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High-brilliance betatron gamma-ray source powered by laser-accelerated electrons

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Thanks to the recent progress in laser-driven plasma acceleration of electrons, the ultra-short, compact and spatially coherent X-ray betatron sources based on this technique have been successfully applied to high-resolution imaging in the last few years. However, due to a difficulty to both optimize the electron energy and wiggling, the scope of the betatron sources is limited by a low energy efficiency and a photon energy in the 10's of keV range. Here, based on three-dimensional particle-in-cell simulations, we propose an original hybrid scheme that combines a low-density laser-driven plasma accelerator with a high-density beam-driven plasma radiator. We show that this scheme greatly improves the energy efficiency, with about 1% of the laser energy transferred to the radiation, and that the gamma-ray photon energy exceeds the MeV range when using a 15 J laser pulse. This high-brilliance hybrid betatron source opens the way to a wide range of applications requiring MeV photons, such as the production of medical isotopes with photo-nuclear reactions, radiography of dense objects in the defense or industrial domains and imaging in nuclear physics.

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