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Lifetime of beam-driven wakes at FACET-II

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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 0.5J(0.5nC,1GeV) e-bunch excited a first wake supported excitation of a second wake at the same location with indistinguishable beam properties within 60ns; in [2] a similar study was carried out in hydrogen plasmas. We report 2024 results at SLAC's FACET-II facility where 20J(2nC,10GeV) e-bunches excited meter-long nonlinear wakes in stationary lithium, hydrogen, and argon plasmas of density ne≈10^{16}cm^{-3}. Shallow angle optical probing (~100fs, ~1°) was used to study wakefield remnants at delays 1ns⊠Δt⊠10μs. In lithium plasma, probe scatter remained visible out to Δt≈2μs. Probe signal persisted up to Δt≈100ns and Δt≈300 ns, in hydrogen and argon plasmas, respectively. Bessel beam interferometry revealed nonzero phase shift out to (and possibly beyond) Δt≈10μs in argon wakes. The results will be discussed considering findings of experiment E-224 [3], which showed that ion motion dominated energy transport out of the beam-excited region for Δt⊠0.3ns.

[1]R.D'Arcy et al., Nature 603, 58-62(2022).
[2]R.Pompili et al., Commun Phys 7, 241(2024).
[3]R.Zgadzaj et al., Nat Commun 11, 4753(2020).

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