Plasma acceleration, beam manipulation and advanced radiation sources

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Introduction

It is widely accepted by the international scientific community that a fundamental milestone towards the realization of a plasma driven future Linear Collider (LC) will be the integration of the new high gradient accelerating plasma modules in a short wavelength Free Electron Laser user. Applications of high quality beams to material science and radiobiology, either directly, or via other compact secondary emission mechanisms, including Compton γ-ray and positron sources, will be also possible. To this end a number of crucial components can be developed in the existing Italian test facilities SPARC_LAB (INFN-LNF). In the following abstracts we propose to investigate experimentally important aspects of novel acceleration techniques and advanced radiation sources.

Abs_1 - Adiabatic plasma lenses (Id: 123)

One of the key elements of the plasma blowout regime is the strong, linear focusing provided by the ion density. This focusing provides highly effective transverse guiding of beams. Another advantage of underdense plasma focusing is its flexibility, the extreme strength of the focusing gradient is simply proportional to plasma density , which may be easily changed experimentally. The adiabatic plasma lens is a potentially transformative technique for advanced radiation sources, and is based on this flexibility, relying on an adiabatic increase in focusing to funnel the beam size down to very small spots. As such, it may be used to mitigate the need for very long beam transport and matching systems.

Abs_2 - Energy spread de-chirper (Id: 124)

We aim to show energy-chirp compensation of electron beams in a plasma, providing the basis for efficient beam transport and ultimately to allow the utilization of plasma accelerated beams for photon source application. The proposed method relies on the fact that longitudinal fields as seen by a short driving beam are decelerating and thus, can be used to compensate an initially imposed energy-chirp. This offers the possibility to cancel the energy chirp of the accelerated beam by making him drive a plasma wave. The resulting wakefields will make the tail of the drive beam lose energy, while the head is unaffected. Since the accelerated beam is very shorter, the plasma density can be adjusted at the end of the acceleration module to bring the beam to drive a wake for “self-dechirping”. To this end a dedicated design, production and test of the plasma module is required.

Abs_3 - Plasma driven UV FEL test experiment (Id: 121)

As an outcome of the previous abstracts the high quality electron beams eventually produced by a plasma accelerator module at SPARC_LAB could be injected in the existing undulator chain or in a short period undulator of new type, for example a RF undulator, thus enabling the investigation of the performances of a compact UV FEL source, an extremely important contribution towards the V generation light sources development like EuPRAXIA.

Abs_4 – Plasma Acceleration staging (Id: 122)

The basic of Laser Wake field acceleration (LWFA) scheme is limited by the diffraction of the laser pulse, the de-phasing of the electron bunch and finally by laser energy depletion. To overcome these three limitations of LWFA schemes various solutions were proposed and demonstrated, except for laser energy depletion. Concatenating (staging) tens GeV-level acceleration units is a natural solution to drive X-FEL photon sources. However, employing conventional optics to couple the laser energy into the acceleration region sets the length of a single unit to more than one meter. We propose demonstration of employing the curved capillaries (developed in Hebrew University) to combine guided multiple high intensity laser pulses into a single channel and accelerate the electrons injected by the SPARC_LAB high brightness photoinjector. This proof of principle experiment can lead to the compact multistage LWFA acceleration channel where the interaction with electron bunch takes place.