Biomedical X-ray imaging at the Munich Compact Light Source

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Summary: The Munich Compact Light Source (MuCLS) is the first commercial installation of a laboratory-scale synchrotron X-ray source based on inverse Compton scattering. It produces partially-coherent X-rays with a narrow tunable spectrum and a high flux density. Following a discussion of the source itself, we present results obtained by utilizing these special source properties for various biomedical applications.

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 source that allows to apply modern synchrotron techniques in an ordinary research laboratory setting. 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 just 45 MeV and thus with a storage ring of just a few meters in size [1,2].

We have equipped the MuCLS with two experimental endstations, which are mainly designed for – but not limited to – biomedical applications. These applications utilize the different special source properties [1] of the MuCLS:

The narrow tunable spectrum allows not only to perform quantitative computed tomography (CT) without beam-hardening artifacts [3], but also to employ K-edge imaging in various applications, e.g. coronary angiography [4]. The comparatively high flux density enables radiation therapy studies [5], as well as high-resolution micro-CT and fast dynamical imaging, e.g., for investigating respiratory processes [6]. 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 [7,8] and tomography [9] of larger specimens, as well as for (directional) dark-field imaging [10,11]. In the near experimental hutch, propagation-based phase-contrast imaging experiments, e.g. small-animal studies, [6] are carried out.

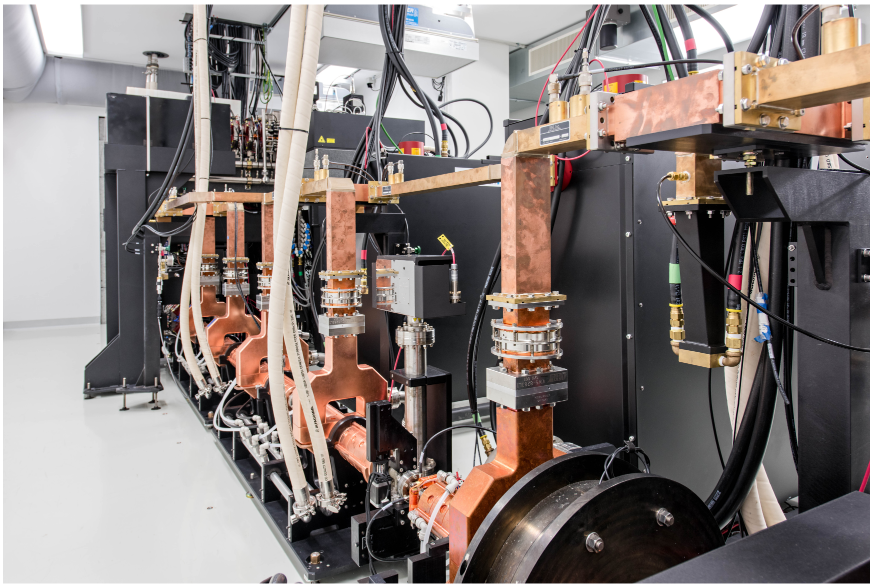

Figure 1: View along the linear accelerator of the Munich Compact Light Source (photo: A.Heddergott, TUM).

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