Beitrag ID: **63** Typ: **Invited Talk**

Ultra-high Flux of Direct Laser Accelerated Electrons, MeV Photons and Neutrons using Overdense Foams

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Ultra-bright, well-collimated MeV bremsstrahlung radiation was generated through the interaction of high-current electron beams produced via Direct Laser Acceleration (DLA) with a high-Z converter. The DLA mechanism was initiated by a 200 TW, sub-picosecond PHELIX laser pulse at a moderately relativistic intensity of approximately 10^{19} W/cm2, delivering about 60 J into pre-ionized, overcritical-density foam targets [1].

The electron spectrum measured along the laser axis exhibited an effective temperature of approximately 30 MeV and energies exceeding 100 MeV, with a total charge of about 300 nC for electrons with energies above 1.5 MeV (the ponderomotive potential). Of these, roughly 100 nC were directed along the laser axis within a half-angle cone of 12°. The directed fraction of DLA electrons with energies above 7.5 MeV carried a charge of 20–30 nC, corresponding to a flux of up to 2×10^{24} electrons sr^{-1} s^{-1} [2].

These high-current, relativistic electron beams [3] efficiently generate MeV X-rays, enabling the subsequent production of isotopes, positrons, and neutrons with exceptional yield and application potential [4-7]. In laser shots employing overcritical-density foam targets positioned in front of a high-Z converter, bremsstrahlung photons with energies up to 70 MeV were generated and analyzed via nuclear activation of tantalum and gold. The formation of the isotopes ^{174}Ta and ^{190}Au, whose photonuclear cross-section peaks occur near 65 MeV, confirmed the presence of high-energy photons. In contrast, no activation was observed in control shots where the laser was directed onto the converter without foam, demonstrating that high-energy photon generation is intrinsically linked to the DLA process in pre-ionized foam targets [2].

Autoradiographic measurements revealed a bremsstrahlung beam divergence of approximately 22° (half-angle) in the 14–21 MeV energy range. These diagnostics indicate an unprecedented photon flux of approximately 2×10^{22} photons sr^{-1} s^{-1}., corresponding to about 10^{11} photons per shot with energies exceeding 7.5 MeV. The conversion efficiency of focused laser energy into bremsstrahlung photons exceeds 1% within the (FWHM) of the X-ray beam. More than 2×10^9 photoneutrons per shot were emitted isotropically, corresponding to a peak flux of 2×10^{20} cm⁻2 s^{-1}, or 4×10^{18} cm⁻2 s^{-1} J^{-1} [2].

This approach demonstrates a robust and scalable method for generating ultra-intense MeV photon beams at kilojoule, petawatt-class laser facilities operating at moderately relativistic intensities, with strong implications for high-energy-density physics and nuclear astrophysics research.

[1] Rosmej, Olga N., et al. "Advanced plasma target from pre-ionized low-density foam for effective and robust direct laser acceleration of electrons." High Power Laser Science and Engineering 13 (2025): e3.

[2] Tavana, P., et al. "Ultrahigh Flux of Direct Laser-accelerated Electrons, MeV Photons, and Neutrons from Overdense Foams."Physical Review Applied, Jan. 2026, https://doi.org/10.1103/5mpy-2jw5

[3] Rosmej, O. N., et al. "High-current laser-driven beams of relativistic electrons for high energy density research." Plasma Physics and Controlled Fusion 62.11 (2020): 115024.

[4] Günther, Marc M., et al. "Forward-looking insights in laser-generated ultra-intense γ-ray and neutron sources for nuclear application and science." Nature Communications 13.1 (2022): 170.

[5] Tavana, P., et al. "Ultra-high efficiency bremsstrahlung production in the interaction of direct laser-accelerated electrons with high-Z material." Frontiers in Physics 11 (2023): 1178967.

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[7] Gyrdymov, Mikhail, et al. "High-brightness betatron emission from the interaction of a sub picosecond laser pulse with pre-ionized low-density polymer foam for ICF research." Scientific Reports 14.1 (2024): 14785.

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