Schemes of Electron Beam Loading in the Blowout Regime in Plasma Wakefield Accelerators

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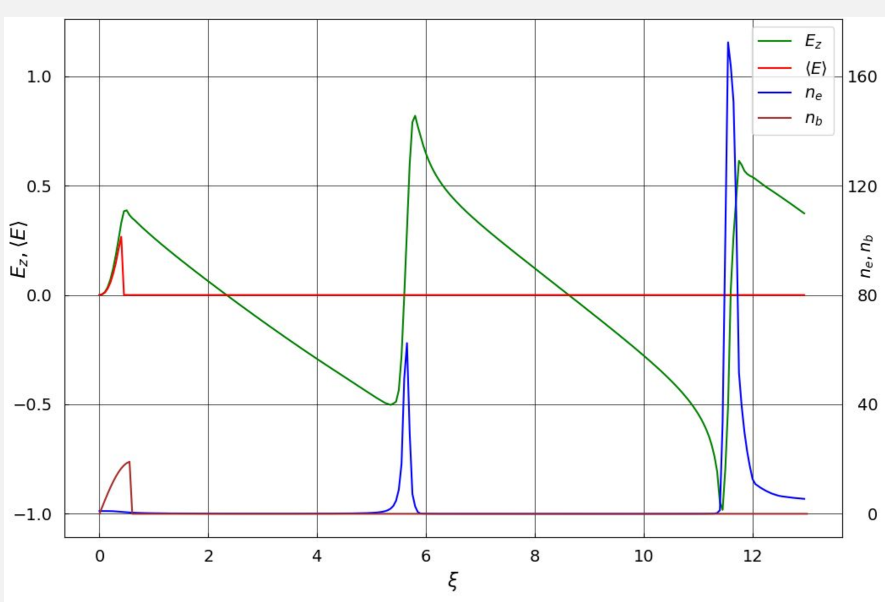
Motivation and results

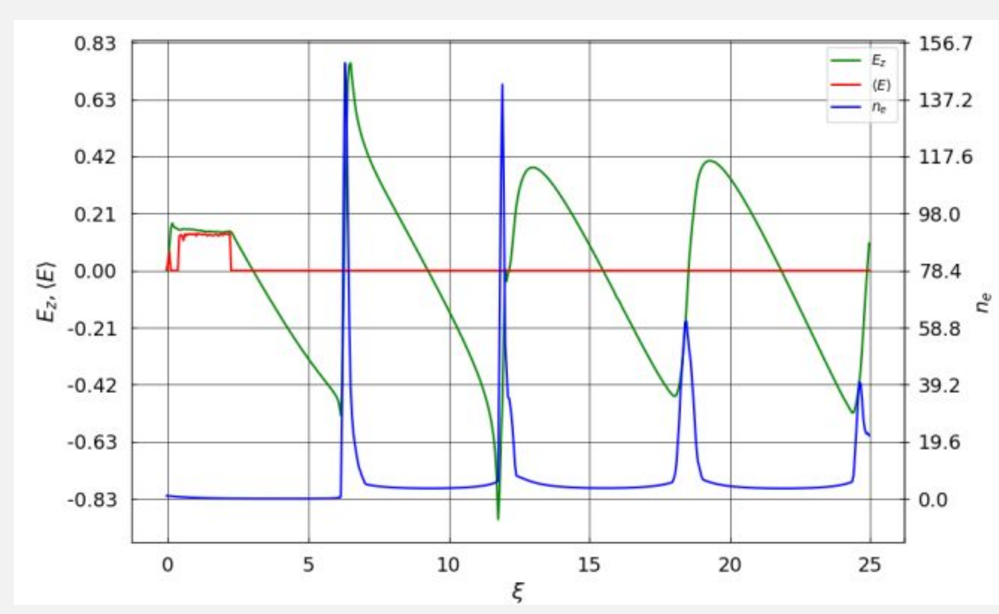
Future applications of plasma-wakefield accelerators, in particular particle colliders and free-electron lasers, demand beams with low energy spread, small emittance and high charge, with large transformer ratios and high-efficiency operation. Achieving these properties simultaneously requires the formation of plateaus in both the accelerating field for witness bunches and the decelerating fields for driver bunches. Plateau formation is facilitated by controlled beam loading with carefully shaped current profiles. With numerical simulations, we demonstrate optimal beam loading conditions in a blowout electron-driven plasma accelerator.

1. Usage of accelerating wakefield, distributed according to linear dependence, short and long driver cases

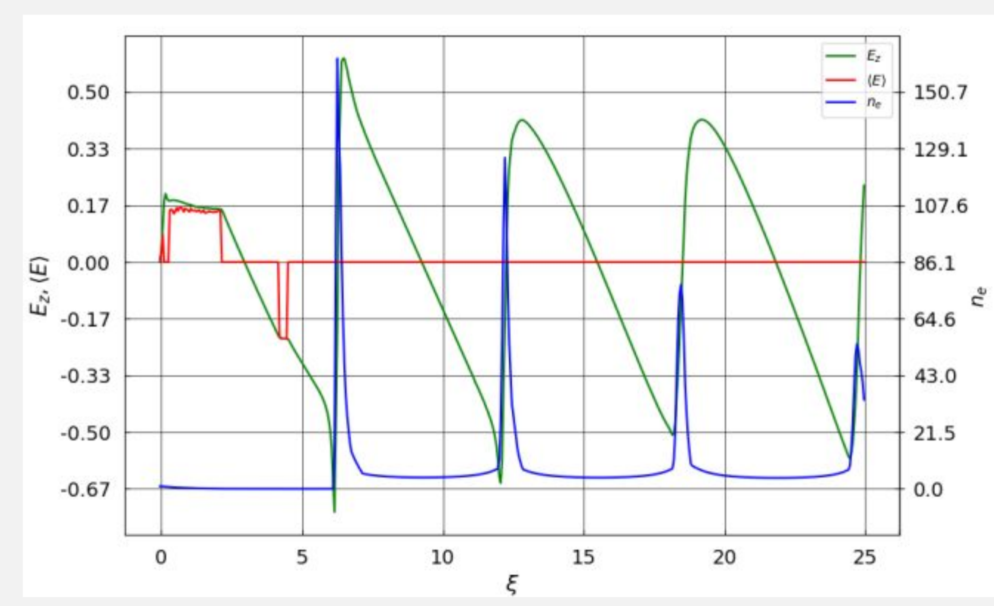
1. Linear longitudinal profile of the accelerating wakefield [1]



2. Increased size of the driver for effective acceleration

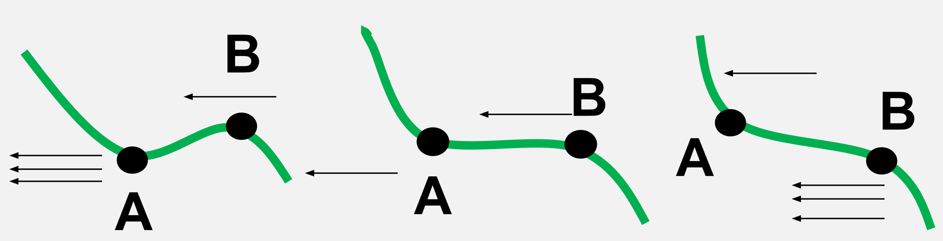


3. Conservation of plateau-like accelerating field due to linearity

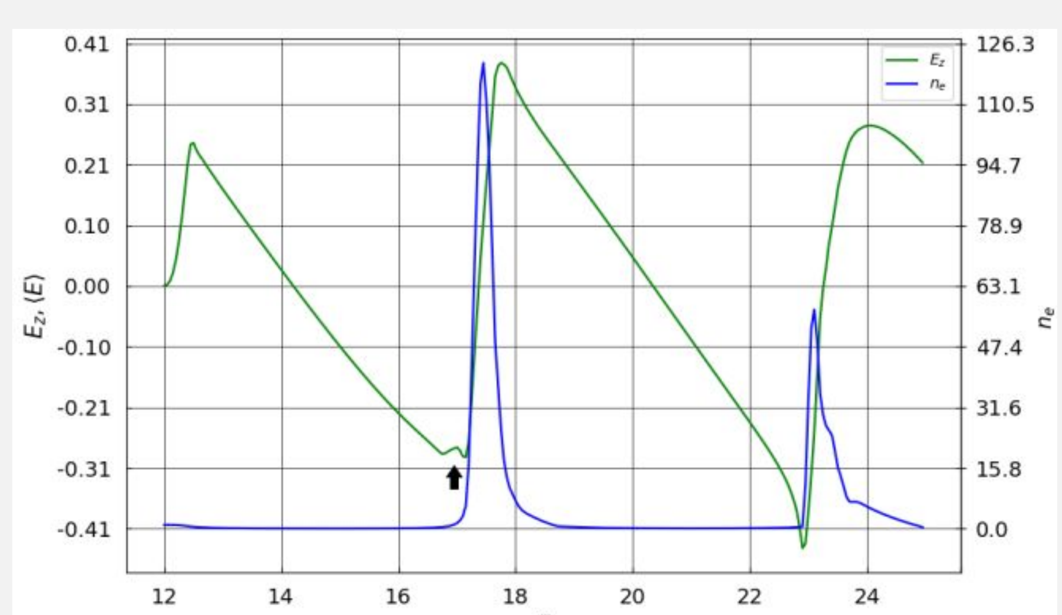


2. Compensation effect: the process of plateau formation

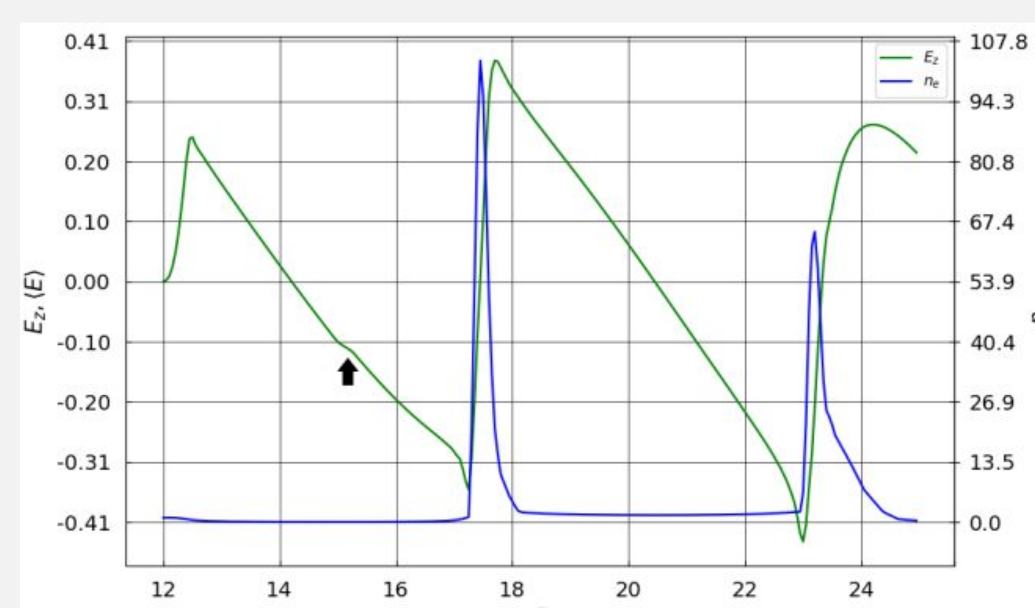
1. The plateau for the witness could be reached at different sections of the almost-linear curve of the electric field and even shifted from one region to another with a little parameters adjustment.



2. Near the back of the bubble, the slope of $E_z(x_i)$ is positive

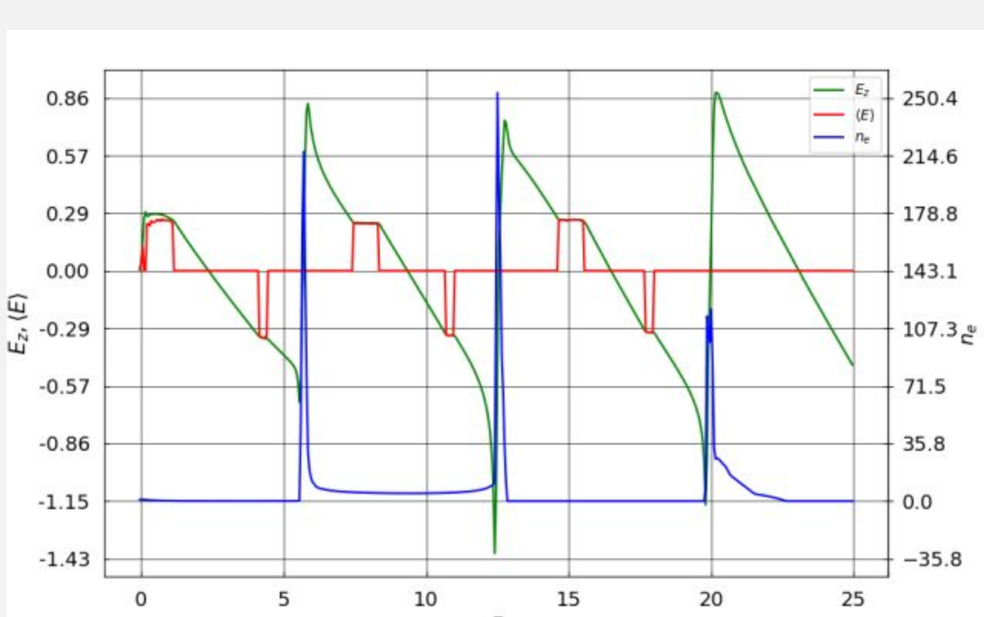


3. If the bunch is shifted forward, the slope is negative

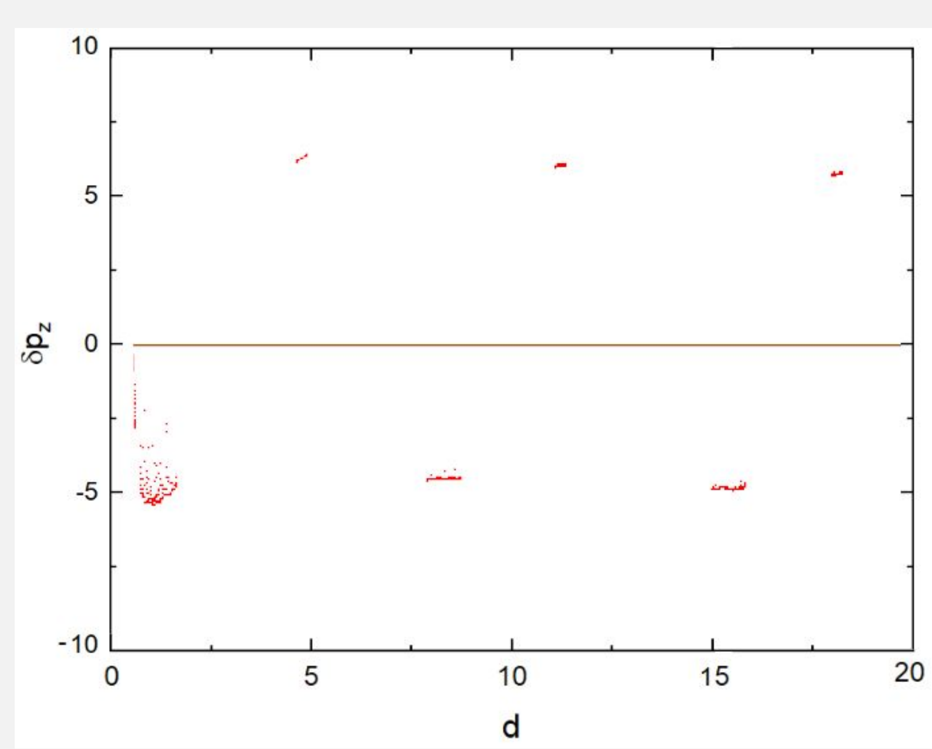


3. A chain of driver and witness bunches

1. All plateaus are approximately at the same level, which means they have the same accelerating/decelerating field.



2. The momentum spread $\delta p_z = p_z - p_{z0}$, where p_{z0} is the initial momentum of the beam.



By using a chain of driver and witness bunches we could increase the total charge of accelerated particles.

The spread of the witness z-momentum is 0.02% for the relativistic factor of bunch γ = 1000.

References

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Conclusions

In the accelerating region, the E_z field depends roughly linearly on the longitudinal coordinate x_i.
For a given current profile, changing the longitudinal position of the witness beam changes the beam loading.
In this configuration, It is possible to increase driver size for further efficiency increase.
By the means of using a chain of driver and witness bunches the total charge of configuration increases.

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