Effect of density ramp on electron acceleration driven by tightly focused ultrashort laser pulses

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In the present work we investigate the optimization of electron acceleration in high density plasma, where the scale length of the density ramp is similar to the Rayleigh length of a tightly focused laser pulse. By changing the focus position relative to the density ramp at the front side of the gas target the pulse envelope can evolve very differently, which results in different electron spectra (see Fig. 1). The counter-acting relativistic self-focusing and pulse diffraction decide the evolution of the peak intensity, which in turn influences the electron injection and wakefield amplitude. Up to now only several relevant works have been published and they show different results, depending on the focusing optics or other setup parameters [1].

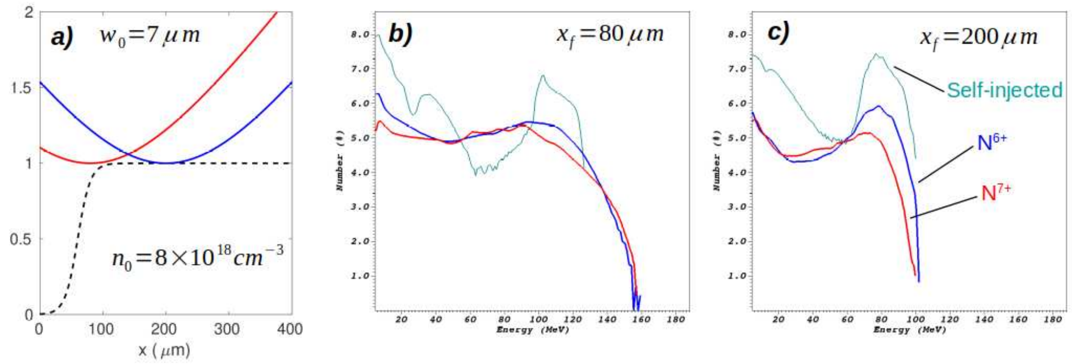

Figure 1: *(a) Simulation setup: dashed lines shows the plasma density profile and the full lines present the laser waist size agains propagation distance in vacuum. Resulting electron spectra (log_{10}) are shown for two focus positions: at the end of the density up-ramp (b) and much deeper inside the plasma (c).*

In Fig. 1 the 3D simulation was performed with a grid resolution of 500x300x300, which is used to resolve a domain size of 24x32x32 μm^3. The pulse duration is 8 fs, contains 80 mJ energy, $w_0 = 7\,\mu$m and the density profile is described as: $n_e = n_0[1+\tanh(x/\sigma - 3)]/2$, where $\sigma = 20\,\mu$m. We consider to use Gaussian density profiles as well in future simulations. The target gas was composed of He and 1 % Nitrogen, but self injection is dominant.

References

[1] F. Salehi, et al., Phys Rev X **11**, 021055 (2021)