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APPLICATIONS OF FREE ELECTRON LASERS IN BIOLOGY AND MEDICINE

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Synchrotron radiation (SR), both from storage rings and from free electron lasers (FEL), has been extensively applied in biology and in medicine for more than thirty years, opening up new opportunities to study life forms on different levels, from biomolecules and subcellular structures up to whole organisms [1, 2]. Intense synchrotron beams turned out to be invaluable in soft tissue probing with superior sensitivity, capable to detect even small tissue variations.

In recent few years, a rapidly growing interest in application of FEL beams is observed in many areas of science and technology. It is due to the fact that FELs show specific advantages to classical SR synchrotron sources, strongly enhancing probing of soft matter structure and dynamics of processes with very high spatial and temporal resolution. They were also successfully tested as precise tissue ablation tools in surgery and oncology being superior to regularly used classical laser sources.

FELs utilize a relativistic electron beam as a lasing medium. As a result, a monochromatic radiation is generated in ultrafast pulses, of duration down to the fs range, with a unique combination of tunability, coherence, polarization, and high power that can exceed more than 1 GW in a single pulse. Some FEL types can deliver radiation in the spectral regions of short wavelengths, ranging from vacuum ultraviolet (VUV-FEL) to X-ray regions (X-FEL), unattainable with other types of lasers. Spectral brightness of the new X-FEL sources, to be operational in the next few years, will be up to 9 orders of magnitude higher, as compared to the most intense 3GLS sources and will reach a value of 10^{29} photons/s · mrad^2 · mm^2 · 0.1% BW, emitted in ultrafast pulses of only 10-20 fs [3].

The aim of this report is to draw a spectrum of biomedical applications at FEL sources operating with a wide ranges of wavelegths, from Terahertz up to soft X-rays, that are currently available at various FEL machines. It will be shown, basing on examples of particular applications, the importance of the new sources to study ultrafast dynamics of life processes, imaging soft tissue and proteins with unprecedented spatial resolution, as well as search of new medical techniques for surgery and therapy, which can be further transferred to common clinical tools with conventional intense lasers. Possible biomedical applications at the Polish Free Electron Laser (POLFEL), proposed to be built at the Andrzej Soltan Institute for Nuclear Studies in Świerk near Warsaw will be metioned as well.

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