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Transverse electron beam dynamics in a nanocoloumb-class laser wakefield accelerator

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Laser-plasma wakefield accelerators have shown generation of quasi-monoenergetic (QME) electron bunches with reaching to multiple GeVs range. Scaling the accelerated charge within the QME bunch from pC to nC is one of the important issues for many applications. This high charge naturally brings laser wakefield in the so-called beam loading regime, which can deteriorate the beam quality if not properly controlled.
In our recent experiments carried out with the Draco Ti:Sapphire laser we explore the influence of beam loading on the transverse electron beam dynamics. Utilizing 2D x-ray spectroscopy technique we deduced the electron beam size close the plasma exit by analyzing the x-ray spectrum emitted as relativistic electrons perform betatron oscillation during acceleration. Simultaneously electron spectra and divergence were recorded at a charge calibrated point-to-point imaging electron spectrometer. We show that as the electron beam size increases with charge, the beam divergence reaches a minimum value at the optimum loading condition where, at the same time, the energy spread reaches a minimum. We anticipate that this result will open a new path for beam optimization in high charge laser wakefield accelerators.

Primary author: Mr KOEHLER, Alexander (Helmholtz-Zentrum Dresden - Rossendorf)

Co-authors: Dr DEBUS, Alexander (Helmholtz-Zentrum Dresden-Rossendorf); Dr IRMAN, Arie (Helmholtz Zentrum Dresden Rossendorf); Mr KRÄMER, Jakob (Danfysik A/S); Mr COUPERUS, Jurjen (Helmholtz-Zentrum Dresden - Rossendorf); Dr BUSSMANN, Michael (Forschungszentrum Dresden-Rossendorf e.V.); Mr ZARINI, Omid (Helmholtz-Zentrum Dresden - Rossendorf e.V.); Mr PAUSCH, Richard (Helmholtz-Zentrum Dresden - Rossendorf); Mr KURZ, Thomas (Helmholtz-Zentrum Dresden - Rossendorf); Prof. SCHRAMM, Ulrich (Helmholtz-Zentrum Dresden-Rossendorf)

Presenter: Mr KOEHLER, Alexander (Helmholtz-Zentrum Dresden - Rossendorf)

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