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Using Laser Accelerated Proton Beams to Explore Radiobiological Effects in the Ultra-High Instantaneous Dose Rate Regime

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Laser-driven (LD) proton sources are of interest for various applications due to their ability to produce short proton bunches with high charge and low emittance. These sources can be used in biological studies investigating improvements to radiation cancer therapy. Recently, the differential sparing effect on normal tissues versus tumors using the delivery of high radiation doses >10 Gy at extremely high dose rates (DR), has received increasing attention and was termed the FLASH effect. However, the molecular and cellular mechanisms underlying FLASH are not yet fully understood. To explore these mechanisms, we have implemented a beamline at the BELLA PW laser of Berkeley Lab that delivers proton bunches at ultra-high instantaneous DR (UHIDR) up to 10⁸ Gy/s to a sample irradiation site. This allowed us to study in vitro the differential sparing of normal versus prostate cancer cells [Bin Sci. Rep. 12:1585 (2022)]. More recently, we extended our capabilities to investigate in vivo the acute skin damage and late radiation-induced fibrosis in mouse ears after UHIDR with 10 MeV protons and prescribed doses up to 50 Gy.

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