Beamline Jockey Days - Challenges in Imaging

Monday 12 November 2018 - Tuesday 13 November 2018

Helmholtz-Zentrum Geesthacht
 outstation at DESY

Book of Abstracts

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Welcome address

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Overview of P05 μCT setup

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The talk will briefly introduce the P05 μCT setup. Currently used detector systems, scintillators and our experience using these systems will be shown. Future options will be presented and should be discussed.

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Photon efficient detector solution for full field XRM

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The nanotomography station at the imaging beamline IBL/P05 at PETRAIII is offering full field X-ray microscopy (XRM) at an energy range of 11-14keV using Fresnel Zone Plates (FZPs) [1,2]. A sample-to-detector distance of $18 - 22$ m can be realised by placing the detector in the microtomography hutch. Making use of this distance in the XRM mode no light optical magnification is needed, thus resulting in higher photon efficiency. This setup configuration leads to an effective pixel size of $13 - 20$ nm and scan times of below 1 hour for a full tomographic scan (1200 projections). Recently scan times of 15min and below have been realised in flight scan mode for XRM as well as Zernike Phase contrast mode. Thanks to the high flexibility of the nanotomography setup other imaging modes e.g. cone beam experiments can be instrumented and are currently under commissioning.

[1]L Larsson, D Gürsoy, F De Carlo, E Lilleodden, M Storm, F Wilde, K Hu, M Müller and I Greving; Nanoporous gold: A hierarchical and multiscale 3D test pattern for characterizing X-ray nano-tomography systems. Journal of Synchr. Rad., in Press, 2018

[2]I Greving, M Ogurreck, F Marschall, A Last, F Wilde, T Dose, H Burmester, L Lottermoser, M Müller, C David, F Beckmann; Nanotomography endstation at the P05 beamline: Status and perspectives. Journal of Physics: Conference Series, vol. 849 (012056) pp. 1-5, 2017

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Grating-based phase-contrast microtomography at PETRA III

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The Helmholtz-Zentrum Geesthacht, Germany, is operating the user experiments for microtomography at the beamlines P05 and P07 of PETRA III at DESY, Hamburg, Germany. Attenuation-contrast and phase-contrast techniques were established to provide an imaging tool for applications in biology, medical science and materials science. Here we will present the current status of the grating-based phase-contrast setup including the development of a 20 MPixel high speed

CMOS camera together with the optimisation of the used grating setup. Selected examples of user applications will be given.

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Phase-contrast X-ray microscopy and tomography on EMBL beamline P14 at PETRA III

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EMBL Hamburg operates the P14 beamline at the high-brilliance PETRA III storage ring at DESY. Delivering hard X-rays (6 – 30 keV), P14 is very versatile: shape, size and intensity of the X-ray beam are easily tunable by using both reflective and refractive optical elements. Sample stage and detecting systems are state-of-the-art including a high-precision vertical goniometer (developed in collaboration with EMBL Grenoble and ARINAX, a robotized sample changer (developed in-house) and a DECTRIS (Baden, Switzerland) EIGER 16M detector. These features enable crystallography of large macromolecular complexes, serial crystallography, time-resolved and in-situ diffraction data collection. Exploiting the flexibility of the beamline optics, we are investigating new methods and techniques to look into samples of interest via full-field phase-contrast X-ray imaging and microscopy. Unlike conventional absorption X-ray imaging, phase contrast makes interfaces and density gradients clearly visible in a biological sample. To achieve higher resolution and to see fine structure, we also implement X-ray refractive lenses as an objective in the microscopy mode. This approach allows us to magnify details of the sample up to 15 times prior to the optical detection of X-rays that carry the phase-contrast information from the interaction with sample. With the current setup, a sub-100nm resolution can be achieved and it is possible to visualize crystal boundaries and their local deformations in situ. High-precision rotation of the sample stage at P14 also allows to perform X-ray tomography. Due to the use of high-energy X-rays for the imaging process, materials and tissues with thicknesses in the mm-range can be penetrated. The latter also allows P14 to look forward for time-resolved experimental applications with other biological objects.

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Imaging at Diamond I12-Jeep: Surviving the dust storm !

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The continuing development of ring artefacts in images is one of the problems that annoys X-ray tomography users the most, (perhaps next to the difficulty of coping with the large amounts of data) Considerable effort has been put into developing ways to use data despite the artefacts; including attempting to acquire data so as to avoid the bad parts of the detection system, and novel mathematical filters and processing of the data to retrieve the desired sample information. But, it would be better not to have these problems in the first place. Unfortunately, we find that putting the optical system into the X-ray beam seems to result in degradation products from X-ray interaction; with the optic mounts, mirrors, scintillators and anything included to try to protect the scintillators, getting all over the system and causing the ring-generating defects. For this workshop I will discuss each of these things, data acquistion strategy, reconstruction algorithms, and optics re-design – each of which is still not complete or perfect, in hope of exchanging ideas for improvements in each area.

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The ANATOMIX beamline at SOLEIL

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ANATOMIX is a beamline for full-field X-ray radiography and tomography currently entering operation at Synchrotron SOLEIL. It uses an undulator as its source and can operate both in monochromatic and white-beam mode. The range of accessible photon energies starts at around 5 keV and goes up to roughly 25 keV with a monochromator and 50 keV or higher with a white beam.
A parallel-beam microtomography station has been open to users for several months; the beam size at the sample position for this modality can be varied between a few mm in each dimension and an extra-wide beam with roughly 40 mm width and 15 mm height. Without X-ray optics, the beam size at sample is around 20 mm (H) $\times$ 15 mm (V).
To cover this wide range of beam sizes, several detector optics have been developed in-house at SOLEIL. They are all based on the conventional concept of indirect detection with a single-crystal scintillator, lens optics and a CMOS or CCD sensor.
The scintillators are predominantly LuAG:Ce supplied by Crytur (Turnov, CZ), from which we also bought some YAG:Ce, and some LSO:Tb from the ESRF (Grenoble, FR).
The detector optics for pixel sizes below approximately 5 μm (optical magnification from 2$\times$ to 50$\times$) use microscope objectives (Mitutoyo, Kawasaki, JP); two different optics ensembles following this principle have been commissioned and in use for regular beamline operation. For more moderate resolution (optical magnification from 0.28$\times$ to 3.6$\times$) and a correspondingly large beam, photo objectives (Hasselblad, Gothenburg, SE) in tandem geometry are used. The corresponding optics units are under commissioning.
A distortion correction of the images for tomography has so far not been necessary with these detection systems. However, our experience shows that careful handling and adjustment of mirrors and lenses is necessary to avoid aberrations and a degradation of spatial resolution even in the 2D images obtained.
Concerning the sensors, the working horse is an Orca Flash 4.0 V2 (Hamamatsu K.K., Hamamatsu, JP), complemented by a pco.dimax HS4 for fast acquisitions and a pco.4000 (PCO AG, Kelheim, DE) for applications requiring a larger pixel array and/or longer exposures.
These indirect detectors are also used with a zone-plate transmission X-ray microscope (TXM) currently under construction at the beamline, using diffractive optics supplied by the Paul Scherrer Institut (Villigen, CH).
The camera control computers are located in cooled racks close to the computer cluster used for tomographic reconstruction. To transport their CameraLink protocol over the large distance thus required, we use fiber-optic extenders (Phrontier Technologies LLC, Lake Forest, Calif., US), in combination with fiber-optic network wall plugs.

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Presentation, developments, ideas, and points for discussion from beamline PSICHE at Synchrotron SOLEIL.

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PSICHE (Pressure, Structure, and Image by Contrast at High Energy) is a multi-purpose tomography beamline at Synchrotron SOLEIL. It performs parallel beam tomography for materials science as well as many other applications. It also performs a wide range of diffraction experiments at extreme conditions of temperature and pressure. The very flexible nature of the instrument allows many interesting combinations of imaging and diffraction to be employed. This presentation

will introduce the beamline, and give a brief overview of our activities. This can be a starting point for discussions and for the sharing of ideas for the future.

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Detector technologies

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Advances in detectors can enable a variety of new experiments at synchrotrons. Pixel detectors currently in use at synchrotrons use a variety of basic technologies - hybrid pixel, CCD, CMOS - with different advantages and disadvantages. We present an overview of these technologies, with an emphasis on detectors for X-ray imaging.

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The versatile indirect X-ray imaging detector pool at beamline ID19 of ESRF

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Beamline ID19 of the European Synchrotron Radiation Facility offers hard X-ray imaging with a high level of versatility: the beam size can vary from a few millimeter in square up to 1 cm x 5 cm. The energy level spans from 15 to 250 keV. Depending on the user experiment, high temporal or spatial resolution with different contrast modes are requested. This presentation will outline the comparable large detector pool which has been established at the beamline in order to tune the hardware to the needs of the experiments: different optical systems, cameras and scintillators have been made available for routine use. Maintenance concepts are available as well.

Session 3 / 18

'Scintillation Materials and detector systems' at I13 Diamond-Manchester Imaging Branchline

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The I13 imaging and coherence beamline at Diamond Light Source consists of two independently operating branchlines, one focussing on imaging techniques in reciprocal space such as ptychography, the other mainly operating with micro-tomography (μCT) techniques (absorption and in-line phase contrast (PC), grating interferometry) and also a transmission X-ray microscope (TXM). We will focus in the presentation on detector instrumentation – and especially on scintillation screens - for μCT. The detectors cover a large range of spatial and temporal resolutions. For μCT we developed a detector system based on scintillation screens coupled via microscope optics to a CCD or sCMOS detector. This optical setup is designed for achieving highest spatial resolution. We are currently using a large range of scintillation screen materials*procured mostly from commercial suppliers. We will provide a brief review about our experience with these materials and suppliers in terms of surface quality, internal defects, efficiency and resolution. The surface quality of the screens depends on scratches, digs and dust; these – together with deeper defects such as microfractures – limit image quality significantly. Negotiating with suppliers to obtain scintillators of sufficient quality is non-trivial due to the aim of exceeding the best scratch-dig specifications. For*

dust protection we have trialled various approaches based on earthing and physical shielding, such as using conductive covering slides, ensuring good conductive contacts with housing, and sputtering protective earthing layers or bonding a protective kapton cover directly onto the scintillator. The other factors that we are looking at are scintillators with anti-reflection coating vs. the spray-coated scintillators. We have also tried using intermediate optical components to reduce browning of the 4x and 10x objectives, which so far has not significantly reduced browning significantly. Recently we are also investigating using GAGG scintillators (high yield). For medium resolution optical systems we have been carrying out some initial tests with camera objectives; this project has not been followed up any further so far. For the TXM we procured a Hamamatsu detector system, which provides a high photon yield at moderate spatial resolution. We would like to highlight our experience with different suppliers of scintillation screens and challenges met with quality and performance. If time allows within this workshop we would like to address also some more general issues relating to our detector systems. CdWO4; ZnWO4; LuAG:Ce; GGG:Eu

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Updating the BAMline tomography setup

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The microtomography setup at the BAMline was designed in 2008. The original setup is still in use for CT measurements. With a recent investment into the optics of BAMline, we want to build a pink beam tomography setup by replacing the detector and optics, in order to reduce the scanning time from currently several hours down to minutes. In this talk, the current ideas are presented.

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Scintillators and Detectors at the TOMCAT Beamline: latest developments and challenges

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At the Swiss Light Source (SLS, Paul Scherrer Institut, Switzerland), the TOmographic Microscopy and Coherent rAdiology experimentTs (TOMCAT) beamline offers multiple X-ray tomographic microscopy end-stations with absorption and phase contrast imaging capabilities: propagation-based tomography [1], grating-based interferometry [2] with directional sensitivity [3] and Zernike Phase Contrast (ZPC) nano-tomography [4]. Sitting on a 2.9T superbend with a critical energy of 11.1keV, the beamline can be operated in monochromatic mode either with a Double Crystal Multilayer Monochromator (DCMM) with a bandwidth of a few percent or with Silicon (111) crystals providing a bandwidth down to $10-4$. Both cover an energy range between 8 and 45 keV [5]. The beamline can also be operated in white-beam mode, providing the ideal conditions for ultra-fast acquisitions, thanks to the in-house developed high-speed X-ray detector GigaFRoST [6]. Several microscopes are in operation, which cover isotropic voxel sizes from 11 microns down to 60 nm, allowing a broad range of research and industrial applications: biology, geology, material characterization, paleontology, etc.
This talk will give an overview of the different X-ray microscopes and detectors available for the users. Highlights will be put on the latest camera and detector developments. Furthermore, depending on user requirements (optimizing for speed and/or resolution), several scintillators type and thicknesses are in use: the LuAG:Ce scintillators (CRYTUR, Czech Republic) are our work horses. Lately, because of their degradations (delamination, dust issues, aging, . . .), we

enlarged our scintillators portfolio towards LSO:Ce and GGG:Eu (ESRF). However, we are still facing several problems, illustrated in this talk. This is why cleaning procedure and scintillators handling are in constant evolution and new solutions are currently under investigations.
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high data rate processing at P06

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