

Plasma density and ionisation degree evolution with long-term ion motion in a beam-driven plasma-wakefield accelerator

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Beam-driven plasma-wakefield acceleration is a promising avenue for the future design of compact linear accelerators with applications in high-energy physics and photon science. Meeting the luminosity and brilliance demands of current users requires the delivery of thousands of bunches per second: many orders of magnitude beyond the current state-of-the-art of plasma-wakefield accelerators, which typically operate at the Hz-level. As recently explored at FLASHForward, a fundamental limitation for the highest repetition rate is the long-term motion of ions that follows the dissipation of the driven wakefield (R. D'Arcy, et al. Nature 603, 58,62 (2022)). The duration of this ion motion could vary with the mass of the plasma ions, thus significantly decreasing in lighter gas species. To observe this, the understanding of the background processes, such as microsecond-level plasma density evolution of different gases in a capillary, is needed. Here we present the exploration of plasma density evolution together with insights into the estimated ionisation degree.

Primary authors: Dr LINDSTRØM, Carl A. (University of Oslo); Mr PEÑA, Felipe (DESY); LOISCH, Gregor (DESY Zeuthen); JONES, Harry (DESY); CHAPPELL, James (John Adams Institute for Accelerator Science and Department of Physics); OSTERHOFF, Jens (Deutsches Elektronen-Synchrotron DESY, Notkestraße 85, 22607 Hamburg, Germany and Universität Hamburg, Luruper Chaussee 149, 22761 Hamburg, Germany); Dr BJÖRKLUND SVENSSON, Jonas (DESY); BEINORTAITE, Judita (FLASHForward, DESY, UCL); GARLAND, Matthew James; WING, Matthew (UCL); D'ARCY, Richard (University of Oxford); SCHROEDER, Sarah (DESY); WESCH, Stephan (Deutsches Elektronen-Synchrotron DESY)

Presenter: BEINORTAITE, Judita (FLASHForward, DESY, UCL)

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