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# Advancements in Plasma-Driven Acceleration for Non-Relativistic Particles

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In plasma-wakefield acceleration, non-relativistic particles quickly lose phase-locking due to the substantial difference between the driver's group velocity (nearly the speed of light) and the particles' velocities. Heavier particles such as muons [1] and pions have thus conventionally been excluded from this method. Recent advancements have introduced methods for shaping electromagnetic wave packet spectra, producing pulses with variable group velocities [2,3,4]. These pulses can drive subluminal acceleration plasma wakes. Through theoretical analysis and numerical calculations, we demonstrate how employing these pulses as subluminal drivers alongside a tailored plasma density profile enables the possibility to accelerate these particles from non-relativistic to relativistic speeds within a single acceleration stage. Our theoretical model predicts muons and pions can accelerate from around 0.9c to 0.99c in millimetre-scale plasma. These findings align well with quasi-3D particle-in-cell simulations using the OSIRIS code [5], suggesting that 3 Joules lasers could achieve this goal.

[1] K.R. Long et al., Nat. Phys. 17, 289–292 (2021).
[2] A. Sainte-Marie et al., Optica 4, 1298-1304 (2017).
[3] D.H. Froula et al., Nature Photonics 12, 262–265 (2018).
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[5] R.A. Fonseca et al., Phys. Plasmas Control. Fusion 55, 124011 (2013).

## Available for oral presentation in a session

Yes

**Primary author:** BADIALI, Chiara

**Co-authors:** Mr MALACA, Bernardo (GoLP/Instituto de Plasmas e Fusão Nuclear, Instituto Superior Técnico, Universidade de Lisboa, 1049-001 Lisbon, Portugal); VIEIRA, Jorge; RUSSO DE ALMEIDA, Rafael (IST); Dr SILVA, Thales (GoLP/Instituto de Plasmas e Fusão Nuclear, Instituto Superior Técnico, Universidade de Lisboa, 1049-001 Lisbon, Portugal)

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