Contribution ID: **199** Type: **talk**

Influence of medium length in self-guided laser wakefield accelerators

Tuesday, 15 September 2015 17:10 (20 minutes)

Laser wakefield accelerators appear promising as compact sources of highly relativistic electrons and ultrashort pulses of X-rays. However, improving the control of the electron- and X-ray beam parameters is crucially important in order to enable laser wakefield accelerators to be efficiently used in applications. We report on our recent experiments of laser wakefield acceleration and X-ray generation inside a variable length gas cell. The motivation is to generate electron beams with a well defined electron kinetic energy and with low shot-to-shot fluctuations in charge, divergence and pointing. The experiments are performed using the Ti:Sapphire-based multi-terawatt laser at the Lund Laser Centre. Electrons are trapped in the accelerating phase of the plasma wave by self-injection and ionization-induced injection. Stable electron- and X-ray beams are generated both when the cell is filled with pure hydrogen and with an addition of 1% nitrogen. The evolution of the electron- and X-ray energy spectra is studied as a function of acceleration distance by varying the length of the gas cell. The experimental findings are qualitatively reproduced in particle-in-cell simulations.

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Session Classification: WG1 - Electron beams from plasmas

Track Classification: WG1 - Electron beams from plasmas