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Relativistic Electron Beams from Laser-Solid Interactions at 0.5 kHz

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Relativistic monoenergetic electron beams from laser-plasma sources can make accessible, in a laboratory set-up, both the science and applications that were once limited to large-scale accelerator facilities. Owing to their ultrafast nature – typically sub-picosecond, comparable to the driving laser pulse duration – these beams could be used to drive ultrafast radiation sources covering almost the entire spectrum, from γ-rays to infrared. Such sources are instrumental for the study of transient dynamics in solid-state physics, material science and bio-chemistry. Moreover, relativistic electrons beams are emerging as an alternative to x rays for cancer radiotherapy due to their superior penetration depth. All these applications would greatly benefit from high electron fluxes. However, to date, monoenergetic electron beams have been primarily obtained from wakefield accelerators produced by low repetition rate lasers in under-dense plasmas. Here we present recent findings on the production of electron beams from the interaction of a high repetition rate laser with an SiO_2 target around the relativistic-intensity threshold ($a_o \simeq 1$). In particular we investigate the effects of the plasma scale-length on the beam spatial and spectral characteristics. At the intermediate scale-length of $\lambda/2$, the electrons were emitted in collimated beams with a quasimonoenergetic distributions. Although the spectral peak occurs at moderately relativistic energies ($E_o \sim 0.8$ MeV) with a relatively large energy spread ($\Delta E/E_o \simeq 30\%$), these beams are potentially suitable as seeds to be injected in a two-stage accelerator scheme that could produce 50 MeV electron beams with better than 10^{-2} energy spread at kilohertz repetition rates.