The design and performance of an asymmetrical nozzle in Laser Wake Field electron acceleration

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Laser Wakefield is a method for the acceleration of electrons up to the GeV level, with important applications[1]. Experimentally, the acceleration is realized by focusing an ultra-intense ($I>10^{18}$ W/cm^2), ultra-short ($t<50$ fs) laser pulse on an under-dense gaseous target. The parameters that interplay and lead to the tunability of the acceleration process are the laser pulse characteristics (e.g energy, pulse duration) as well as the gas density profile.

The gas density profile is defined by the gas itself, the backing pressure, and the nozzle geometry. The importance of the gas density profile has been examined by many groups experimentally and numerically. One of the significant ideas is the plasma density down-ramp, which is reported to enhance the control over the electron beam quality[2,3]. To achieve such a profile either a complex target is needed (multiple jets[2], blade[3]), or the design of a specific asymmetric nozzle[4].

We are working on the development of an asymmetric nozzle by conducting 3D computational Fluid Dynamic (CFD) simulations. We have conducted studies for conical nozzles using 2D simulations. Based on the results of these simulation studies, nozzles were 3D printed and used in our experiments[5,6]. Based on 3D simulations we now examine an advanced, asymmetrical nozzle design. This nozzle, producing a high-density peak, followed by a lower density plateau, is expected to improve electron beam quality. The nozzle's profile characterization and its performance in our experiments will be presented.

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