Analytical and Numerical Studies of Underdense and Overdense Regimes in Plasma-Dielectric Wakefield Accelerators

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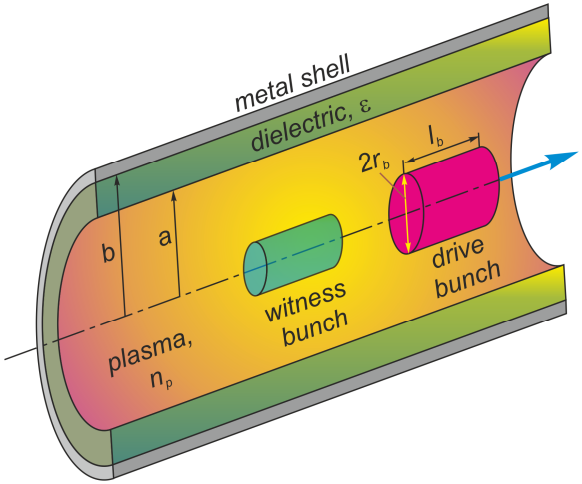
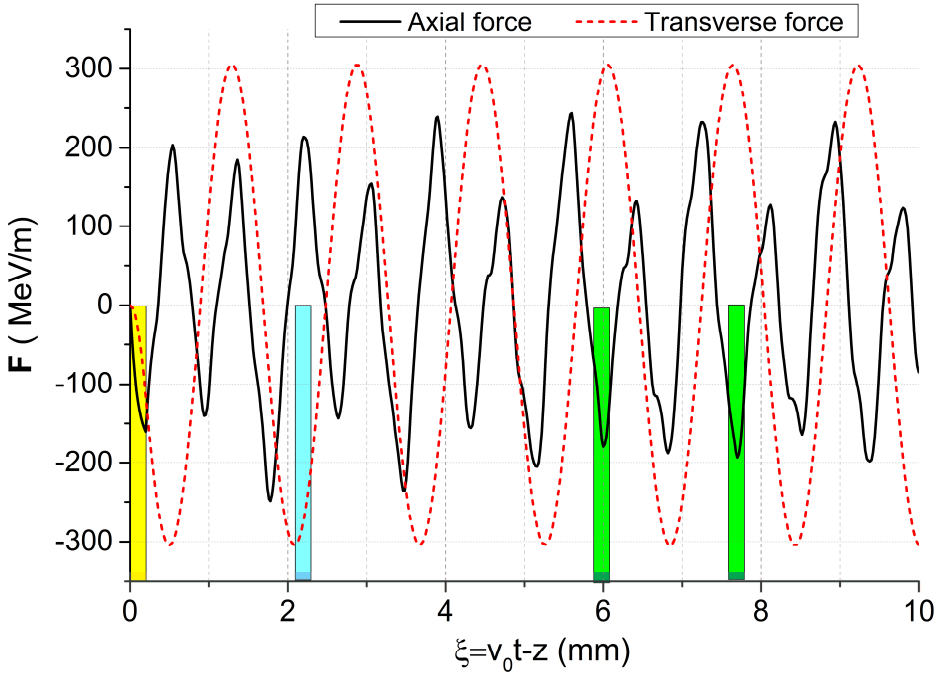
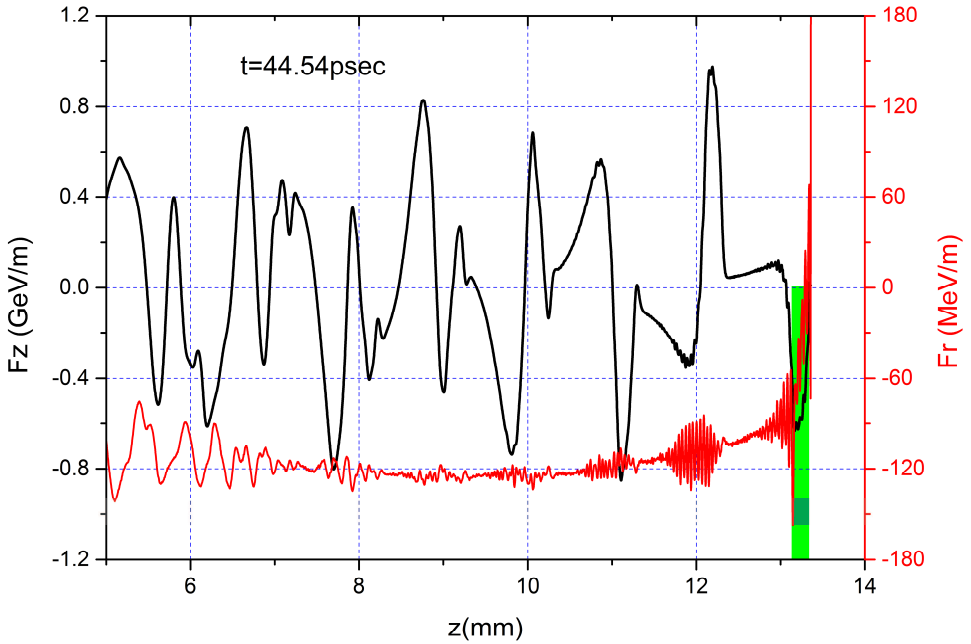


Analytical studies and PIC simulations of wakefields excited by an electron bunch in a single-channel Plasma Dielectric Wakefield Accelerator (PDWA) showed:

1. Filling up the dielectric waveguide vacuum transport channel with isotropic plasma having a specific density sets up a focusing wakefield for drive and witness bunches, and a witness bunch can be accelerated.
2. For the case of a linear plasma ("overdense" regime), the focusing of witness bunch particles is provided by the plasma wave, and acceleration is provided by the eigen waves of the empty dielectric waveguide.
3. The focusing mechanism is charge symmetrical in case (2): it can be used both for accelerating electron bunches and for accelerating positron bunches.
4. For the case of nonlinear plasma, focusing is provided by the plasma ions remaining in the transport channel after pushing out the plasma electrons. Acceleration, as before, is provided by the dielectric wave.





Overdense regime of PDWA: Axial profile of the axial force (black line) and transverse force (red line) at the distance r=0.45mm. Cyan rectangle shows possible location of electron witness bunch and green rectangles show possible location of positron witness bunch. OD=1.2mm. ID=1mm, n_b/n_p=1/3, n_p=4.5·10^{14} cm^{-3}. Bunch energy is 5 GeV, bunch charge is 3nC. The focusing force amplitude is approximately 300MeV/m, which equals a focusing magnetic field induction ~1T. Drive bunch, which moves right to left, is shown as a yellow rectangle.

Underdense regime of PDWA: Axial profile of the axial force (black line) and transverse force (red line) in the case of underdense ("blowout") excitation regime of PDWA: Drive bunch moves from left to right, its location is shown as a green rectangle. OD=1.0mm. ID=0.4mm, Plasma density n_p=·10^{14} cm^{-3} , n_b/ n_p=30. Bunch energy is 5 GeV, bunch charge is 3nC. At plasma density n_p=4.5·10^{14} cm^{-3} it is possible to expect amplitude of the focusing force ~530 MeV/m , corresponding to a focusing magnetic field ~1.8 T.