



## MAX IV User Meeting

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## MAX IV User Meeting

The thirtieth user meeting in the history of MAX-lab and MAX IV was held on September 24–26, 2018, in Lund, Sweden. It marked a unique point in time for the laboratory; 2018 saw the first presentations by MAX IV users, and the first thesis and poster awards for work performed on MAX IV instruments. The shutdown of the old MAX-lab in 2015 was followed by a period without regular user operation while the new facility was in construction. MAX IV is now in transition from a project into the complex reality of an operating scientific facility for users, while building new beamlines for many years to come.

### Status of MAX IV

Opening the user meeting, interim director Ian McNulty met a curious audience of 303 users, collaborators, exhibitors, and staff. Ian had been appointed interim director only a few weeks earlier, coming from Argonne. He started by briefly outlining the status: the three accelerators are running with a performance well within expectations, three beamlines are receiving general users, and several more beamlines are on the brink of getting ready for users. “Let me address the elephant in the room,” Ian continued. “We are delayed in delivering beamlines to users compared to what we have communicated earlier. This has, and rightfully so, led to criticism from users and funders. Addressing these concerns will take time, and the lab will need your patience and help with this. None of the criticism, however, was about the quality of the immense work that people at the lab have put into MAX IV or about the quality of the product of the work.” On this positive note, the meeting then turned to status reports on the MAX IV accelerators and beamlines.

Pedro Fernandes Tavares, machine director, reported that the seven-bend achromat-based 3 GeV ring, the world’s first MBA, has been operating with up to 190 mA in top-up delivery and 400 mA in studies. During 2018, reliability was 97%. At press time, 4285 h of

beam delivery to beamlines was scheduled for 2018. Although a fast orbit feedback system is still to be implemented, passive stability of the accelerator is unprecedented. Integrated up to 100 Hz, perturbations are about 1.3% rms of the beam size horizontally and 5.5% rms vertically. A recent significant achievement was the successful operation of the first prototype of a multipole injection kicker, developed in collaboration with SOLEIL. This device already performs well enough to be used routinely, reducing perturbations by a factor of 60 compared to the dipole injection kicker used before. Top-up injections with the multipole injection perturb the beam position horizontally by  $\pm 13 \mu\text{m}$  and vertically by  $\pm 8 \mu\text{m}$ . Still, beamlines can see the injections, and a next version of the multipole injection kicker, manufactured to tighter tolerances, is scheduled for installation during the summer of 2019. Pedro also reported good news from the second, smaller storage ring that MAX IV operates, the 1.5 GeV DBA ring. This machine operates top-up routinely with 150 mA delivered to beamlines and has demonstrated 500 mA stored current in studies. Finally, the 3.4 GeV linac of the MAX IV facility works reliably as a full energy injector and as a source for the short pulse facility (SPF) delivering

light to the FemtoMAX beamline. Linac operation is limited to 2 Hz by the current radiological safety permit; however, MAX IV aims to increase the repetition rate to as high as 100 Hz in the future.

Marjolein Thunnissen, new life science director, gave the third of three management updates at the user meeting with a report on the beamlines and science. Marjolein has been part of MAX-lab and MAX IV for many years. After discussing the overall priorities for beamline development at MAX IV, she highlighted several early results achieved with photons at the new facility. NanoMAX, the hard X-ray nano-imaging beamline, obtained measurements of its nano-focused X-ray beam down to 40 nm FWHM and in-situ electrochemistry measurements on single nanoparticles. At the BioMAX protein crystallography beamline, the sample changer is now going into routine operation, and a first serial crystallography measurement was successfully performed on Cytochrome C oxidase (Gisela Brandén, Gothenburg University, and Ilme Schlichting, MPI Heidelberg, Germany), measuring 20 to 50 crystals per second and collecting a total of 20 TB data from just three proteins. The final example was from the BLOCH beamline for soft X-ray angle-resolved photoemission



The MAX IV User Meeting featured a lively poster session.



Poster and thesis winners and presenters (left to right): Niclas Johansson, Ian McNulty, Marjolein Thunnissen, and Isabella Silva Barreto.

experiments. The analyzer at BLOCH enables measuring 3D Fermi maps without moving the sample or having to make consecutive measurements, showing exceptionally well-resolved Dirac cones. In addition to these exciting results, Marjolein highlighted the first user publications from MAX IV. She concluded by reporting that, during the first 18 months of operation, MAX IV had 391 general user visits based on 54 accepted proposals, not to mention the substantial number of expert users who helped to commission the beamlines and endstations.

The highlight of the opening session was the keynote given by Steve Kevan, ALS director, who shared exciting looks into a future of science enabled by the ALS-U. He presented new opportunities opened up by the emerging class of (near) diffraction-limited storage rings. Steve presented cross-cutting science challenges, and urged the audience to not think of the upcoming capabilities merely as isolated tools, but rather as a suite of instruments that in combination make new science possible, addressing multiple properties of matter over a large range of length and time scales.

### An active user community

The afternoon ended with an overview of the activities of the Swedish and European user associations SSUO and ESUO, the traditional meeting of the MAX IV user organization FASM, as well as a presentation of an ongoing survey of the Swedish needs for X-ray and neutron science performed by the Swedish Research Council. A new board for FASM was elected, and it was encouraging to see many first timers becoming active for user interests. The board consists of: Jonas Weissenrieder (Chair, KTH Royal Institute of Technology), Maria Hahlin (Uppsala University), Leila Lo Leggio (Copenhagen University), German Salazar Alvarez (Stockholm University), Jonas Sellberg (KTH Royal Technical Institute), Rainer Timm (Lund University), and Minna Patanen (University of Oulu).

The evening featured the traditional mingling and poster session. A number of posters showed collaboration projects between the user community and MAX IV. One example of such a collaboration framework is the agreement with Chalmers University of Technology in Gothenburg. Project examples include the development of a mechanical nanomanipula-

tion sample environment and in-situ transport measurements combined with spectroscopy. The first posters from regular user experiments performed at MAX IV were presented. One of those was awarded the student poster award sponsored by SPECS Surface Nano Analysis GmbH: Isabella Silva Barreto (Lund University) presented a study of mineralization in developing long bones of embryonic mice, performed with XRF and WAXS at the NanoMAX beamline. A recent thesis related to MAX IV was also awarded a prize during the user meeting: Niclas Johansson's (Lund University) thesis focused on "Synchrotron-based in situ electron spectroscopy applied to oxide formation and catalysis," work performed at the SPECIES endstation for ambient pressure XPS.

### Parallel scientific sessions

The second day was dedicated to parallel scientific sessions. "Imaging Today" highlighted first user results from the NanoMAX beamline. Marcus Osterhoff (Göttingen University) reported that his group had earlier established X-ray propagation-based holography by filtering the coherent fraction at third-generation light sources with waveguide optics. At NanoMAX, they could now demonstrate how a clean wavefront is achieved in the nano focus of the standard KB system, allowing for holography in the unfiltered beam with shorter acquisition times. Vincent Jacques (University Paris Orsay) showed first nanodiffraction results obtained from charge-density-wave systems at MAX IV.

The second part of the imaging session provided a look into the future, with emphasis on data handling. Filipe Maia (Uppsala University), among other speakers, addressed the "Opportunities and Challenges in the Era of Superluminous Lightsources." A session dedicated to new opportunities enabled only at sources with extremely high coherence covered a range of topics. Steve Kevan followed up on his plenary and talked about "Fast Time Correlation Soft X-ray XPCS." Another talk was on the rather novel concept of ghost imaging (Young Yong Kim, DESY, Germany). Scattering and diffraction techniques will be developed at several upcoming beamlines at MAX IV. A session dedicated to these tech-



niques spanned a wider range of applications from “Chemistry Beyond the Crystal” (Simon A. J. Kimber, Dijon, France) to the investigation of protective tool coatings (Jens Birch, Linköping University). Amelie Jarnac (Synchrotron SOLEIL, France) presented the first demonstration of sub-ps time-resolved XRD measurements performed at the FemtoMAX beamline. A large number of speakers from the user community and several synchrotrons from Europe and the US presented current developments in serial crystallography. The session was connected to the MicroMAX beamline project, which recently received funding from the Novo Nordisk Foundation. Here, Gisela Brandén gave a more in-depth account on serial crystallography. Other sessions dealt with spectroscopy and with industry partnerships.

### MAX IV in a regional, national, and Nordic environment

The last day of the user meeting was opened with a presentation by Ian McNulty, who on stage literally switched hats to show that he now speaks in his capacity as physical science director (on leave). He presented various ideas on how to utilize the unique coherent properties of the MAX IV source, in a combination of existing or already planned and added capabilities. Following up on Steve Kevan’s theme, Ian saw large potential in enabling science with combinations of beamlines and methods. As part of more “crazy” approaches possible, Ian suggesting thinking about how the unprecedentedly high-photon degeneracy of the MAX IV beam could be utilized. For MAX IV, 16 beamlines are currently defined and funded, which is somewhere between one-half and two-thirds of the full capacity of the facility. In this way, a large fraction of the beamline program is already defined. Ian called for a careful process in re-

fining the program for the next suite of beamlines. He asked the community to consider how new instruments can make the best use of the unique capabilities of the MAX IV MBA and other accelerators, helping the Swedish and Nordic community to reach and maintain a leading position in the field.

The meeting ended with an exciting look into the regional, national, and Nordic environment forming around MAX IV. The audience heard about the current status of the European Spallation Source ERIC, ESS, and Ulrich Lienert (DESY, Hamburg) gave an update on the Swedish Materials Science Beamline at PETRA III. Finally, the outcome report of the SWEbeams initiative was presented. Fredrik Hörstedt (Chalmers University of Technology) summarized the process, in which the needs and potential of Swedish photon and neutron use in science and industry have been carefully mapped. The report gives specific recommendations for actions and will serve as input to the next revision of the Swedish government research and innovation bill. Among many attractive concepts, the report proposes to found regional step-stone environments. These would be hosted by strong research centers in a certain field, would be located all over Sweden, and would help to ease access to MAX IV.

The meeting saw a vibrant community of former and new users, eagerly waiting to explore the new possibilities at MAX IV. It also gave proof of initiatives coherently linking all of the Swedish (and beyond) potential user community in order to support and utilize the new facility. ■

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