ELI-ELBA: Laser wakefield accelerator to enable fundamental science investigations

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The ELI-ELBA scientific program is devoted to the experimental investigation of different fundamental scientific problems by using a combination of multi-PW and sub-PW lasers available at the ELI-Beamlines research facility. The core plasma technology used is laser wakefield acceleration, which is needed to produce ultra-relativistic electron beams in extremely short distances by using very high accelerating gradients (>100 MeV/mm). ELI-ELBA experiments driven by multi-PW laser systems aim at the acceleration of multi-GeV electron beams for counter-propagating them with intense (>1020 W/cm2) laser pulses in order to study novel regimes of electromagnetic field interaction with matter and quantum vacuum. Different techniques of electron injection inside the plasma wave are investigated and compared, with the goal of producing stable and reproducible electron beams. Among the techniques investigated, the best results have been obtained with shock assisted ionization injection, where the injection of the electron inside the plasma waves is limited transversally by the ionization potential of high Z gas and longitudinally by plasma density tailoring.

ELI-ELBA experiments driven by TW laser systems aim at the understanding of laser wakefield acceleration in near critical density plasmas. Moreover, these laser systems can be operated at kHz repetition rate, resulting in an increased average beam power which is of interest for multi-disciplinary applications of laser wakefield acceleration, including medical imaging, radiobiology, and non-destructive testing. In order to successfully perform laser wakefield acceleration with TW kHz laser systems, the laser time duration has to be carefully tuned. In fact, single cycle laser pulses will limit the accelerating length and, on the other hand, laser pulses longer than the plasma wavelength might lead to laser defocusing induced by the plasma waves.

In the presentation the actual status of the beamline will be presented, along with recent experimental and theoretical results obtained as part of the group activity.