R. DiffMAX

External collaborations	LU, Chalmers, UU, LiU, ESS and others
Original budget and funders	So far unfunded beamline in design phase. Estimated investment budget 100 MSEK
Official start	Expecting a possibility to apply for funding in 2017
Expected date of completion	First beam in 2020 is possible

DiffMAX will cover a wide range of useful diffraction and scattering based structural characterisation techniques that find uses in many fields ranging from pharmaceuticals and soft matter systems to metallurgy and catalysis. The technical performances of the beamline will be world class, completed by an emphasis on enabling full integration of complex (and large) sample environments. There is at present no beamline at MAX IV that can offer the fundamental diffraction and scattering possibilities, all existing beamlines are specialised, with sometimes limiting sample environment, and their respective communities will use all available beamtime. DiffMAX aims at covering this gap and provide state of the art capabilities that do not exist in the current portfolio of beamlines at MAX IV, but are successful and oversubscribed in virtually every other synchrotron. Since diffraction and scattering are well established techniques that have been extensively used for a long time in many fields and the data analysis strategies are well established, it is expected that the user community served will be broad and productive at an early stage after the beamline is open.

While the initial scope of the beamline is to provide "classical" diffraction techniques, the evolution of many similar beamlines at other synchrotrons show that the additional capabilities available thanks to local conditions (high coherent fraction, energy resolution/scanning, fast scanning stages,…) often enable new unique experiments. Once the initial performances are achieved at DiffMAX, and a dynamic user community is present, further developments should occur exploiting the unique properties of MAX IV. The philosophy of the beamline will be to provide a fertile environment to foster and exploit those innovative ideas, together with a reliable and productive classical measurement tool.

Technical description

DiffMAX will offer two experimental stations, one providing excellent capabilities for powder diffraction (including pair distribution function (PDF)), and one flexible station equipped for receiving large sample environments (including vacuum chambers, molecular beam epitaxy (MBE) chamber, catalytic reactors, electrochemical environments, corrosion studies reactors, high pressure cells,…) and detector positioning in space with high spatial (i.e. translational and angular) accuracy. All modalities of scattering and diffraction should be feasible, including those requiring a grazing incidence incoming beam (either due to the technique itself (reflectivity, GIXD, GISAXS, SXRD) or because the sample is a planar structure (thin films, coatings, supported nanoparticles/nanowhiskers, all types of interfaces: solid-solid, solid-liquid, liquid-liquid, liquid-gas, solid-gas, soft and hard matter).

The optics of the beamline will be realised preserving the coherence of the beam as much as possible in order to make feasible coherent diffraction imaging (CDI) or X-ray photon correlation spectroscopy (XPCS) experiments. Energy scans providing chemical sensitivity will be feasible. Beam size should be from maximum 1 mm to minimum 1 µm.

The energy range should be from a few keV (5-7) to as high as reasonably feasible at MAX IV (35-60 keV).This will impose extra effort on undulator design.The experimental hutch(es) will be built such that a third experimental station will be feasible.

Present status

The project has been discussed with a large number of users who have expressed their strong support, in particular through the University Reference Groups (URGs). Several options are possible for the actual design of the beamline, and the choice depends on many external factors such as the current advancement in undulator technology, as well as the complementarity with other beamlines in design or construction stages.

Expected status end 2018

In 2018, the beamline project should be in procurement phase / construction of the lead hutches, undulator and optics.

Major partners and additional funding

Several scientific orientations have been discussed as additional specialisation areas for the beamline, their realisation depends partly on funding level, but also on the exact number and know-how of the future scientists at the beamline. Some of the actors involved would be in capacity of providing additional funding and/or knowledgeable manpower, however the beamline must first exist at all for them to commit.

Changes made since the start

The initial project (2013) was describing only a single experimental station, this has now changed to two stations.

Strong interest from a user community in the field of reflectivity/reflectometry on solid and liquid surfaces appeared recently. Since the initial project includes reflectivity on solids, adapting the beamline to scattering on liquid surfaces/interfaces can easily be achieved, welcoming an additional user community.

Opening the energy range towards higher energies (up to 60 keV) requires a technical feasibility study of the undulator design. Higher energy would however be of benefit for a large number of users, as much on the powder station (penetrating power and PDF studies) as on the flexible diffractometer (larger accessible reciprocal space, higher penetrating power). This feasibility study would likely be useful for several other future MAX IV beamlines.

The more and more precise technical description of DanMAX, CoSAXS, The Swedish beamline at Petra, and NanoMAX, all have an impact on the design of DiffMAX.

Comparison to similar beamlines world wide

ID03, ID22, Swiss Norwegian Beamline, XMAS at ESRF (France), SIXS, DIffABS, at SOLEIL (France), I07 at Diamond Light Source (France), Beamline MS at PSI (Switzerland), XPD, CHX (in some aspects) at NSLS II (USA) and P02, P06 at Petra (Germany).

Future development

Development areas for the beamline include optics, detector and experimental stations.

- Optics: add stronger focusing, quarter wave plates, post-monochromator.
- Detector: energy dispersive 2D detector / fast 2D detectors.
- Experimental stations: Bragg ”dark field” microscopy (see ESRF ID01, ID06), magnetic measurements (interactions with ESS). Specific sample environments to be developed in collaboration with user groups.
- A noticeable and increasing user interest is prompting us to consider a third experimental station. A few additional techniques have been named and would be very useful for materials sciences studies, completing structural data with chemical information. The present beamline’s optics would allow techniques high-energy X-ray photoemission spectroscopy HAXPES, HERFD (resonant inelastic scattering RIXS or x-ray emission spectroscopy XES) to be integrated and find a natural place at DiffMAX. The beamline in its present concept has two experimental stations, it is crucial to allow enough space from the start so that these new techniques can be accommodated.

These developments should aim at completing the portfolio of techniques available at MAX IV, the needs of the user communities should be a driving motivation.