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Simultaneous Space Time Focusing in Controlled Ionisation Injection

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Controlling the injection and trapping of electrons into plasma wakefields is key to improving the beam quality and reproducibility of accelerated beams. Injecting electrons into a narrow (r_p) transverse region of the wakefield is fundamental to achieving low beam emittance. Brief ($T_{inj} L_{acc}/c$) injection into a short (z_p) longitudinal region yields low energy spread. Several schemes have been proposed for controlling injection by generating electrons within the wakefield itself by laser ionisation of a dopant species. These include Trojan Horse, Two-Pulse Ionization Injection (2PII), Resonant Multi-Pulse Ionization Injection (REMPI) and Two-Colour Laser-Ionization Injection. In this work we investigate how simultaneous space-time focusing (SSTF) of the injection pulse can reduce both the volume and duration of ionisation injection.

To test these ideas we investigate the use of SSTF pulses in the Trojan Horse scheme. We use PIC simulations to show that a correctly tailored SSTF pulse can reduce the normalized transverse emittance of the injected and accelerated bunch ($E = 350$ MeV) from $N = 100$ nm rad to $N = 6$ nm rad. The approach we present could be applied to injection schemes based on laser ionisation injection

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