Neutron shielding strategies for dose quantification in Neutron Capture Enhanced Particle Therapy

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Background: Neutron Capture Enhanced Particle Therapy (NCEPT) boosts the effectiveness of particle therapy by capturing thermal neutrons produced by beam-target interactions in and around the treatment site, using tumour-specific ^{10}B or ^{157}Gd-based neutron capture agents. Neutron capture by these isotopes results in the production of high-LET secondary particles and prompt gamma photons of 478 keV and 7.94 MeV for ^{10}B and ^{157}Gd, respectively and if quantified, a measure of the neutron capture dose. However, neutrons present in the mixed radiation field may contribute to false positive counts, which arrive within the same timing and energy windows as these photons, but are not the result of neutron capture. As such, neutron shielding or discrimination is necessary.
Material and Methods: A Geant4 simulation to determine neutron fluence changes with thickness and shielding material has been constructed, with front and side shielding strategies proposed through a MATLAB optimisation process. These strategies were then tested via an additional simulation of a full detection system, with the calculation of the true:false positive ratio (R_{TF}) for different conditions as in [1].
Preliminary Results: Thermal neutron ratios for ^{10}B NCEPT are presented in Table 1.

	MATLAB Optimisation	Simplified option
Materials	0.41 cm polyethylene 0.04 cm gadolinium oxide 0.04 cm gadolinium	0.8 cm polyethylene 0.02 cm gadolinium oxide
neutrons < 0.4 eV	0.0037 ± 0.0002	0.0097 ± 0.0004

Table 1: Thermal neutron ratios for ^{10}B NCEPT shielding

[1] A. Chacon, M. Kielly *et. al.* Sci Rep, 12 (2022) 1-14