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High-efficiency wake excitation in beam-ionized plasmas at FACET-II

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FACET-II is a new 10 GeV electron beam facility hosted by the SLAC National Accelerator Laboratory and E300 is the flagship experiment aiming at demonstrating high-quality two-bunch PWFA [1, 2]. An important goal of E300 is to demonstrate efficient (40%) energy transfer from the drive to the trailing bunch [1]. This number in turn is the product of the drive beam to the wake (80%) and from the wake to the trailing bunch (50%) efficiencies. In order to obtain such a high drive beam to the wake energy transfer, the bulk of the particles must be nearly fully depleted of their energy. In this talk, we will present experimental results on high-efficiency wake excitation which is an important stepping stone for achieving overall high energy transfer efficiency. We show that up to 70% of the charge contained in the FACET-II beam can self-ionize static fill (up to 2 Torr) of hydrogen gas over greater than one meter and lose significant amount of its energy in driving a wake. Correlation measurements on the integrated plasma emission and the energy spectrum of the beam after interaction suggest a beam-to-wake energy transfer efficiency up to ~70%. The measurements also show evidence for that a portion of the 10 GeV drive beam has lost all its 10 GeV energy (pump depletion), which is necessary for achieving high beam-to-wake energy transfer efficiency.

References

- [1] Joshi C. et al., "Plasma wakefield acceleration experiments at FACET II." *Plasma Physics and Controlled Fusion* 60, no. 3 (2018): 034001.
- [2] Yakimenko V. et al., "FACET-II facility for advanced accelerator experimental tests." *Physical Review Accelerators and Beams* 22, no. 10 (2019).

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