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Department of Physics

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Mechanistic modeling at the cell-scale - connecting physics and biology

Abstract

Modeling approaches offer a strong tool for understanding the mechanisms of complex processes, allowing us to probe correlations that are not accessible with experimental techniques. My lab specializes in Monte Carlo simulations investigating radiation-tissue interactions across multiple biological scales. By connecting initial physical energy deposition events at the cellular level to downstream biological outcomes, we gain critical insights into the fundamental mechanisms driving radiation therapy efficacy.

I will present our recent advancements using the TOPAS-nBio framework, which integrates detailed cellular geometries, radiolysis-induced chemical processes, and DNA repair kinetics modeling. We apply our simulations to investigate the mechanisms of emerging treatment modalities, including ultra-high dose rate (FLASH) radiotherapy and targeted radionuclide therapies, with the goal of optimizing clinical outcomes and treatment planning.

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