# Direct laser acceleration enhancement using plasma density modulations

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High-intensity laser pulses are able to accelerate electrons to high energies during their interaction with plasmas. The interaction length needed for the acceleration is very short (a few millimeters) which makes it a suitable alternative to conventional accelerators. One of the most examined mechanisms of electron acceleration is called direct laser acceleration (DLA). When a laser pulse propagates through gaseous plasma, it creates a plasma channel that triggers electron oscillations around the channel axis. The resonance of oscillations inside the channel with the oscillations in the field of laser pulse might result in efficient electron acceleration. The mechanism produces high charge electron bunches ($\sim$ 100 nC) with a broad Maxwellian-like energy spectrum.

Even though the mechanism has been studied both theoretically and by experiments, the acceleration is still not completely understood due to its complexity. Many nonlinear plasma phenomena are present during the interaction. This limits the validity of simplified analytical models and opens many paths towards the optimization of the process. It has been shown experimentally [1] that varying density profile might be beneficial for the acceleration process.

In our work, we explain how the modulation of plasma density enhances the acceleration based on the results of quasi 3D particle-in-cell simulations using the OSIRIS platform - fully relativistic Particle-in-Cell code. We show that increasing density profile enables the acceleration of electrons that would not be accelerated in the constant density regime.We also demonstrate the importance of laser pulse self-focusing and propose how density profiling can be used to ameliorate the DLA.

## References

[1] A. E. Hussein *et al.*, New Journal of Physics **23** (2021)