1 kHz Ultrarelativistic Electron Beams for On-Demand Applications

C M Lazzarini[1], A Špádová[1,2], G M Grittani[1], I Zymak[1], L Goncalves[1], S Lorenz[1], J Matěj[1,3], E R Szabó[4], J Dudás[4], R Polanek[4,5], K Hideghety[4,5], and S V Bulanov[1,6]

[1]*Extreme Light Infrastructure ERIC, Dolní Břežany, Czech Republic*
[2]*Faculty of Nuclear Sciences and Physical Engineering, Czech Technical University in Prague, Prague, Czech Republic*
[3]*Faculty of Information Technology, Czech Technical University in Prague, Prague, Czech Republic*
[4]*ELI ALPS, ELI-HU Non-Profit Ltd, Szeged, Hungary*
[5]*Department of Oncotherapy, Faculty of Medicine, University of Szeged, Szeged, Hungary*
[6]*National Institutes for Quantum Science and Technology, Kansi Photon Science Institute, Kyoto, Japan*
Contact Email: CarloMaria.Lazzarini@eli-beams.eu

The extremely high electric fields sustainable by plasma make the Laser Wakefield Acceleration (LWFA) the most compact technique to generate very highly relativistic electron beams in the MeV-to-GeV regime. However, the limited repetition rate and low efficiency of this technology has, to date, prevented people from unleashing their full potential as a unique source for basic research, biomedical applications and high flux sources of secondary radiation such as hard X-rays.

In recent years a new direction emerged showing the possibility of accelerating electron beams at 1 kHz repetition rate. We previously reported the acceleration of collimated, quasi-monoenergetic electron beams with at a record energy driven by 1 kHz repetition rate 1,7 TW OPCPA laser system.

In this talk, I will show the ALFA beamline where the electrons are accelerated and the in-air beam profiling, pointing and dose rate characterization will be presented, highlighting the importance of stability and the precision of delivering electron beams, specially requested for medical applications such as radiotherapy treatments. I will show the optimization of the laser-plasma interaction to have stable high-power electron beams in the tens of MeV range, a current up to 0,3 nA, and the use of such electron beams for the first on-demand in-air irradiation of biological samples performed at ELI-Beamlines with high dose rate (up to Gy/sec). These findings pave the way for a future demonstration of laboratory-based laser-driven electron radiotherapy treatment planning.