Contribution ID: **182** Type: **not specified**

Lifetime of beam-driven wakes at FACET-II

Monday, 22 July 2024 13:30 (20 minutes)

The time for stationary plasma to recover its original state after a wake is excited determines repetition rate and luminosity of plasma-based colliders. Recent measurements at DESY [1] showed that an argon plasma of density ne ≈ 10^{16} cm^{-3} in which a 0.5 J (0.5 nC, 1 GeV) e-bunch excited a first wake supported excitation of a second wake at the same location with indistinguishable beam properties within 60 ns. Here, we report Spring 2024 results of experiment E-324 at SLAC's FACET-II in which 20 J (2 nC, 10 GeV) e-bunches excited meter-long nonlinear wakes in stationary lithium, hydrogen, and argon plasmas of density ne ≈ 10^{16} cm^{-3}. Scattered light from a 1 mJ, 100 fs optical pulse impinging on the plasma filament at grazing incidence (~1°) at delays 1 ns ≤ Δt ⊠ 1 ms then sensitively probed wakefield remnants. In lithium plasma, probe scatter peaked at Δt ≈ 100 ns and remained visible out to Δt ≈ 2 microseconds. In contrast, no scattering was visible from the e-beam-excited hydrogen plasma beyond Δt ≈ 100 ns; scattering from Argon disappeared at Δt ≈ 300 ns. The results will be discussed in light of earlier findings of experiment E-224 [2], which showed that ion motion dominated energy transport out of the beam-excited region for Δt ⊠ 0.3 ns.

References:
[1] R. D'Arcy et al., Nature 603, 58-62 (2022).
[2] R. Zgadzaj et al., Nat Commun 11, 4753 (2020).

Working group

WG3 : Beam-driven plasma acceleration

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Session Classification: WG3