ID contributo: **307** Tipo: **Oral contribution**

Gas-dynamic density downramp injection in a beam-driven plasma wakefield accelerator

giovedì 21 settembre 2023 17:05 (20 minuti)

Development of internal injection methods in beam-driven plasma accelerators (PWFAs) is a crucial task toward high-quality low-emittance bunch generation and improved control over bunch parameters for quality-demanding applications like free-electron lasers. For this, ultrashort high peak current electron beams are required to drive a PWFA in the blowout regime which enables trapping of the background plasma. Here we present the experimental demonstration of density downramp injection at a gas-dynamic shock in a beam driven plasma accelerator powered by laser-accelerated electron beams. The femtosecond electron beam driver with a peak-current exceeding 10 kA enables injection of electron witness bunches at gentle density ramps, i.e., longer than the plasma wavelength, which nurtures prospects for ultralow bunch emittance. By precision control over the position of injection we show that
these bunches can be energy-tuned in acceleration gradients of near 120 GV/m. We anticipate that this setup paves the way for further investigation of various internal injection schemes in PWFAs for the generation of high brightness witness beam.

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Classifica Sessioni: WG1:Plasma-based accelerators and ancillary components

Classificazione della track: WG1: Plasma-based accelerators and ancillary components