Contribution ID: **29** Type: **not specified**

Making GHz Frame-Rate Movies of Plasma Accelerator Devices

When two short electron bunches, separated in time by a few hundred femtoseconds, are focussed in to a plasma the space-charge force of the leading bunch expels plasma electrons from its vicinity. This creates accelerating and focussing electric fields for the trailing bunch with GV/m strengths, at least an order of magnitude greater than radiofrequency accelerators. Plasma accelerators therefore hold great promise to dramatically reduce the size and cost of future electron accelerators, providing a route to increased access to accelerator facilities and reduced environmental impact [1-5].

A key upcoming challenge for plasma accelerators is to raise their repetition rate from the current state of the art of 1-10 Hz to levels required for Collider or Free Electron Laser facilities, which is typically of order 10 kHz, or even 1 MHz. The first concrete steps towards this goal are currently being made as part of the FLASHForward experiment at DESY [6]. In order to produce the same accelerated beam properties every time the density profile of the plasma target must be kept the same, which is no easy challenge when both the drive bunch and the electric pulse used to create the plasma each deliver of order 100 J/m^3/us average power densities into the plasma source. Due to the rapid evolution of high energy density systems, diagnostics are required on the significantly sub-microsecond level.

This project will contribute to understanding the energy dissipation process from the plasma creation by using an ICCD camera to take nanosecond-gated images of the plasma evolution in the capillary to build up a GHz frame-rate movie of the plasma evolution. By spectrally filtering the light coming from the plasma, the behavior of trace elements used for density and temperature analysis can be mapped out, contributing to a fuller understanding of the plasma source. If time allows, the project could be extended to studying the effects of modifications to the plasma source design, which could be rapidly prototyped using 3D printing. Finally, a recently demonstrated statistical method could be attempted to provide high-time-resolution movies without the need for expensive cameras [7], making it suitable for implementation into the accelerator environment at FLASHForward.

Bibliography
[1] T. Tajima and J. M. Dawson, Laser electron accelerator, Phys. Rev. Lett. 43, 267 (1979).
[2] P. Chen et al., Phys. Rev. Lett. 54, 693 (1985).
[3] M. Litos et al., Nature 515, 92–95 (2014).
[4] C. A. Lindstrøm et al., Phys. Rev. Lett. 126, 014801 (2021).
[5] B. Foster et al., New J. Phys. 25 093037 (2023)
[6] https://mpl.desy.de/ffwd/
[7] V. Lee et al., Phys. Plasmas 31, 013104 (2024)

Group

FH-FTX-AST

Project Category

B3. Research on accelerators

Special Qualifications

This is an experimental-based project. Some lab experience would be advantageous. Skills in data analysis in a language such as Python or MATLAB will be required.

DESY Site

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