Compact “laser-drive” Free Electron Laser development at ELI-Beamlines: from modelling to realization

DOI: 10.34854/ICPAF.2020.47.1.015

Alexander Molodozhentsev

ELI-Beamlines, Institute of Physics CAS, Prague, Czech Republic

Laser wakefield acceleration (LWFA) approach allows to overcome the limits of the accelerating electric field in the traditional RF cavities, providing the accelerating gradients of tens of GV/m in plasma channels with the length of a few centimeters. The guasi-monoenergetic electron bunches with energy of e few GeV obtained experimentally in different research centers around the world. It opens the way to build an extremely compact multi-GeV electron accelerator. LWFA technique allows to produce electron beams with unique parameters such as extremely short bunch length of a few femtoseconds and extremely small RMS transverse emittance. Although the LWFA electron beam quality, in particular the transverse beam divergence and the energy spread, is still significantly lower than the parameters provided by conventional RF accelerators, the “laser wakefield” electron beam acceleration approach has a great potential to be considered as an electron beam driver for new generation of Free Electron Lasers and even for colliders.

ELI-Beamlines Centre, located near Prague (Czech Republic) is an international user facility for fundamental and applied research using ultra-intense lasers and ultra-short high-energy electron beams. Constant improvement of the high-power laser technology allows to provide a stable LWFA operation with high repetition rate. Using the optical parametric chirped-pulse amplification (OPCPA) technique, the ELI-Beamlines laser system will provide the laser pulse energy up to 10 Joules with the repetition rate up to 25 Hz, which will be used to accelerate electrons for the compact high-repetition-rate laser-driven compact FEL.

An overview of the “LUIS” research program at ELI-Beamlines, dedicated to development of the laser-driven compact FEL from the ‘demo’-FEL to the soft X-ray FEL, will be presented in frame of this report. Main challenges, key components of the “LUIS” setup at ELI-Beamlines and future development of the next generation of FEL will be discussed.