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Beam-Driven Plasma Wakefield Acceleration

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The plasma wakefield accelerator (PWFA) concept is experiencing renewed interest thanks to the recent experimental results that showed that ultrarelativistic electrons can gain as much as 42GeV in only 85cm of plasmas. In the PWFA a short particle bunch drives large amplitude wakefields in a neutral plasma. The wakefields can have a very large longitudinal component (>10GV/m) that leads to energy loss and energy gain, and a very strong transverse component (>1MT/m) that naturally lead to propagation of the bunch over long distances with small transverse size. This combination can lead to very large energy gain over very short distances, making the PWFA concept very attractive for a future, more compact and affordable electron/positron linear collider. However, beyond these physics experiments that prove that such fields can be driven in plasmas, the acceleration of good quality electron and positron bunches must be demonstrated. The questions of efficiency and available drive beam energy and power must be addressed. Toward this goal a new facility, FACET will come into operation this year at SLAC, delivering ultra-short electron and positron bunches to meter scale plasmas. These single bunches can be tailored into trains of drive and witness bunches. Low energy experiments are conducted at the Brookhaven National Laboratory Accelerator Test Facility to explore resonant excitation of plasma wakefields and the possibility large energy gain through large transformer ratios. A new experimental program using high-energy proton bunches available at CERN is being proposed to investigate the possibility of generating TeV-calss electron bunches in a single plasma cell. The PWFA principle will be described, recent key experimental results, and plan and prospects for current and future experiments will be presented.

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