Commissioning experiments with the 100 TW and 1 PW lasers at ELI-NP

D. Doria[1]

[1]Extreme Light Infrastructure (ELI-NP), and Horia Hulubei National Institute for R&D in Physics and Nuclear Engineering (IFIN-HH)

e-mail: domenico.doria@eli-np.ro

The ELI-NP (Extreme Light Infrastructure - Nuclear Physics) research facility is approaching full operational status [1-3]. Some of the experimental areas for laser-driven experiments are currently under commissioning.

The HPLS can deliver 2 laser beams at the same time and can operate at three different main output powers of 10 PW, 1 PW, or 100 TW, with maximum output energy of the laser beams of about 250 J, 25 J, 2.5 J, respectively [4]. The lasers have a wavelength centered around 810 nm, and a minimum pulse duration of 22.5 fs (25 fs typical). Each main laser power output has a different repetition rate since it uses different stages of amplification, that is 10 Hz, 1 Hz, and 1/60 Hz for 100 TW, 1 PW, and 10 PW, respectively.

Recently, the commissioning of the 100 TW experimental area has been successfully attained with a LWFA experiment on electron acceleration. In this experiment, the laser beam was focused by a parabolic mirror with F/28 to a maximum peak intensity of $I_0 \sim 1.7\times10^{19}$ Wcm^{-2} and interacted with a gas-jet of 2 mm output diameter. The beam's energy fluctuation was < 5%, and its pointing stability ±7 μrad during a full day of run. We shot on two different gases: pure He and a gas mixture of He and 2% Nitrogen. Several important parameters, like electron beam pointing and divergence, charge, energy spectrum, laser beam pointing, near-field, and energy, were grabbed at a full-power shot via online diagnostics and on a shot-to-shot basis. Simulations were performed with a PIC code and are in good agreement with experimental data. Further, the commissioning of the 1 PW area has started in June 2021 and will continue until the end of the year. It will focus on benchmarking the 1 PW laser system (200 mm beam diameter, 25 J, 25 fs) and the experimental area, denominated E5, through the acceleration of ions via solid target (e.g., acceleration of proton via TNSA), and electron via LWFA in a gas target. For the ion acceleration the laser beam will be focused using an F/3.5 parabolic mirror to a peak intensity up to $I_0 \sim 5\times10^{21}$ Wcm^{-2} onto solid targets of various thicknesses and materials. A large variety of detectors will be employed to characterize the by-products of the interaction, among which, a stack of radiochromic films, a Thomson parabola with Image plate detector or a Lanex screen for online detection, an optical probe for laser temporal contrast evaluation via preplasma detection, laser near-field and far-field. The electron acceleration will be performed by employing gas cell and gas-jet targets and two gas types (He, and He+2%N_2) by focusing the laser beam with a parabolic mirror of a focal length of 480 cm, that corresponds to an f-number of about 24. The goals of the commission are attaining a few 10s of MeV proton energy from plastic and metal foils and more than 1 GeV electron from the gas target, then achieving the expected values from the literature.

The setup and the results of the commissioning experiments with the 100 TW and 1 PW lasers will be presented at this conference.

References

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