LABORATOIRE DE L'ACCÉLÉRATEUR LINÉAIRE

Séminaire LAL

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The Munich Compact Light Source - a laboratory-scale synchrotron facility for biomedical research

High-brilliance X-ray sources based on multi-GeV accelerators have allowed scientists to push the frontiers of X- ray imaging towards nanometer-scale resolutions and extremely high sensitivities. The coherence properties of third- generation synchrotrons, e.g., have enabled phase-sensitive imaging techniques with improved contrast for weakly- absorbing materials like soft tissue. However, for many of the developed techniques, the transfer from the synchrotron back to clinical imaging or at least preclinical biomedical applications is not straightforward. This is mainly due to the rather different characteristics of the X-ray tube sources typically employed in the latter cases. The Munich Compact Light Source (MuCLS) aims at bridging this performance gap, i.e. to provide an X-ray facility that allows to apply modern synchrotron techniques in an ordinary research laboratory setting. In terms of the X-ray source, this is achieved through inverse Compton scattering of infrared laser photons at relativistic electrons, which allows to generate brilliant quasi-monochromatic X-rays of 15 keV to 35 keV with an electron beam energy of at most 45 MeV and thus with a storage ring of just a few meters in size.

Our group has designed and commissioned two experimental endstations for the MuCLS, with a strong emphasis on – but not limited to – biomedical applications. These applications utilize the different special source properties of the MuCLS: The narrow tunable spectrum allows not only to perform quantitative computed tomography (CT) without beam-hardening artifacts, but also to employ K-edge imaging in various applications, e.g. coronary angiography. The comparatively high flux density enables radiation therapy studies, as well as high-resolution micro-CT and fast dynamical imaging, e.g., for investigating respiratory processes. Finally, the partial coherence of the source is essential for phase-contrast and dark-field imaging applications: In the far experimental hutch, the large field of view of several centimeters diameter is used for grating-based phase-contrast radiography and tomography of larger specimens, as well as for (directional) dark-field imaging. In the near experimental hutch, propagation-based phase-contrast imaging experiments, e.g. small-animal studies of respiratory processes, are carried out.

Following a discussion of the X-ray source itself, results obtained by utilizing the special source properties for various biomedical applications will be presented. Furthermore, based on our experiences during the last four years, the presentation will have a look at the requirements and challenges which arise from operating an inverse Compton source on a daily basis in a mode primarily focussed on enabling applications like the aforementioned biomedical research.

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