From survival curves to isoeffective dose:
radiobiological modelling of BNCT mixed-field effects

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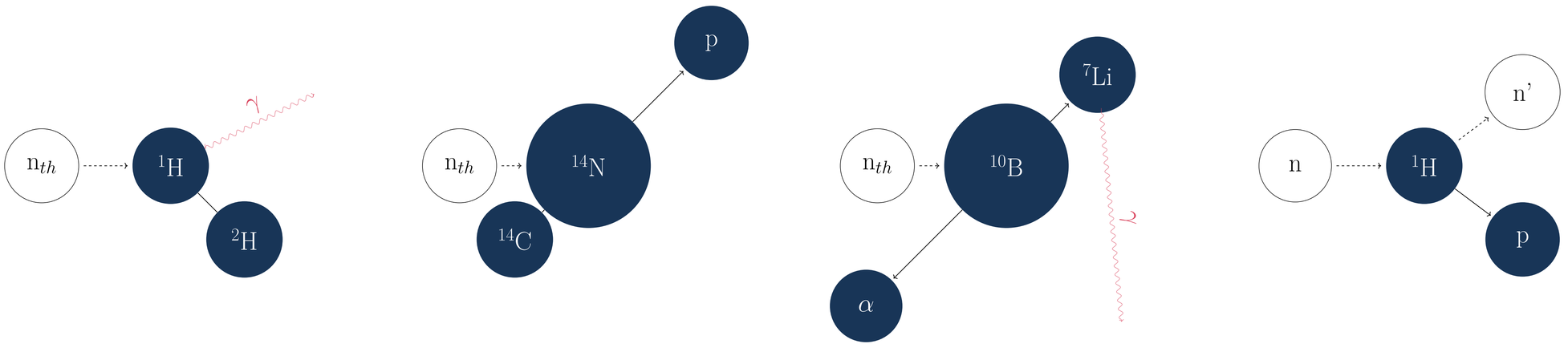
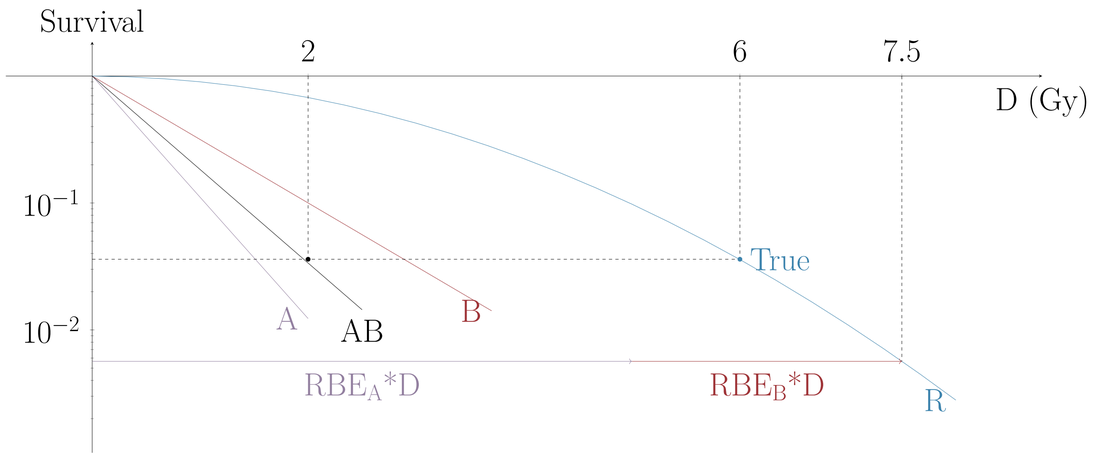
Background and aims in BNCT

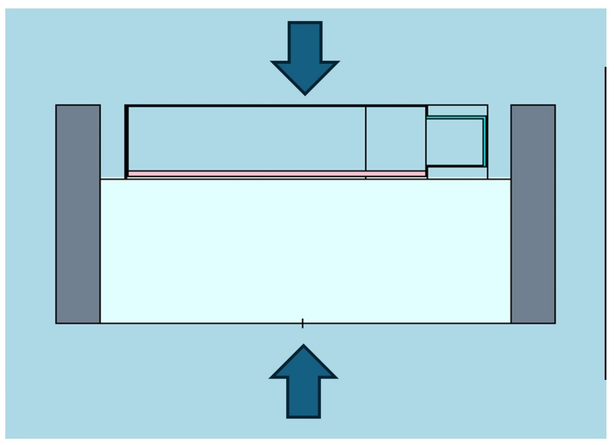


Boron Neutron Capture Therapy (BNCT) produces tumor-selective, high-LET damage via a mixed radiation field in which the $^{10}B(n,\alpha)^{7}Li$ reaction products coexist with accompanying photons and recoil protons. At the University of Pavia and relative INFN section we couple radiobiological experiments with high-fidelity Monte Carlo dosimetry to refine mixed-field dose-response models and to strengthen the photon iso-effective dose formalism used for treatment evaluation and planning.

Methods: experiments and Monte Carlo



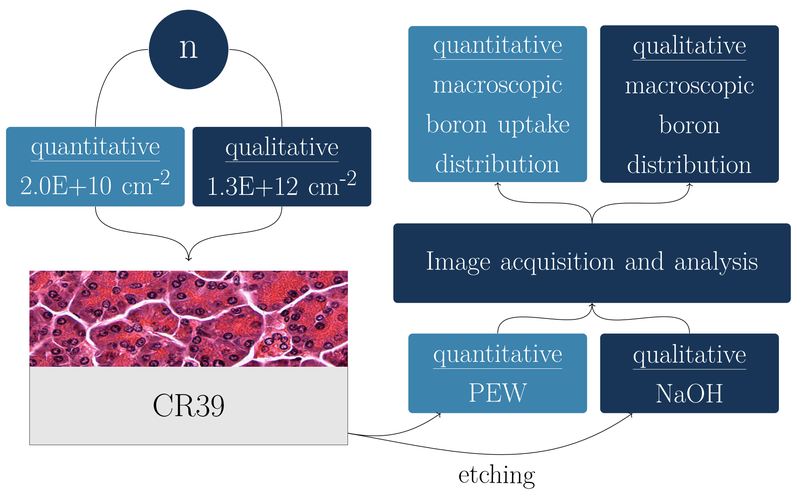
González, Sara J. et al. Radiation research 178.6 (2012): 609-621.

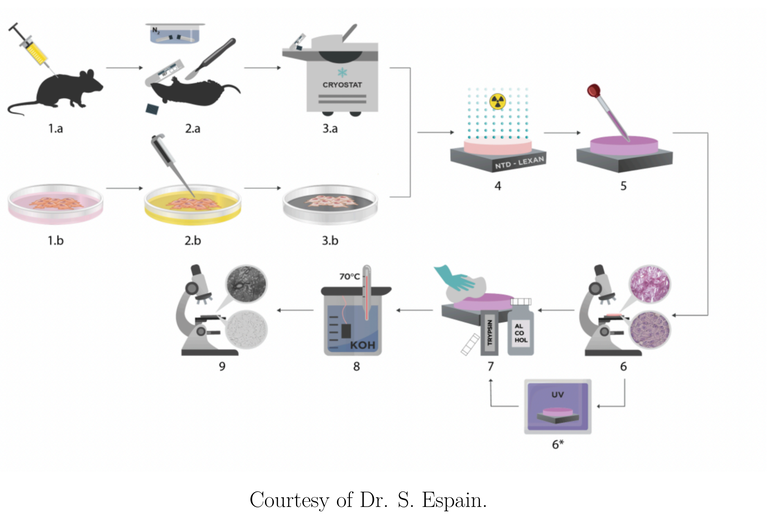


Plot of an MCNP simulation set-up to extract the energy deposited in a thin layer of cells in non CPE condition.

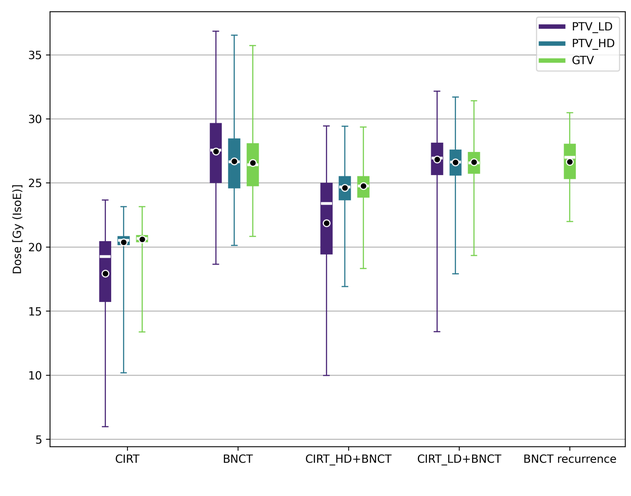
In vitro clonogenic survival assays in monolayer cultures are complemented by Monte Carlo particle-transport simulations of both neutral and charged secondaries, enabling component-resolved absorbed-dose quantification and consistent correction of survival curves. In parallel, we isolate and characterize the biological effectiveness of individual BNCT-relevant components, such as 583 keV protons from the $^{14}N(n,p)^{14}C$ reaction, to constrain model parameters governing neutron-induced dose contributions.

Results: component-resolved insights





Courtesy of Dr. S. Espain.



Truly isoeffective dose models make BNCT comparable across radiotherapy modalities.

Neutron autoradiography combined with UV-imprint techniques is being developed to quantify subcellular boron distributions, enabling model extensions that explicitly account for cellular-scale heterogeneity. Together, these component-resolved measurements and simulations aim to link mixed-field dose metrics to biological response, thereby improving BNCT optimization and supporting its translation within the broader radiotherapy and hadrontherapy landscape.

Conclusion and outlook

These activities converge on biologically anchored mixed-field dose metrics and on a strengthened photon iso-effective dose formalism for BNCT treatment evaluation and planning. By integrating radiobiology, component-resolved dosimetry, and cellular-scale boron mapping, the approach provides a coherent framework to quantify mixed-field contributions and to guide treatment optimization.

Acknowledgements

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