Terahertz Acceleration

Franz X. Kärtner
Center for Free-Electron Laser Science and Deutsches Elektronen-Synchrotron (DESY), Notkestraße 85, 22607 Hamburg, Germany and Department of Physics and Center for Ultrafast Imaging, Universität Hamburg, Luruper Chaussee 149, 22761 Hamburg, Germany

Email: franz.kaertner@desy.de

Over the last years, demonstrations have shown the feasibility of a THz accelerator technology. A proof of principle THz acceleration experiment based on laser-generated single-cycle THz pulses with 10 μJ pulse energy at 0.45 THz has been performed [1]. First THz guns based on a parallel plate THz waveguides have been reported producing quasi-monochromatic electron bunches with a few percent energy spread around 400 eV mean energy [2]. More advanced THz gun structures driven with single-cycle THz pulses have been proposed [3]. These gun structures are based on a segmented THz waveguide device composed of arrays of parallel plate waveguides with dielectric fillings to delay the THz pulses in each waveguide, such that when excited with a single high energy THz pulse jointly, a tilted pulse front is created at the interaction point with electrons. This leads to continuous acceleration of the electron bunch in the interaction areas, see Fig. 1 left. To demonstrate this single cycle accelerator concept, we used a UV-photo-triggered, 55 kV DC-gun to inject an electron bunch into the accelerating structure. The accelerating structure is driven by two single-cycle THz pulses with about 10 μJ of THz energy. Figure 1 (right) shows that up to 30 keV electron acceleration is achieved and that the device can be utilized for electron bunch compression, focusing and streaking. [4] The deflection strength of about 140 μrad/fs allows for sub-10 femtosecond resolution and focussing and defocussing with up to 2kT/m focussing strength is achieved.

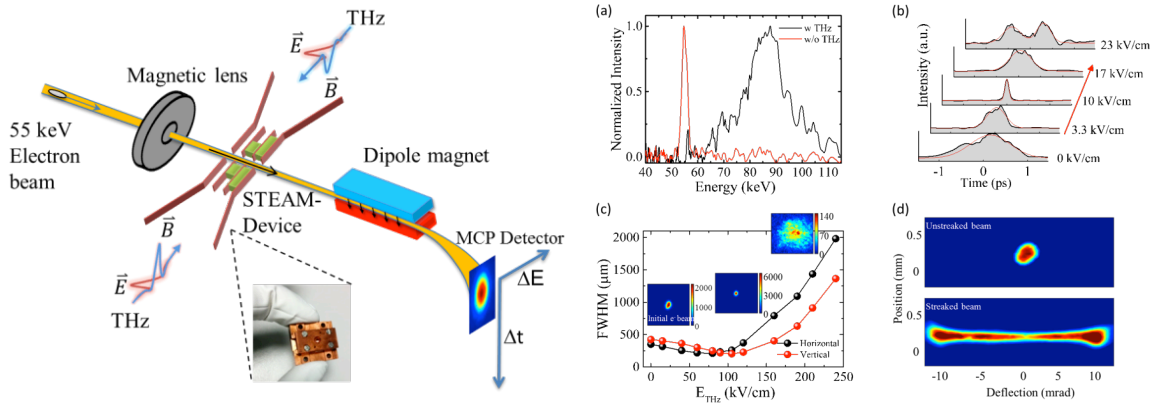

Fig. 1. left: Schematic illustration of the experimental setup. The two counter-propagating THz beams interact with the 55 keV electron beam inside the STEAM device. Subsequently, the electron beam is detected by the camera. Inset: photograph of the STEAM device; right: (a) Electron energy spectra for input beam (red curve) and accelerated beam (black curve). (b) Temporal profiles of the electron pulses as the THz field in the buncher is increased. (c) Transverse electron beam size as a function of the THz field at the focusing mode. (d) Images of the electron beam on the detector with and without the THz deflection field. [4]

References

[1] E. A. Nanni, W. R. Huang, K. -H. Hong, K. Ravi, A. Fallahi, G. Moriena, R. J. D Miller, and F. X. Kärtner,, Nat. Communications 6, 8486 (2015).
[2] W. R. Huang, et al, Optica 3, p. 1209 (2016).
[4] A. Fallahi, M. Fakhari, A. Yahaghi, M. Arrieta, and F. X. Kärtner, " Phys. Rev. Accel. Beams **19**, 081302 (2016).
[3] D. Zhang, A. Fallahi, M. Hemmer, X. Wu, M. Fakhari, Y. Hua, H. Cankaya, A.-L. Calendron, L. E. Zapata, N. H. Matlis, and F. X. Kärtner, https://arxiv.org/abs/1711.03024.