

Laser-Driven Very High Energy Electrons for Femtosecond-Scale Irradiation of In Vitro Cell Lines

Laser-driven plasma accelerators offer a compact, cost-effective alternative to conventional radiofrequency accelerators, capable of generating very high energy and ultra-high dose-rate radiation sources that induce unique cellular responses. We report on the characterisation of laser-driven, very high energy electrons and the response of seven in vitro cell lines to this radiation source.

High-charge electron beams (\sim nC) were generated using a laser-driven wakefield accelerator, depositing doses up to 3Gy per pulse across cm^2 areas. Electron beam durations were estimated to be on the order of tens of femtoseconds, equating to unprecedented dose-rates $> 10^{13}$ Gy/s.

Exposure of in vitro cell samples to this radiation source resulted in significantly different responses compared to conventional x-ray irradiation. Notably, we observed a statistically significant increase in RBE (1.40 ± 0.08 at 50% survival) in one healthy and one cancerous cell line, alongside a reduction in the relative radioresistance of the cancer cells.

Recent experiments have shown similar results, observed across the seven different in vitro cell lines, indicating a universal response to this radiation source. Dose profiles obtained from radiochromic films and Monte Carlo simulations demonstrated good longitudinal and transverse uniformity, further establishing this radiation source as an exciting, novel approach to radiobiology research.

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