ST 1: X-ray Imaging

Time: Monday 15:00–17:30 Location: H48

ST 1.1 Mon 15:00 H48

Dynamic X-ray Imaging at the Munich Compact Light Source — •Regine Gradl[1], Martin Dierolf[1], David Kutschke[2], Lin Yang[2], Otmar Schmid[2], Franz Pfeiffer[1], and Kaye S. Morgan[1,3] — [1]Chair of Biomedical Physics and Munich School of BioEngineering; Institute for Advanced Studies, Technical University of Munich, Garching, Germany — [2]Comprehensive Pneumology Center, Institute of Lung Biology and Disease, Helmholtz Zentrum München, Neuherberg, Germany — [3]School of Physics and Astronomy, Monash University, Clayton, Australia

In vivo dynamic respiratory phase-contrast x-ray imaging in small animal models is a powerful research tool, which can be used to increase physiological understanding, and accelerate new therapies towards the clinics. Previously, these experiments were mainly limited to synchrotron facilities. Here we present results for dynamic in vivo x-ray phase-contrast imaging obtained in a laboratory environment using the Munich Compact Light Source. By employing inverse Compton scattering instead of permanent magnet undulators, it is possible to shrink the storage ring to a few meters in circumference, generating brilliant, partially coherent and quasi-monochromatic x-rays. Two different experimental set-ups for dynamic phase-contrast imaging have been implemented at this source. Firstly, a grating interferometer which is used for imaging repeated motion (e.g. the breath cycle of a mouse) and secondly, a propagation-based imaging set-up for detecting irreversible changes. This presentation will describe the set-ups and current applications of these laboratory-based imaging systems.

ST 1.2 Mon 15:15 H48

Dose-compatible grating-based phase-contrast mammography on mastectomy specimens using a compact synchrotron source — Elena Eggl[1,2], •Lisa Heck[1,2,3], Susanne Grandl[4], Martin Dierolf[1,2], Klaus Achterhold[1,2], Franz Pfeiffer[1,2,4], and Julia Herzen[1,2] — [1]Chair of Biomedical Physics, Department of Physics, TU Munich, Germany — [2]Munich School of BioEngineering, TU Munich, Germany — [3]Chair of Experimental Physics IV, TU Dortmund, Germany — [4]Department of Diagnostic and Interventional Radiology, Klinikum rechts der Isar, TU Munich, Germany

Although the introduction of screening mammography has reduced the mortality rate of breast cancer, many women still undergo unnecessary subsequent examinations due to inconclusive diagnoses. In breast imaging, the low soft-tissue contrast of conventional attenuation-based images can be improved by phase-contrast imaging. Here, the diagnostic performance of multimodal grating-based mammography on four freshly dissected breast specimens and one mammographic accreditation phantom was evaluated at a compact synchrotron source. We found enhanced diagnostic information in monochromatic grating-based phase-contrast and dark-field images while the applied dose was lower or equal to the clinical dose. Microcalcifications could be identified equally well at significantly reduced dose in the monochromatic images. The results indicate that compact synchrotron sources can bring benefits to clinical imaging for mammography.

ST 1.3 Mon 15:30 H48

Evaluation of X-ray Dark-Field Signal for Imaging Ex-situ Human Lung Specimens and Structure Size Determination — •Kirsten Taphorn[1], Fabio De Marco[1], Jana Andrejewski[1], Konstantin Willer[1], Christian Braun[2], Alexander Fingerle[3], Franz Pfeiffer[1,3], and Julia Herzen[1] — [1]Chair of Biomedical Physics, Department of Physics and Munich School of BioEngineering, TUM, Garching, Germany — [2]Institute of Forensic Medicine, Ludwig-Maximilians University, München, Germany — [3]Department of Diagnostic and Interventional Radiology, Klinikum rechts der Isar, TUM, Munich, Germany

Grating-based x-ray dark-field (XDF) imaging accesses information on small-angle scattering properties of the sample. However, the appearance of different pathologies in XDF lung imaging is not yet known. To elucidate this question, we report the design and implementation of a preclinical study on ex-situ human lung specimens with a Talbot-Lau interferometric setup that provides a field-of-view comparable to an x-ray chest radiography system. We constructed a device for lung ventilation as well as a thorax phantom and performed measurements of ex-situ human lung specimens. Furthermore, we investigated the spectral XDF signal of several phantom materials and found a correlation with mean chord length (MCL) obtained from micro CT, a medically approved size measure for alveolar structure. Structural lung diseases are known to effect changes in MCL. Thus, we show that a prediction of structural properties using spectral XDF imaging is possible, potentially enhancing the diagnostic power of XDF lung imaging.

ST 1.4 Mon 15:45 H48

Improved Grating Interferometer for Dynamical Imaging at the Munich Compact Light Source — •Johannes Brantl, Martin Dierolf, Christoph Jud, Klaus Achterhold, and Franz Pfeiffer — Chair of Biomedical Physics, Department of Physics and Munich School of BioEngineering, Technical University of Munich, 85748 Garching, Germany

X-ray grating interferometry allows the measurement of three complementary image modalities, attenuation, phase contrast and dark field. In the default acquisition scheme, phase and absorption grating have to be translated relative to each other resulting in a stepping curve. This can limit the visualisation of dynamical systems even if the flux is sufficiently high to allow for short exposure times. This is the case at the Munich Compact Light Source (MuCLS) [1], where a synchrotron-like X-ray beam is produced by inverse Compton scattering. Despite the high flux, dynamical imaging could so far only been performed for periodic processes, e.g. for in-vivo phase-contrast imaging of the respiratory system of mice [2], due to the limited stepping speed. The extension to temporal measurements of non-periodic dynamical systems is achieved by upgrading the current setup with a piezo actuator for stepping. We will present first results of imaging dynamical processes on the subsecond scale.

[1] Eggl, Elena et al., "The Munich Compact Light Source: initial performance measures", J. of Synch. Rad. 23 (2016): 1137-1142.

[2] Gradl, R., et al. "Dynamic in vivo chest x-ray dark-field imaging in mice", IEEE Trans. Med. Imag. (2018).

ST 1.5 Mon 16:00 H48

Characterization and optimization of a small animal in-vivo grating-based dark-field CT scanner — •Stephan Umkehrer[1], Katharina Hellbach[2], Ali Önder Yildirim[3], Julia Herzen[1], and Franz Pfeiffer[1,4] — [1]Chair of Biomedical Physics and Munich School of BioEngineering, TU Munich, Garching — [2]Department of Radiology, University Hospital, LMU Munich, Munich — [3]Comprehensive Pneumology Center, Institute of Lung Biology and Disease, Helmholtz Center Munich, Munich — [4]Department of Diagnostic and Interventional Radiology, Klinikum rechts der Isar, TU Munich, Munich

In contrast to conventional X-ray attenuation, grating-based dark-field imaging provides sample small-angle scattering information. Especially for early detection of lung diseases, such as pulmonary emphysema, pulmonary fibrosis, or pulmonary carcinoma the dark-field signal provides promising diagnostic value. Using in vivo radiography, structural pathologic changes in the lung tissue due to alveolar structure change can be observed by a decreased dark-field signal. Even though research has been very successful concerning the increased sensitivity of the dark-field signal compared to conventional absorption contrast the diagnostic potential of dark-field computed tomography (CT) for early pulmonary disease detection and assess has to be investigated. In this presentation, we will describe the recent progress of the first preclinical small animal in-vivo dark-field CT scanner, which was developed in collaboration with Bruker MicroCT (former Skyscan).

15 min. break

ST 1.6 Mon 16:30 H48

K-edge subtraction imaging at a compact synchrotron source — •Stephanie Kulpe[1,2], Martin Dierolf[1,2], Eva Braig[1,2,3], Benedikt Günther[1,2], Klaus Achterhold[1,2], Bernhard Gleich[2], Julia Herzen[1,2], Ernst Rummeny[3], Franz Pfeiffer[1,2,3], and Daniela Pfeiffer[3] — [1]Chair of Biomedical Physics, Department of Physics, TU Munich, Germany — [2]Munich School of BioEngineering, TU Munich, Germany — [3]Department of Diagnostic and Interventional Radiology, Klinikum rechts der Isar, TU Munich, Germany

About one third of all deaths worldwide can be traced back to cardiovascular diseases, for which digital subtraction angiography (DSA) is an important diagnostic radiological procedure. An alternative to DSA is K-edge subtraction (KES) imaging, which can eliminate image artifacts caused by patient movement. As highly brilliant, monochromatic X-rays are desirable for this method, it has been limited to synchrotron facilities so far, restraining the feasibility in clinical routine. Compact synchrotron X-ray sources based on inverse Compton scattering, which have been evolving substantially over the past decade, provide X-rays with sufficient brilliance that meet spatial and financial requirements affordable in laboratory settings or for university hospitals. In this study, we demonstrate a first proof-of-principle KES imaging experiment using the Munich Compact Light Source (MuCLS), the first user-dedicated installation of a compact synchrotron X-ray source worldwide. We believe that KES at a compact synchrotron source can become an important tool in pre-clinical research.

ST 1.7 Mon 16:45 H48

3D X-ray phase-contrast Histology — •Josef Scholz[1,2], Lorenz Birnbacher[1,2], Christian Petrich[1,2], Franz Pfeiffer[1,2], and Julia Herzen[1,2] — [1]Chair of Biomedical Physics, Department of Physics, TU Munich, Germany — [2]Munich School of BioEngineering, TU Munich, Germany

The study of diseased tissue in anatomical pathology usually includes laborious pre-preparation processes, in particular staining and sectioning of the samples taken, before examination using light microscopy. Here, the sectioning process by itself causes a distortion of the individual slices and the subsequent arrangement of the 2D data results in anisotropic voxel sizes of the reconstructed 3D volume. Due to the comparably high sensitivity of grating based X-ray setups in terms of soft tissue variations, grating-based X-ray phase-contrast computed tomography (gbXPC-CT) constitutes a promising complementary method in histopathology, allowing for preliminary examination and localisation of diseased areas before sectioning non-destructively. Therefore, a resolution below 10 microns over a scan volume sufficient to the specimen size while not exceeding reasonable scan times has to be achieved, which remains a challenging problem using conventional lab sources. The presentation will show first results using a high-sensitivity gbXPC-CT setup.

ST 1.8 Mon 17:00 H48

Hematein-based X-ray suitable Stain enables 3D Visualization of the Cell Nuclei — •Katharina Scheidt[1], Mark Müller[1], Melanie A. Kimm[2], Simone Ferstl[1], Sebastian Allner[1], Klaus Achterhold[1], Julia Herzen[1], Franz Pfeiffer[1,2], and Madleen Busse[1] — [1]Department of Physics and Munich School of Bioengineering, TU Munich, Germany — [2]Department of Diagnostic and Interventional Radiology, Klinikum rechts der Isar, TU Munich, Germany

The current gold standard for the investigations of anatomical structures on a cellular level is histology which is limited to two-dimensional imaging and often shows disruption of the cell architecture due to the sectioning of the tissue. In contrast to that, non-destructive 3D imaging methodologies such as X-ray microscopic and nanoscopic CT struggle with the weak attenuation of soft tissue hampering their application in virtual 3D histology. The presented nucleus-specific X-ray stain provides a visualization of anatomical structures in three dimensions whereby it addresses specifically the cell nuclei. With this technique, the real 3D morphology and the spatial distribution of cell nuclei is maintained. Together with a newly developed laboratory nanoscopic CT system, 3D visualization in nanometer range is possible. Furthermore, the staining technique is compatible with conventional 2D histology as microscopic slides can be derived from the very same stained soft-tissue sample and further counter staining is possible.[1]

[1] M.Müller, A.M.Kimm et al., Non-destructive high-resolution 3D virtual histology enabled through a cell nucleus-specific stain for X-ray computes tomography. Sci. Rep., 2018, manuscript accepted.

ST 1.9 Mon 17:15 H48

Bismuth-Oxo-Clusters as Novel X-Ray Stain for Soft-Tissue Samples — •Toni Bürkner[1], Madleen Busse[1], Mark Müller[1], Melanie A. Kimm[2], and Franz Pfeiffer[1,2] — [1]Department of Physics and Munich School of BioEngineering, Technical University of Munich, 85748 Garching, Germany. — [2]Department of Diagnostic and Interventional Radiology, Klinikum rechts der Isar, Technical University of Munich, 81675 Munich, Germany.

X-ray absorption-based micro-computed tomography enables 3D imaging with micrometer resolution[1]. This technique is commonly used in material science and is interesting for medical and biological sample screening as it is a non-destructive imaging method. The big drawback of soft-tissue samples is their missing contrast, which is mandatory to visualize internal structures on a microscopic scale, which will enable compatibility with conventional 2D histology [2,3]. Contrast agents (stains) and staining protocols are developed to overcome this problem and enhance the contrast. Within this work, we present a novel staining method based on bismuth-oxo-clusters, which was especially developed for soft-tissue X-ray imaging . Different clusters were synthesized and tested on various soft-tissue samples such as whole mouse organs, e.g. spleen and kidney.

[1] Stock, S. R. (2009). Micro-Computed Tomography - Methodology and Applications. CRC Press, Boca Raton, FL.

[2] M. Müller et al, PNAS 114 (2017) 12378-12383.

[3] M. Busse and M. Müller et al, PNAS 115 (2018) 2293-2298.