ACCELERATION DYNAMICS IN LASER-DRIVEN WAKEFIELDS

A. Popp\textsuperscript{1}, R. Weingartner\textsuperscript{1}, S.-W. Chou\textsuperscript{1}, M. Heigoldt\textsuperscript{1}, K. Khrennikov\textsuperscript{1}, J. Wenz\textsuperscript{1}, F. Krausz\textsuperscript{1,2} and S. Karsch\textsuperscript{1,2}
\textsuperscript{1}Ludwig-Maximilians-University Munich, Am Coulombwall 1, 85748 Garching, Germany
\textsuperscript{2}MPI of Quantum Optics, Hans-Kopfermann-Str. 1, 85748 Garching, Germany

In the presented experiments the dynamics during the acceleration of electrons in a laser-driven wakefield is studied by means of a length-variable gas cell. The electron bunches that were accelerated by the 25 fs, 1.8 Joules pulses of the ATLAS-laser, could be extracted and analyzed after different acceleration distances between 2mm and 14 mm. As the bunches from the steady-state flow gas-cell exhibit high stability and reproducibility this measurement could be conducted with significant statistics.

From the evolution of the energy spectrum important acceleration parameters could be deduced directly, such as the dephasing length (4.9 mm @ 6.4 \times 10^{18} \text{ cm}^{-3}) and the corresponding longitudinal electric field (160 GV/m). Both values are in good agreement with theory.

Scanning the gas-cell length at different electron densities also reveals the factors that limit the acceleration under the respective conditions, such as laser energy depletion or insufficient self-guiding.

While plasma-length scans have been performed by other groups this is the first comprehensive scan that covers a wide range of lengths, even beyond the dephasing length, thus allowing for a reliable determination of acceleration parameters. Only with this knowledge the gas target length and electron density can be optimized for given laser parameters.

In addition, the evolution of several other electron bunch parameters could be quantified. Especially, the change in emittance (0.2 p mm mrad) and bunch duration (~5 fs) could be determined with elaborate single-shot diagnostics.

With increasing acceleration distance the transition to a beam-driven regime could be identified.

* Work supported by DFG (MAP&TR-18), Euratom, Leverhulme Foundation and MPG