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Laser-driven very high energy electrons for radiotherapy: beam characterization and radiobiological evaluation

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Laser-Plasma Accelerators (LPAs) are emerging as versatile sources for generating ultra-high dose rate beams for radiotherapy research. With ultrashort pulse durations from femtoseconds to nanoseconds, they enable instantaneous dose rates exceeding 10^9 Gy/s. Their acceleration gradients, surpassing 100 GV/m, allow for the generation of Very High Energy Electron (VHEE) beams (>50 MeV) in a compact setup, overcoming the limitations of conventional linear accelerators. These beams are investigated as a novel radiotherapy modality, offering clinical advantages over photons and protons.

We characterized the LPA at the Laboratoire d'Optique Appliquée, optimizing acceleration conditions for stable VHEE beam delivery (50-100 MeV, 350 mGy/shot, 10 Gy/min average dose rate). To assess the biological effects of LPA-driven VHEE beams, we performed a comparative study against Conventionally Accelerated Electrons (CAE, 7 MeV) across multiple assays: i) in vitro survival of U87 human glioblastoma cells, ii) ex vivo quantification of dividing cells in mouse lung slices, and iii) in vivo growth monitoring of zebrafish embryos post-irradiation.

Results demonstrated that LPA-driven VHEE beams exhibit comparable antitumoral efficacy and toxicity to CAE, supporting their feasibility for radiobiological applications. This work establishes laser-driven VHEE beams as a promising platform for preclinical studies and a viable alternative to conventional electron therapy.

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