PhD Thesis Title: Accurate relative stopping power prediction from dual energy CT for proton therapy: Methodology and experimental validation

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Graduation Date: November 24, 2017
Available Online:
https://www.rug.nl/research/portal/publications/accurate-relative-stopping-power-prediction-from-dual-energy-ct-for-proton-therapy(c547f8f7-2b5e-42ad-9b95-208b524e28d0).html

ABSTRACT:

Proton therapy is part of radiotherapy and increasingly applied in treatment of cancer, especially for children and patients with tumours in the head and neck region. With proton therapy, the tumour can be irradiated with less damage to the surrounding healthy tissues and critical structures compared to irradiation with photons. To optimally exploit this benefit of protons, the energy transferred by the protons to the tissues (the dose distribution) must be calculated very accurately. For this, the specific energy loss of the protons for each tissue is determined based on x-ray computed tomography (CT) imaging. In clinical practice, a phenomenological model is used based on an image obtained with a single x-ray spectrum (single energy CT, SECT). The predictions of this model are not patient specific and very inaccurate for materials which differ in composition and density from the materials used for determination of the model parameters. We have developed a method using two x-ray spectra (dual energy CT, DECT). With this method, the electron densities and effective atomic numbers, which determine the specific energy loss of protons in a material, are derived from two images on basis of fundamental theory of the interactions of x-rays. This method provides patient specific predictions with an accuracy better than 2%. This is a large improvement in accuracy and stability of the method with respect to the clinically applied SECT method and can reduce the risk of high doses to healthy tissue or low doses to the tumour due to inaccurate prediction of proton energy loss in the tissues on the beam path.

Reference to author publication that relate specifically to the dissertation:

J. K. van Abbema, M.-J. van Goethem, M. J. W. Greuter, A. van der Schaaf, S. Brandenburg, and E. R. van der Graaf, “Relative electron density determination using a physics based parameterization of photon interactions in medical DECT,” Phys. Med. Biol. **60**, 3825–3846 (2015). https://doi.org/10.1088/0031-9155/60/9/3825
http://iopscience.iop.org/article/10.1088/0031-9155/60/9/3825/meta