ST 5: Imaging with Ionizing Radiation I

Time: Thursday 10:00–11:45 Location: POT 112

ST 5.1 Thu 10:00 POT 112

Simulation of grating-based X-ray phase contrast tomography — •Klaus Achterhold, Julia Herzen, and Franz Pfeiffer — Department of Physics (E17) and Institute of Medical Engineering (IMETUM), Technische Universität München, Germany

Grating-based X-ray phase contrast tomography proved to achieve better contrast in soft tissue than conventional X-ray absorption. The real part of the refractive index of the tissue results in a slight deflection of the X-rays. These tiny angles of approximately 20 nrad can be detected by a combination of a phase and absorption gratings. With an absorption grating near the anode of a conventional X-ray tube the method is applicable as part of a medical device. Hence X-ray phase contrast can be used in the detection of soft tissue pathologies e.g. breast tumor in mammography. The application in the clinics demands the lowest dose for the patient though the best contrast to noise ratio (CNR). To accomplish this, we simulated the imaging varying the height and pitch of the gratings for a given power and spectrum of the X-ray tube. Source, detector and grating distances were under the constraint of the dimensions of a putative computer tomograph. Optimal combinations where found for maximal CNR. The results will be important for the design and implementation of the X-ray phase contrast method in commercial CT devices.

ST 5.2 Thu 10:15 POT 112

Development of a compact gantry for quantitative phase-contrast CT applications — •Arne Tapfer[1], Martin Bech[1], Bart Pauwels[2], Peter Bruyndonckx[2], Xuan Liu[2], Alexander Sasov[2], Johannes Kenntner[3], Marco Walter[4], Joachim Schulz[4], and Franz Pfeiffer[1] — [1]Department of Physics (E17) and Institute of Medical Engineering (IMETUM), Technische Universität München, Germany — [2]Skyscan, Kontich, Belgium — [3]Karlsruhe Institute of Technology, Karlsruhe, Germany — [4]Microworks, Karlsruhe, Germany

Here we present experimental x-ray cone-beam phase-contrast imaging results of a phantom study obtained with a highly compact grating-based gantry setup. The aim of this study is to investigate the performance, quantitativeness and accuracy of phase-contrast and absorption-based computed tomography scans which yield the three dimensional distribution of attenuation coefficient μ and refractive index decrement δ of different liquids contained in the phantom. Furthermore two different methods of color coding are explored to display both absorption and phase data in a single image. Experimental results for μ and δ match accurately with tabulated data meaning that the gantry setup performs well in both absorption and phase contrast. The substances contained in the phantom can be considerably better distinguished as the grating-based approach - which combines absorption and phase contrast - provides significantly more information than conventional absorption contrast alone.

ST 5.3 Thu 10:30 POT 112

Direct signal-to-noise comparison of radiographic attenuation- and differential phase-contrast X-ray images — •Dieter Hahn, Pierre Thibault, Martin Bech, and Franz Pfeiffer — Department of Physics (E17) and Institute of Medical Engineering (IMETUM), Technische Universität München, Germany

For radiographic applications of X-ray differential phase-contrast imaging, like e.g. mammography, we present the Relative Contrast Gain (RCG) as a novel measure of the relative information content of attenuation- and differential phase-contrast (dpc) radiographs recorded with a grating-based Talbot interferometer. It is a fast and simple method to quantify the gain in soft-tissue contrast of the differential phase-contrast signal compared to the standard attenuation based radiograph. The RCG can also be used as a figure of merit to assess the quality of different experimental setups in terms of providing good feature visibility in soft-tissue samples in the presence of noise. A comparison of a differential signal to a non-differential signal is achieved by analysis of the calculated gradient of the attenuation signal. The Relative Contrast Gain analysis is applied on experimental absorption and phase-contrast projections obtained for human breast samples. The results show a good gain in feature contrast in the dpc signal compared to the attenuation signal as expected from theory.

ST 5.4 Thu 10:45 POT 112

High-resolution x-ray differential phase-contrast imaging with 2D grating structures — •Marco Stockmar[1], Martin Bech[1], Guillaume Potdevin[1], Simone Schleede[1], Michael Chabior[2], Irene Zanette[3], and Franz Pfeiffer[1] — [1]Department of Physics (E17) and Institute of Medical Engineering (IMETUM), Technische Universität München, Germany — [2]Siemens Corporate Technology, Munich, Germany — [3]European Synchrotron Radiation Facility, France

Here we present results of differential phase-contrast (DPC) imaging using a grating interferometer with a high resolution (HR) detector and a 2D grating. The HR detector can directly resolve the interference pattern and allows therefore to omit the usually used analyzer grating. By use of a 2D grating the differential phase shift can be measured in two orthogonal directions improving the results of the phase integration. In addition, the 2D scattering signal allows to make a rough estimate of the preferred direction of sub-resolution sized features. Experimental results for synchrotron and laboratory x-ray sources will be presented.

ST 5.5 Thu 11:00 POT 112

Performance optimization of an X-ray grating interferometer for biomedical imaging — •Marian Willner[1], Dieter Hahn[1], Johannes Kenntner[2], Arne Tapfer[1], Martin Bech[1], Martin Dierolf[1], Pierre Thibault[1], Julia Herzen[1], Klaus Achterhold[1], Jürgen Mohr[2], and Franz Pfeiffer[1] — [1]Department of Physics (E17) and Institute of Medical Engineering (IMETUM), Technische Universität München, Germany — [2]Karlsruhe Institute of Technology, 76344 Eggenstein-Leopoldshafen, Germany

Several phase-sensitive X-ray imaging methods have been developed and demonstrated the high potential to improve soft-tissue contrast compared to conventional absorption imaging. Whereas most of the methods require coherent synchrotron radiation, X-ray grating interferometry has been successfully adapted to work with incoherent sources like standard X-ray tubes as well and is a promising candidate to introduce phase-contrast imaging into the clinics. The experimental setup of an X-ray grating interferometer consists of three optical X-ray gratings. An important performance factor of the imaging system is the visibility, which highly depends on the shape of the effective spectrum, the geometrical adjustment of the gratings and the gratings themselves. The optimization of these parameters to push the visibility to the greatest possible extent is an essential goal on the way towards clinical applications. Here, we present an approach to evaluate the quality of a grating interferometer that will help to design high-visibility setups in the future and thus to establish phase-contrast imaging with high contrast-to-noise ratios at low dose levels in clinical diagnostics.

ST 5.6 Thu 11:15 POT 112

Tumour visualisation in human soft tissue using grating-based X-ray phase contrast imaging — •Julia Herzen, Marian Willner, Simone Schleede, Martin Bech, Arne Tapfer, Marco Stockmar, Klaus Achterhold, and Franz Pfeiffer — Department of Physics (E17) and Institute of Medical Engineering (IMETUM), Technische Universität München, Germany

The grating-based phase-contrast imaging provides enhanced image structure details, which are partly complementary or even not attainable with standard x-ray absorption imaging. Especially in the case of biological soft tissue when standard x-ray radiography is often limited due to the weak absorption contrast, this method represents a real alternative. Based on x-ray optical transmission gratings this modality has transferred the phase-contrast imaging from the highly brilliant synchrotron radiation sources to conventional laboratory-based broadband x-ray tubes. Here, we present a study on human soft tissue specimens containing tumours using the grating-based phase contrast imaging at both highly brilliant synchrotron (ESRF, Grenoble), and at conventional X-ray laboratory radiation sources. Our results demonstrate a superior contrast for different kinds of soft tissue in the phase contrast and verify this imaging modality to be a promising candidate to establish phase-contrast imaging in clinical radiology.

ST 5.7 Thu 11:30 POT 112

Phase-contrast imaging with Compact Light Source based on inverse Compton X-rays — •Simone Schleede[1], Martin Bech[1], Klaus Achterhold[1], Guillaume Potdevin[1], Ronald Ruth[2,3], Jeff Rifkin[3], Rod Loewen[3], Marco Walter[4], and Franz Pfeiffer[1] — [1]Department of Physics (E17) and Institute of Medical Engineering (IMETUM), Technische Universität München, Germany — [2]Stanford Linear Accelerator Center, Menlo Park, USA — [3]Lyncean Technologies Inc., Palo Alto, USA — [4]microworks GmbH, Karlsruhe, Germany

The Compact Light Source, a laser driven small-size synchrotron developed by Lyncean Technologies Inc., produces x-rays at the intersection point of counter propagating laser and electron beam in the process of inverse compton scattering. The small size of the intersection point results in a highly coherent beam with a few milliradian angular divergence and three percent energy bandwidth. The intrinsic monochromaticity and coherence of the produced x-rays can be exploited in high-sensitivity differential phase contrast imaging with a grating-based interferometer. The Compact Light Source has the potential to yield images of quality previously only attained at large-scale synchrotron facilities, while being a small-size and low-cost x-ray source which allows it to be installed in hospitals for medical imaging. Here, we report on the first biomedical imaging results obtained from the Compact Light Source including mammography and computed tomography.