Contribution ID: **38**

Type: **invited**

Laser and Particle Guiding in Plasmas at I-LUCE (INFN Laser indUCEd radiation production)

Thursday, 12 September 2024 11:15 (30 minutes)

The pursuit of compact, high-brightness particle and radiation sources has driven significant advancements in laser technology, emphasizing improved efficiency and repetition rates [1]. These developments have led to the emergence of a new generation of ultrafast high-power laser systems operating at high repetition rates worldwide.

In 2024, a new high-power laser facility called "I-LUCE" (INFN Laser indUced radiation acCEleration) will be established at INFN-LNS (Istituto Nazionale di Fisica Nucleare –Laboratori Nazionali del Sud) [2]. This facility's construction is funded by three projects under Italy's PNRR (Piano Nazionale di Ripresa e Resilienza) program: EuAPS (EuPRAXIA Advanced Photon Sources), Samothrace (SiciliAn MicronanOTecH Research And Innovation), and Anthem (AdvaNced Technologies for Human-centrEd Medicine).

The Ti:Sapphire laser at I-LUCE will have two outputs: a 50 TW beam line (25 fs, 25-30 mJ, 10 Hz) and a main beam line with a 350 TW laser (25 fs, 10 J, 2 Hz). I-LUCE will feature two distinct experimental areas, E1 and E2.

E1 will provide a globally unique setup that combines laser-generated plasmas with accelerated heavy ion beams from a Superconducting Cyclotron and a Tandem (already installed at LNS). This configuration will facilitate pioneering experiments in plasma physics, nuclear physics, and atomic physics. For moderate laser beam intensities (up to 50 TW), E1 will focus on nuclear fusion experiments and the study of stopping power in plasma.

In contrast, the E2 experimental room will specialize in proton and electron acceleration. It will include a specialized beamline designed to select, transport, and focus proton beams with energies ranging from 5-60 MeV, optimized for radiobiological experiments. Additionally, an electron beamline will be implemented to select beams with energies between 0.1-3 GeV. E2 will also enable independent experiments using intense laser beams to explore fields such as X-ray laser generation and neutron production.

References

1. M Tabak et al, Phys. Plasmas. 1 (1994).
2. C Agodi et al, Eur. Phys. J. Plus. 138 (2023) 1038.

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Session Classification: Laser/Plasma & Channeling