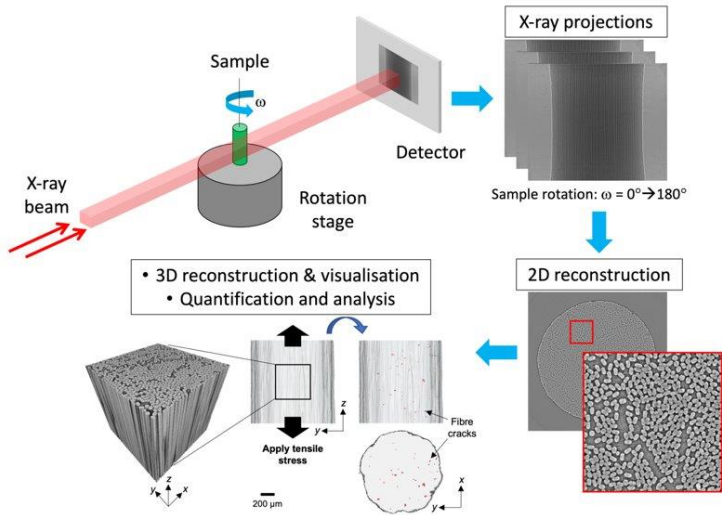


4D tomography time series showing solute transport at the pore scale (Marone et al., Front. Earth Sci., 2020)



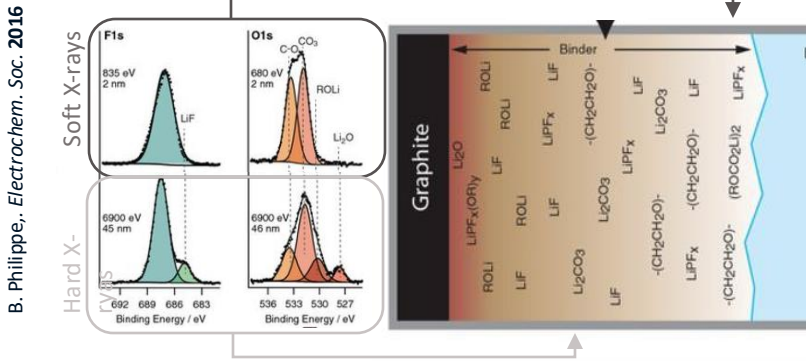
# MAX IV – WISE Beamline Design

WISE funded development of 3 conceptual design reports in 2023.  
 2 proposed beamlines were selected to continue with technical design reports (TDRs).  
 Timeline: TDRs finished March 2025. Aim to open for first users 2029.



A dedicated **tomography** beamline enabling 4D imaging of materials with high spatial and temporal resolution.

## Depth-dependent chemical composition of battery's solid-electrolyte interphase



A HArD X-ray PhotoElectron Spectroscopy (**HAXPES**) beamline for chemical characterization of buried interfaces



TDRs funded by



Wallenberg Initiative  
 Materials Science  
 for Sustainability

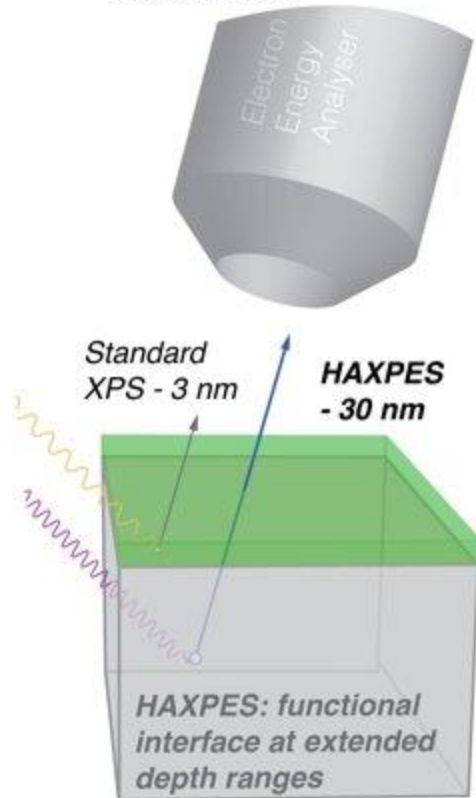


# SpectroWISE Beamline – Science case

## Operando and *in situ* studies of functional interfaces:

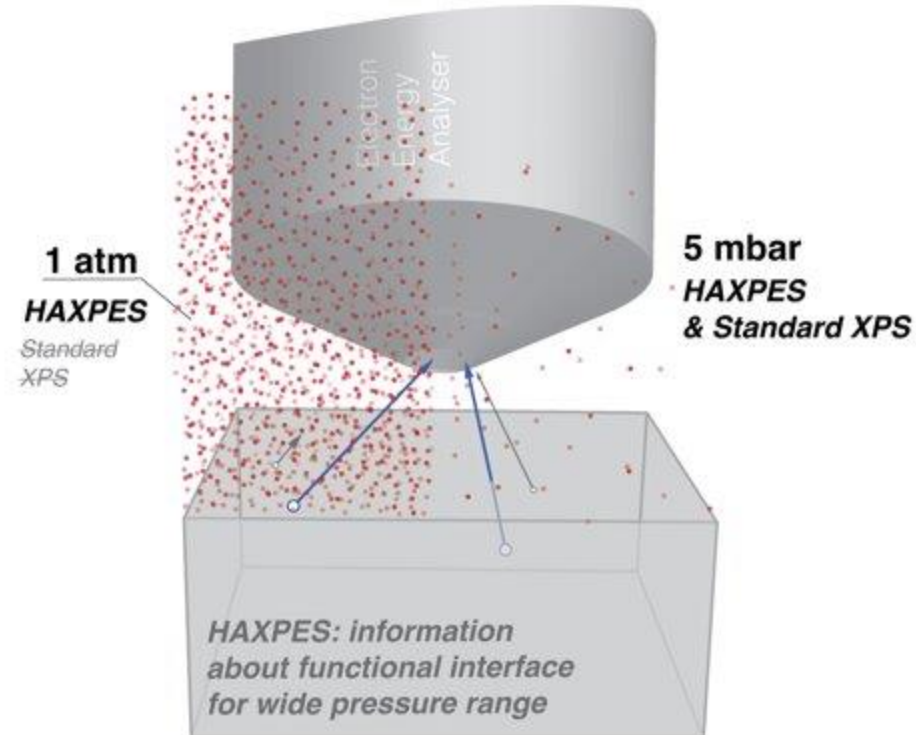
### Solid - solid

E.g. high throughput operando solar cells, and advanced electronics



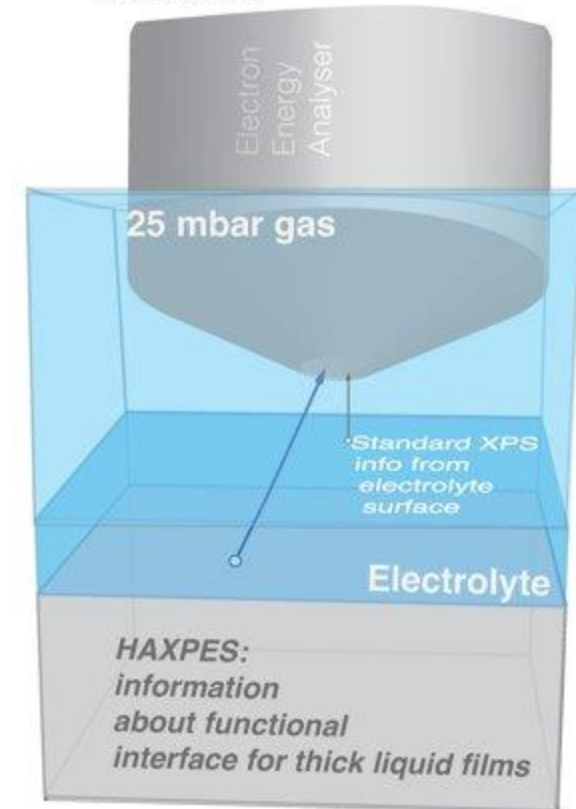
### Solid - gas

E.g. catalysis, corrosion, fuel cells, H<sub>2</sub> storage, extreme temp. conditions

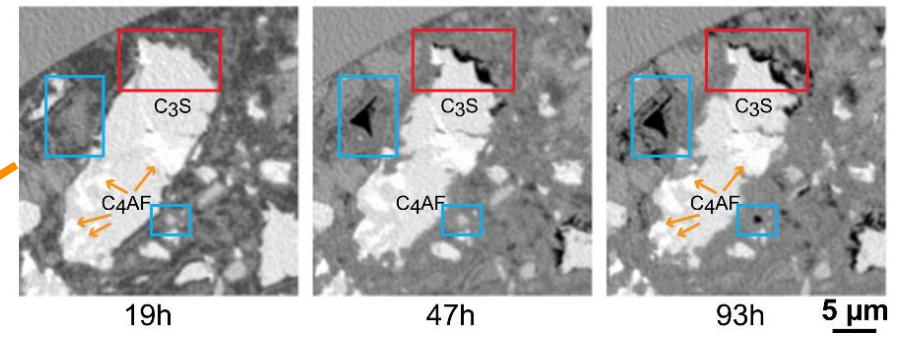
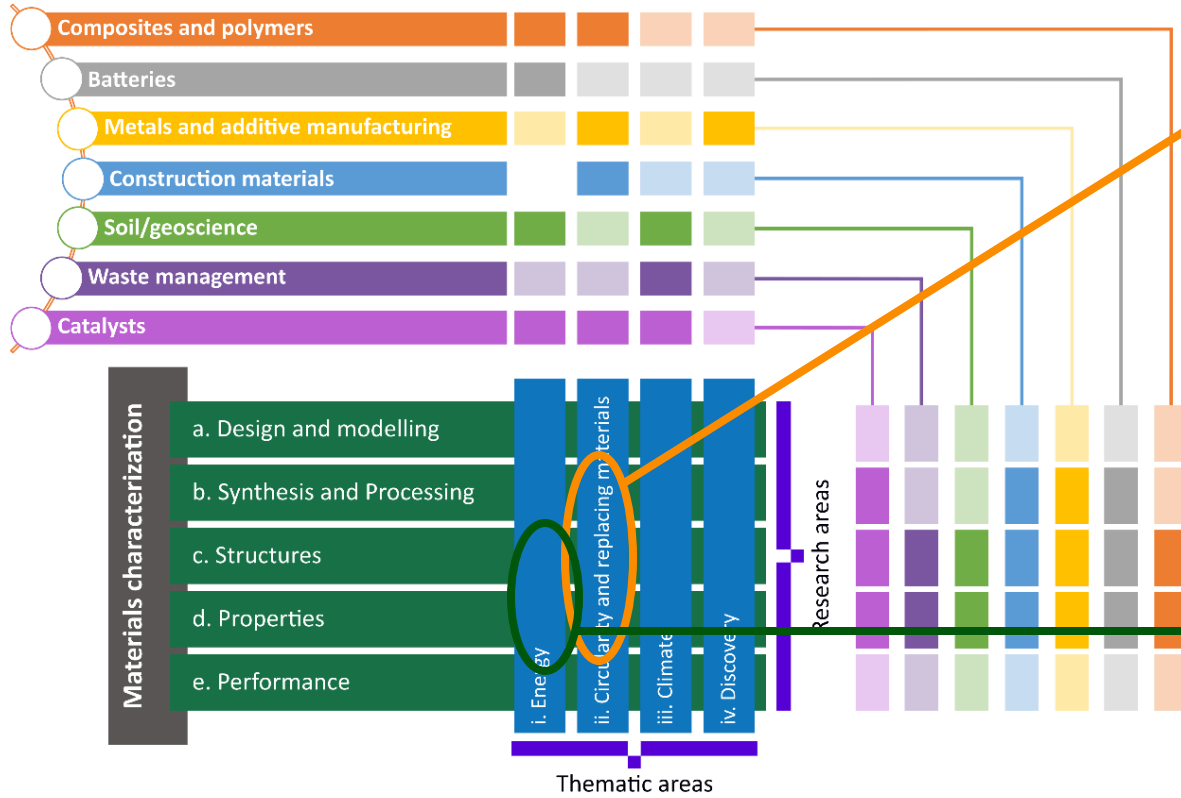


### Solid - liquid

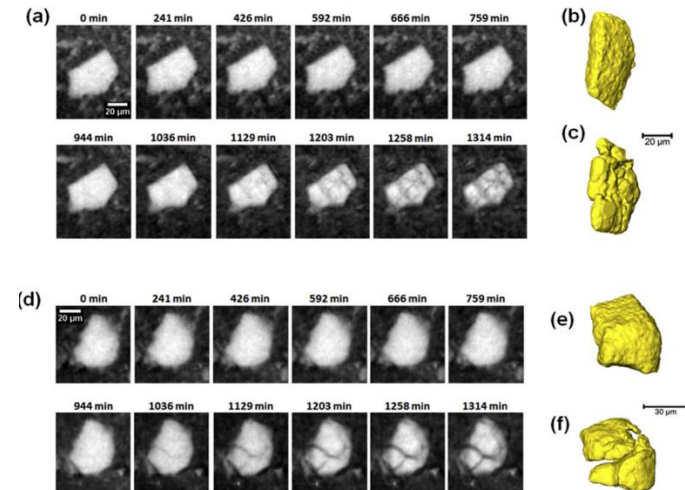
E.g. batteries, corrosion, electrocatalysis, harsh conditions



# TomoWISE – Science Cases



Hydration of Portland cement studied with deep sub- $\mu\text{m}$  resolution measured at the Swiss Light Source. TomoWISE will be able to perform similar measurements 100 times faster, giving access to the early stages of hydration [Nat. Commun. 14 (2023), 2652].



Crack propagation in nanoparticles of the Si electrode of a Li-ion battery measured during lithiation. Similar studies will be possible to do with higher spatial and temporal resolution at TomoWISE [J. Power Sources 342 (2017) 904–912].

## What it means for industry

- Study raw materials behaviour and properties at **unprecedented resolution**
- Enable radical **product optimisation**
- Improve **manufacturing processes**
- Obtain **input and data** for computational modelling, patents, marketing, etc.
- Gain new insights – **transform and accelerate** your business





## Two ways to become a user



- ✓ Free
- ✓ Apply for experiment time (2 open calls/year)
- ✓ Collaborate with an academic research partner
- ✓ Proposals ranked on scientific merit
- ✓ Publish your results



- ✓ Paid
- ✓ Faster, industry-tailored access
- ✓ Full confidentiality and IP rights
- ✓ One time project or long-term framework agreement
- ✓ You own your results



**MAGNUS LARSSON**  
Head of Industrial Relations



**MARC OBIOLS-RABASA**  
Industrial Relations Officer



**MARYAM OLSSON**  
Research and communications  
coordinator



**MAGNUS FREDRIKSSON**  
Program Manager (Alfa Laval)



**CLAIRE LYONS**  
Project Coordinator InfraLife

Contact the  
industry office

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The image features the MAXIV logo in white, centered against a dark background. The logo consists of the letters 'M', 'A', 'X', 'I', and 'V' in a stylized, blocky font. A thin, white, curved line arches over the letters 'A' and 'X'. The background is filled with numerous diagonal streaks of light in shades of blue, purple, and orange, creating a sense of motion and energy.

MAXIV