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Witness beam realignment in plasma wakefield accelerators in the linear collider regime

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Beam driven plasma wakefield acceleration (PWFA) has shown the ability to accelerate electron beams with high acceleration gradients ˜50 GeV/m, high efficiency, and low energy spread. This has inspired future linear collider (LC) designs where witness beams are accelerated over a series of plasma stages. In the LC regime, the witness beam emittance is ˜100 nm and the charge is ˜1 nC. With these parameters, the ion collapse will be drastic and lead to emittance growth. An et al. (2017) [1] showed this emittance growth is tolerable when using a wide driver and assuming no witness beam offset. Mehrling et al. (2018) [2] showed hosing of the witness beam is suppressed in this regime, due to the non-linear focusing created by the ion motion caused by the witness beam itself. Hildebrand et al. (2018) [3] showed that the on-axis ion density formed by a high density
(small spot size) drive beam can fully eliminate the witness beam hosing and realign it with the drive beam at the cost of emittance growth. We will show that using adiabatic density ramps can match the beam with the presence of ion motion and realign an offset witness beam with tolerable emittance growth. We do this by running self-consistent simulations of a full lithium plasma stage in the LC regime using the code QPAD, a quasi-static PIC code with azimuthal decomposition.

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