FLORIDA ATLANTIC UNIVERSITY
CHARLES E. SCHMIDT COLLEGE OF SCIENCE

DEPARTMENT OF PHYSICS

Doctor of Philosophy (Ph.D.) in Physics

Dissertation Defense

Panagiota Galanakou

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NON-RADIOACTIVE ELEMENTS FOR PROMPT GAMMA ENHANCEMENT IN PROTON THERAPY

ABSTRACT

Proton therapy allows for highly conformal dose distributions and better sparing of surrounding organs at risk thanks to the favorable proton depth dose characteristics and the defined range. However, these same characteristics lead to added uncertainties in treatment delivery and thus extended clinical tumor margins. Research in proton therapy is aimed at developing methods to verify the proton range in patients during the treatment. The most promising technique is based on Prompt Gamma (PG) spectroscopy. Indeed, it has been suggested that in-vivo proton range monitoring can be achieved by detecting secondary radiation emitted from the patient due to non-elastic nuclear de-excitations that spontaneously emit PG rays. However, poor PG statistics downgrade the potential of their clinical implementation.

We study injection of the non-radioactive elements ^{19}F, ^{17}O, and ^{127}I in a hypothetical tumor area to enhance the PG production in energy ranges that have been correlated with the accurate monitoring of the in-vivo proton range. We developed a novel Monte Carlo (MC) model using the TOPAS MC package and we showed that PG production enhancement is feasible with results varying with incident proton energy and mixture composition. Then, we evaluated the dosimetric aspects of our MC model based on important dosimetric metrics and we found that the addition of the proposed elements does not significantly alter the dose curves, unless the density of the medium changes drastically. As far as the dose deposition by p, n, α particles, and e- and the spatial emission of PG compared with the expected ones in the water, these are unaltered. The necessary next step is the experimental verification of this promising technique. Successful results could lead to reduction of range uncertainties and thus clinical margins exploiting the full potential of proton therapy.

Dissertation Advisor: Dr. Wazir Muhammad, Ph.D.

All Are Cordially Invited