The Imaging Beamlines at MAX IV

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Summary: The Max IV Laboratory is currently the synchrotron X-ray source with the beam of highest brilliance. Four beamlines with the capacity to acquire tomographic datasets are in commissioning, construction or in the planning phase. Their common characteristic will be the high acquisition rates of phase enhanced images.

1. INTRODUCTION

The MAX IV Laboratory was inaugurated on the 21.6.2016 with the initial portfolio of 14 bemlines. These cover mainly spectroscopy and diffraction while full-field imaging capabilities will be added in the upcoming years. The establishment of coherent imaging techniques oriented towards bio-medical applications is motivated at MAX IV by the consideration that the high coherent flux from this diffraction limited storage ring will facilitate the application of a broad spectrum of phasing techniques. In particular for biological samples there is good hope that the radiation damage may be reduced under certain circumstances as more coherent photons contribute to the image formation.

2. Imaging across scales.

The MAX IV imaging group consists of three beamlines, one of them in commissioning, one in construction and one in planning phase. In addition the DanMAX beamline will devote half of the operation time to imaging and is presented separately. All four beamlines will be situated on the 3 GeV ring of the facility.

NanoMAX is a hard X-ray nanoprobe Max IV beamline with two instruments under development. A scanning X-ray microscopy and diffraction station using a pair of focusing KB mirrors with beam focus down to 50-200 nm will aim to fully utilize the intense and highly coherent photon flux of the Max IV source (10^{12} photons/s on sample at 10 keV). The second instrument is based on Fresnel zone plate optics focusing down to 10 nm. Both instruments will be able to deliver 3D datasets with the main characteristic of being composed of rather few angular projections. The scanning methods will be in general slower than full-field imaging. The beamline opened for limited user operation in 2016.

SoftiMAX is designed to be a two branch soft X-ray spectromicroscopy beamline with the first branch designed for Scanning Transmission X-ray Microscopy (STXM) including ptychography. The second branch will be a modular Coherent X-ray Imaging (CXI) station with a focus on Fourier Transform Holography (FTH). The beamline will provide very high coherent flux between the carbon K-edge and the phosphorus and sulfur K-edges (275-2500 eV), with full polarization control over most of this range, making the beamline suitable for a variety of fields including nanomagnetism, environmental studies and biomaterials. User operation is foreseen to begin in 2019.

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MedMAX will be the first Max IV beamline fully dedicated to full-field imaging in the Fresnel diffraction regime with hard X-rays (12-40 keV). With emphasis on studying processes in biological systems at the micrometer scale, advanced reconstruction routines will be valuable for optimizing the radiation dose on sample. The infrastructure will be set up for in vivo imaging of small animals but applications accross biology and soft matter will all be relevant for this beamline. Funding is not secured for this beamline, yet.

3. Tomographic reconstruction implementations

At MAX IV we are implementing solutions for tomographic reconstruction across beamlines. We aim for having one implementation used by all beamlines who will require to reconstruct a set of angular projections. Currently there are three families of tomographic reconstruction routines implemented at the MAX IV cluster. One being a Log-polar fast Radon transform approach developed at the Mathematics department at Lund University [1], the second being algebraic methods such as SIRT and the third group are discrete methods such as DART and an energy minimization method [2]. The latter are more computationally intensive and therefore slower. But useful for specific cases in particular when a small number of higher quality projections is available. Contrary the first method is fast and qualifies for on-the-fly data analysis during experiment making it particularly valuable for processing time resolved acquisition.

References

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