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Single Shot High Transformer Ratio Measurements in the Nonlinear Plasma Regime

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We demonstrate the first single shot measurement of a multi-period, loaded PWFA wakefield, used to conduct measurements of the transformer ratio (TR), the ratio between the maximum accelerating and decelerating fields in a collinear wakefield accelerator, that far exceed previous measurements. The emittance exchange beamline at the Argonne Wakefield Accelerator was used to create a variable longitudinal drive profile with a long witness to sample multiple wakefield periods. A TR exceeding the limit of 2 for longitudinally asymmetric beams was observed for a linear ramp and wakefield flattening was observed for a beam with a parabolic head. These effects are important for efficient energy transfer from drive to witness beam, and for lengthening the interaction length of the process. Furthermore, by adjusting plasma density parameters, multi-period plasma wakefields were observed transitioning from linear to nonlinear regimes leading to experimental verification of theoretical wakefield properties. 3D Particle in cell simulations are used throughout to support the experimental findings.

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