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Experimental Opportunities for the Plasma Wakefield Acceleration in a Narrow Plasma Channel

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The stability of the drive electron beam in plasma wakefield acceleration (PWFA) is critical for the realization of many applications. The growing instability of a drive electron beam can couple into the plasma wake and further impact the transverse dynamics of the witness beam, rendering the emittance and energy spread to grow. Applications like positron acceleration in an electron-driven blowout wake require a stable drive beam to produce an experimentally usable accelerating phase for the positrons at the tail of the wake.
Recent theoretical developments show that finite radius plasma columns suppress the hosing instability introduced by a tilted drive beam or by a transversely misaligned drive beam. This theoretical work motivates our experimental study. We present experimental opportunities at the Facility for Advanced Accelerator Experimental Tests II (FACET-II) E333 experiment to study the longitudinal dynamics of an electron beam propagating in a laser-ionized plasma column with a finite radius smaller than its blowout radius. Various widths of the plasma column will be formed in the experiment to study the acceleration gradient and energy transformer ratio of a narrow plasma column PWFA and further understand the relationship between beam stability and acceleration efficiency in a finite plasma channel.

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Primary authors: LEE, Valentina (University of Colorado, Boulder); BENEDETTI, Carlo (LBNL); DIEDERICHS, Severin (DESY / LBNL); Dr ESAREY, Eric (Lawrence Berkeley National Laboratory); GESSNER, Spencer (SLAC); Dr HOGAN, Mark (SLAC National Accelerator Laboratory); LITOS, Michael (University of Colorado Boulder); OSTERHOFF, Jens (DESY); SCHROEDER, Carl (LBNL); THÉVENET, Maxence (DESY)

Presenter: LEE, Valentina (University of Colorado, Boulder)

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