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High energy High repetition rate electron beams at ELI Beamlines

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Laser wakefield acceleration (LWFA) is the most compact technique to produce GeV electron beams as short as few fs. To achieve optimal LWFA conditions, the laser pulse energy, time duration and focal spot size must be properly set. At ELI Beamlines there are two LWFA beamlines open for external user access: ELBA and ALFA. ELBA is a laser-electron collider, based on Ti:Sa L3-HAPLS laser, designed to deliver up to 30 J, 30 fs pulses at a 10 Hz repetition rate. ELBA receives the L3-HAPLS laser pulses after more than 100 meters propagation inside a vacuum laser beam transport. Once the square 230 mm x 230 mm laser pulses arrive in ELBA, they are 50:50 wavefront split by a full-size dielectric mirror with a 150 mm hole. The round laser pulses are sent to an off-axis parabola that focuses them down to 55 μm FWHM focal spot 10 meters downstream. The square hollow laser pulses propagate through a delay line before reaching a 375 mm focal length off axis parabola that focuses them onto the counterpropagating electron beam. ELBA is designed to collide 2 GeV electron beam with 10^{21} W/cm^2 laser pulses. At the moment, ELBA has been commissioned with up to 15 J at 0.2 Hz and up to 8 J at 3.3 Hz, achieving GeV electron beams in self-guided regime, and multi-GeV energy in the self-waveguided regime. Five user experimental campaigns have been completed, and the user proposal acceptance rate is around 50%.

ALFA is a kHz LWFA beamline powered by the ELI in-house developed L1-ALLEGRA OPCPA laser, designed to deliver up to 100 mJ, 15 fs laser pulses at 1 kHz repetition rate. ALFA is the highest repetition rate LWFA machine operating in "multi-cycle" mode, since the L1-ALLEGRA central bandwidth is 800 nm. This makes ALFA a highly requested machine from the user community to realize relativistic plasma physics experiments that require a very high (millions) number of shots. At the moment, ALFA has been commissioned with up to 50 mJ at 1 kHz repetition rate, achieving up to 50 MeV electron beams [1,2]. These high repetition rate high energy beams enable Gy/s average dose rate, that in combination with the TGy/s peak dose rate [3], are of great interest for the radio-biology user community.

Nine user experimental campaigns have been completed in ALFA, and the user proposal acceptance rate is around 50%.

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References

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