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All-optical GeV electron bunch generation in a laser-plasma accelerator via truncated-channel injection

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We describe a simple scheme, truncated-channel injection, to inject electrons directly into the wakefield driven by a drive pulse guided by an all-optical plasma channel. We use this approach to generate dark-current-free 1.2 GeV, 4.5% relative energy spread electron bunches with 120 TW laser pulses guided in a 110 mm-long hydrodynamic optical-field-ionized (HOFI) plasma channel. Our experiments and particle-in-cell simulations show that high-quality electron bunches were only obtained when the drive pulse was closely aligned with the channel axis, and was focused close to the density down-ramp formed at the channel entrance. Start-to-end simulations of the channel formation, and electron injection and acceleration show that increasing the channel length to 410 mm would yield 3.65 GeV bunches, with a slice energy spread 5E-4. We will also present initial results of a follow-up experiment in which a second, perpendicular HOFI channel was used to enhance the control of injection of electrons into the plasma wave driven in an approximately 40 mm-long HOFI channel.

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