# Reducing Uncertainty in Proton Therapy Treatment Planning

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Optimising the therapeutic ratio for cancer patients is at the forefront of radiotherapy research. Proton therapy is a modality that has increased in popularity as a promising alternative to photon-based therapies, due to its superior healthy tissue-sparing ability. There are nearly 100 proton therapy centres in clinical operation worldwide as of 2022, with many more under construction [1]. This includes the Australian Bragg Centre in Adelaide, the site of Australia's first proton therapy centre.

Whilst proton therapy is an excellent alternative to photon-based treatments for complex cancers such as in the head and neck, there are limitations in the treatment planning process which introduce considerable uncertainties. Current clinical practice assumes the relative biological effectiveness (RBE) of ionising proton radiation is 1.1 when compared to photon treatments. This means that protons are only more damaging than photons by a factor of 1.1, despite evidence that the RBE varies with position in the Bragg Peak and inherently, proton energy [2].

Currently, dose calculations in proton therapy are performed using a constant RBE, often predicted using the Linear-Quadratic Model (LQM). The LQM is based on a Poisson count process and is limited to low linear energy transfer (high energy) proton radiation. To address this discrepancy we have developed a new stochastic model that can explain all data, including what is not well explained by the LQM. In this talk we will compare the performance of our model in comparison with the LQM. The plan to introduce our model into a proton therapy treatment plan, whilst also using a variable RBE compared to current clinical practice of a constant RBE of 1.1, will be outlined.

We expect that accounting for variable RBE whilst using a more precise dose-response model from which the RBE is predicted will provide better estimates of the true dose delivered to the target and organs at risk. Using our results, uncertainties introduced into current proton therapy treatment planning can be quantified thus showing the effect on the patient's treatment.

[1] Particle Therapy Co-Operative Group (PTCOG), (2022) Facilities in Operation. Available at: https://www.ptcog.ch/index.php/facilities-in-operation (Accessed: 28 June 2022).

[2] Paganetti H. "Relative biological effectiveness (RBE) values for proton beam therapy. Variations as a function of biological endpoint, dose, and linear energy transfer." *Phys Med Biol.* (2014) no. 59, **vol. 22**, pp. 419–472