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Enhanced Betatron Radiation from a Laser Wakefield Accelerator in a Long Focal Length Geometry

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A self-guided, self-injecting laser wakefield accelerator driven by a 120 TW laser pulse was implemented in a long focal length (f/40) geometry. Electrons were accelerated beyond 1.9 GeV in a 10 mm long plasma while maintaining a betatron source size below 0.5 micrometers. When the plasma length was extended beyond 10 mm a second electron bunch was injected with a high charge per unit bandwidth, which increased the number of betatron x-ray photons by a factor of five at moderate photon energies (16 keV critical energy). Simulations suggest this second injection resulted from a dynamic evolution of the bubble size. By further increasing the laser power to 240 TW the peak brightness of the betatron beam was increased above 1.0 x 10^24 photons/s/mm^2/mrad^2/0.1%BW at 18 keV, with the whole beam containing 3 x 10^10 photons above 1 keV. This has led to a significant advancement in the capabilities of the betatron source, demonstrated by a dramatic improvement in the signal to noise ratio of betatron imaging.

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