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Relativistic Laser-Driven, Highly Collimated MeV Gamma-Ray and Electron Beam Generation in Plasma Cone Channels.

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Recent advancements in high-intensity lasers have made all-optical Compton scattering a promising method for generating ultrashort, brilliant γ-rays in compact systems. However, existing Compton γ-ray sources are limited by low conversion efficiency and spectral intensity. In this study, we explore overdense electron acceleration and γ-ray emission through 2D and 3D Particle-In-Cell (PIC) simulations using two setups: one with a hollow-cone plasma channel and one with a standard channel. The hollow cone channel improves laser focusing, resulting in enhanced electron acceleration. Our simulations show a tenfold increase in intensity and a 13% improvement in the electron conversion efficiency when we used the hollow cone setup instead of the standard channel. This is due to the increase in laser intensity when it is focused using the hollow cone plasma channel, compared to the standard channel setup, where intensity is lower because of the lack of focusing. Additionally, 3D PIC simulations reveal a 8% improvement in laser-to-electron conversion efficiency with the cone plasma setup. These findings suggest that the hollow cone plasma can serve as an effective optical element to boost laser intensity in petawatt (PW) laser facilities, enabling efficient γ-ray sources with broad applications.

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