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Short-lived particle acceleration in laser plasma accelerators

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Plasma-based accelerators achieve accelerating fields of 10-100 GV/m. While plasma wakefields naturally accelerate electrons due to their near-light-speed motion [1], heavier particles like muons [2] and pions, with lifetimes from microseconds to nanoseconds, struggle to be trapped due to velocity mismatch with the wake.

We use spatio-temporal spectral shaping [3,4,5] to control the group velocity of drive pulses, generating subluminal wakes suitable for slower particles. PIC simulations with OSIRIS [6] show non-relativistic particles accelerating to relativistic speeds. We can extend the dephasing length by tailoring the plasma density profile, which sustains the acceleration process.
This method enables plasma-based acceleration of unstable particles, with applications in cooled muon injection and enhanced muon yield via pion acceleration and decay.

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