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From Survival Curves to Isoeffective Dose: Radiobiological Modelling of BNCT Mixed-Field Effects

Boron Neutron Capture Therapy (BNCT) delivers tumor-selective high-LET damage through a mixed radiation field in which $^{10}B(n,\alpha)^{7}Li$ products coexist with photons and protons. At the University of Pavia, we integrate radiobiological experiments with detailed Monte Carlo dosimetry to improve mixed-field dose response modeling and strengthen the photon iso-effective dose formalism used for treatment evaluation and planning. In vitro clonogenic survival studies in monolayer cultures are supported by Monte Carlo particle transport simulations of uncharged and charged secondaries, to quantify component-resolved absorbed dose and to correct survival curves. We also investigate the biological effectiveness of single BNCT-relevant components, such as 583 keV protons from the $^{14}N(n,p)^{14}C$ reaction, to constrain model parameters for neutron-induced dose terms. Finally, neutron autoradiography coupled with UV-imprint methods is developed to measure subcellular boron distribution, enabling model extensions towards cellular-scale heterogeneity. Together, these activities aim at biologically anchored mixed-field dose metrics for more reliable BNCT optimisation and translation towards conventional radiotherapy and hadrontherapy.

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