Relativistic electron beams driven by single-cycle laser pulses at kilohertz repetition rate

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We will review our recent developments on a high repetition rate MeV electron source and its potential applications. Due to significantly reduced space charge and velocity dispersion effects, relativistic electron bunches accelerated by laser wakefields have been identified as a candidate tool to achieve unprecedented sub-10 fs temporal resolution in ultrafast electron diffraction (UED) experiments [1], [2]. High repetition rate operation is also desirable to improve data collection statistics and wash out shot-to-shot charge fluctuations inherent to plasma accelerators. It is well known that high-quality electron beams with narrow energy spreads and small divergences can be achieved in the blowout, or bubble wakefield regime [3], which is at present regularly accessed with ~30 fs Joule-class lasers that can perform up to few shots per second. Our group on the contrary employed a cutting edge laser system producing few-mJ pulses compressed nearly to a single optical cycle (3.4 fs) [4] to demonstrate for the first time that, consistently with the scaling laws [5], relativistic electron beams with properties characteristic to the blowout regime and peaked at 4-6 MeV energy can also be achieved at kilohertz repetition rate [6]. We further investigate the plasma density profile effects on the accelerated charge and electron energy and show that using certain structured gas jets several tens of pC/shot can be achieved. We expect this technique to lead to a highly accessible and robust instrument for the scientific community to conduct UED experiments with sub-10 fs temporal resolution.

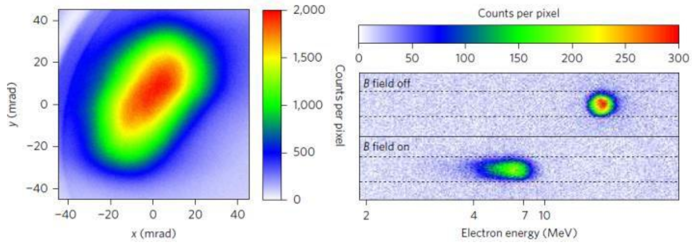

Figure 1. Typical electron beam profile and spectrum [6]

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