



Contribution ID: 127

Type: talk

Beam Matching in PWFA with a Laser-Ionized Plasma Source

Tuesday, 17 September 2019 19:00 (20 minutes)

Plans for a laser-ionized, beam-driven plasma wakefield accelerator at SLAC's FACET-II facility are presented. The plasma source is formed by laser ionization of a volume of uniform density gas, and the plasma density profile is therefore determined by the focal pattern of the laser. This offers the advantage of a tunable density profile that can accommodate entrance and exit ramps suitable for beam matching. Analytical solutions to the transverse beam dynamics in a plasma ramp for near arbitrary ramp profiles will also be presented. Notably, the equations capture the beam envelope oscillations that take place in adiabatic plasma ramps, which have been ignored in previous literature and can contribute to both the emittance growth of the beam and the beam's orientation in phase space at the plasma exit. Using the presented beam dynamics, idealized ramp shapes for beam matching are devised and evaluated. An example plasma source based on parameters relevant to beam-driven plasma wakefield acceleration experiments planned for FACET-II is considered, and the variational tolerance for the most significant adjustable parameters are calculated and shown to have a comfortable margin of error. Finally, experimental plans for the formation and diagnosis of the plasma source are presented.

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Session Classification: WG5

Track Classification: WG5-WG7 Joint Session