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High sensitivity gas-density profilometry for laser- and beam-driven plasma acceleration experiments

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Precise tailoring of plasma-density profiles in longitudinal and transverse direction has been identified to be one of the critical points in achieving stable and reproducible conditions in plasma wakefield accelerators. Here the especially strict requirements of next generation plasma-wakefield concepts, such as hybrid-accelerators, with densities around 10^17 cm-3 pose challenges to target fabrication as well as to their reliable diagnosis. In addition, target complexity has to be minimized to increase reliability for fail-safe accelerator operation. To tackle these issues we combine target simulation with fabrication and characterization. Our target concepts are based on capillaries and gas-cells with multiple gas in- and outlets. The resulting density profiles within are simulated with the fluid code OpenFOAM. Successful simulation results then are followed by fabrication of the desired target shapes with structures down to the few micrometer level. The corresponding longitudinal density profiles at different number densities are measured and benchmarked against the simulation utilizing Raman scattering and longitudinal interferometry, which in combination allow for high sensitivity and thus absolute calibration of targets down to the 10^17 cm-3 regime.

Primary author: Dr SCHAPER, Lucas (University Hamburg / DESY)

Co-authors: MAIER, Andreas (CFEL/UHH); Mr SCHWINKENDORF, Jan-Patrick (Deutsches Elektronen-Synchrotron); Dr OSTERHOFF, Jens (Deutsches Elektronen-Synchrotron DESY); Mr GOLDBERG, Lars (Universität Hamburg); Mr SCHNEPP, Matthias (University of Hamburg); Mr DELBOS, Niels (University of Hamburg / Center for Free Electron Laser Science); KLEINWÄCHTER, Tobias (DESY); PALMER, charlotte (DESY)

Presenter: Dr SCHAPER, Lucas (University Hamburg / DESY)

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