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Bunch Profile Reconstruction and Evolution of Laser-Wakefield accelerated Electron Bunches by Single-Shot Measurement of Coherent Transition Radiation

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A unique property of laser-wakefield accelerated electron bunches is their ultra-short duration, resulting in peak currents in the kA range, which may benefit future applications such as laboratory scale X-ray sources or ultrafast time resolved measurements. We present single-shot, high-resolution measurements of the longitudinal bunch profile based on detection of coherent transition radiation in a broad spectral range. To avoid the necessity for assumption about the bunch shape as well as the spectral shape in unmeasured regions, we have developed an iterative algorithm capable of reconstructing the longitudinal bunch profile. Our method is sensitive to complex features, such as multi-bunch structures. A gas-target of variable length is used to assess the evolution of the bunch profile during the acceleration process. Our results suggest that after laser energy depletion, a mode transition from a laser-driven wakefield to a particle-driven wakefield occurs, associated with the injection of a secondary bunch. The resulting double bunch structure could be exploited for driver-witness type experiments, i.e. allowing a non dephasing-limited acceleration of the secondary bunch in a plasma-afterburner stage.

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