Reducing Uncertainty in Proton Therapy Dose-Response

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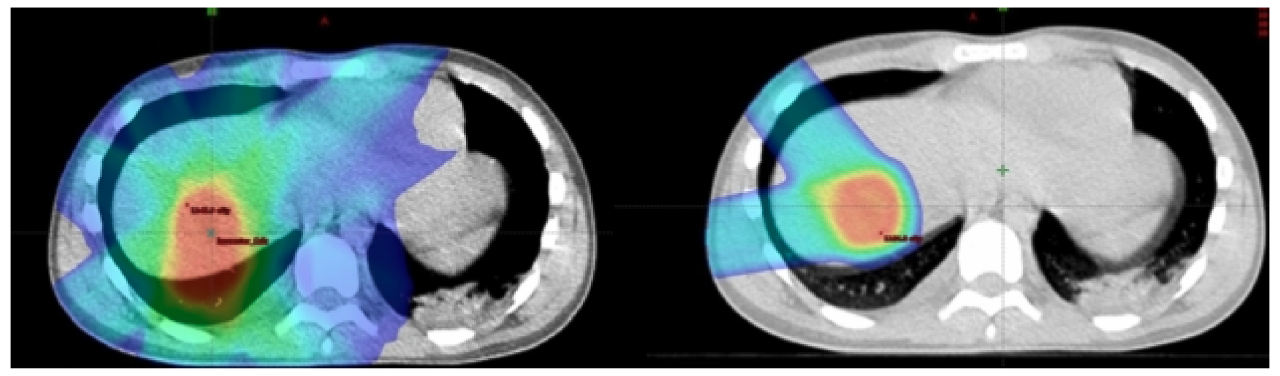
Introduction

- Key objective in radiation therapy is to optimise dose-response in the patient - we want to **maximise the biological effect on the tumour** whilst **minimising impact on organs at risk**.
- Proton Therapy optimises this effect through the **Bragg Peak** (high dose region indicated in red below).



- Our understanding of the **underlying mechanisms that describe how the tumour responds** to ionising radiation can be improved.

The Problems

- **Relative Biological Effectiveness (RBE)** quantifies the **doses required for photon and proton radiation to achieve the same biological effect**

$$RBE = \frac{Dose_{\text{Photon}}}{Dose_{\text{Proton}}}.$$

- In treatment planning a **constant proton RBE of 1.1 is assumed** despite clear correlation with beam energy and linear energy transfer (LET) (Fig.1)
- The **RBE uncertainty increases** with LET (Fig.1)

Methods

- We will simulate cell response data and identify the parameters that have the biggest impact on RBE uncertainty.
- Then we will test using a variable and uncertainty reduced RBE on real patient treatment plans.
- We except that **accounting for uncertainty** in the biological response of tissues to radiation will **improve treatment outcomes for cancer patients**.

“**Cancer patient treatment outcomes** can be improved by **identifying sources of uncertainty** when quantifying the biological effect of radiation.”

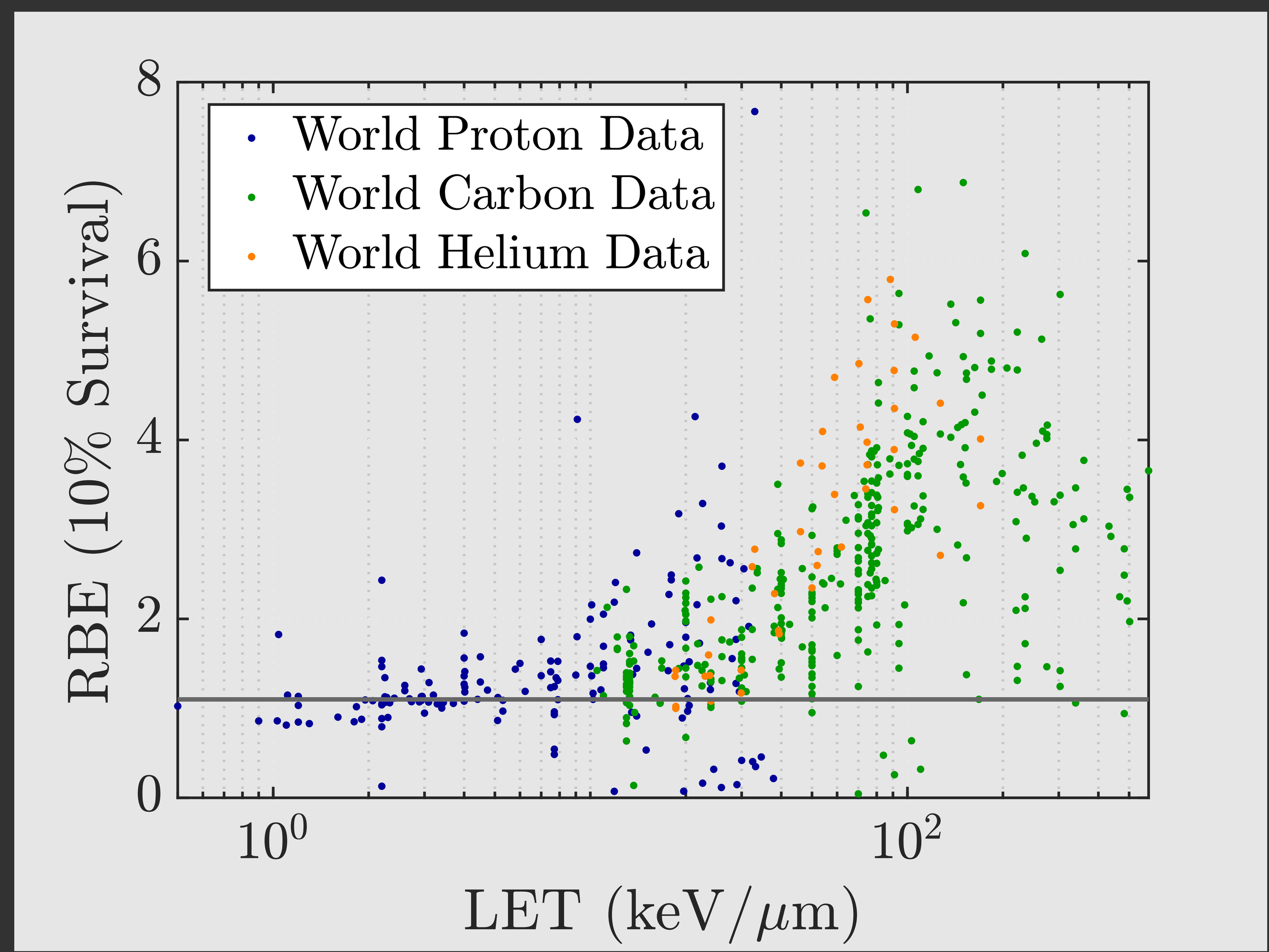
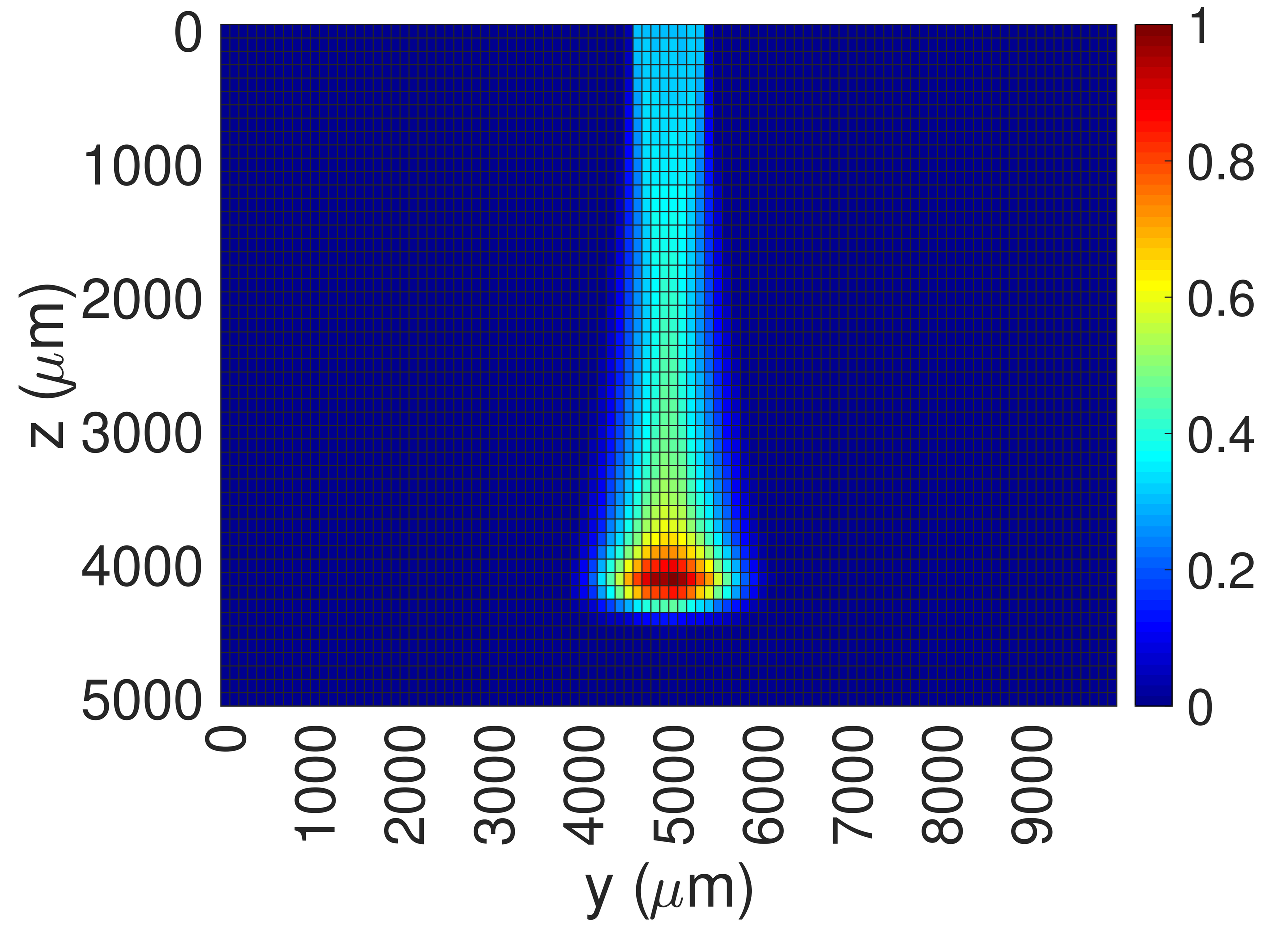


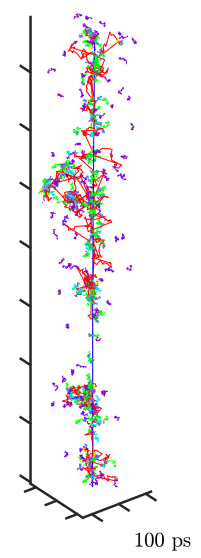
Figure 1

The underlying mechanisms of cell response to ionising radiation :

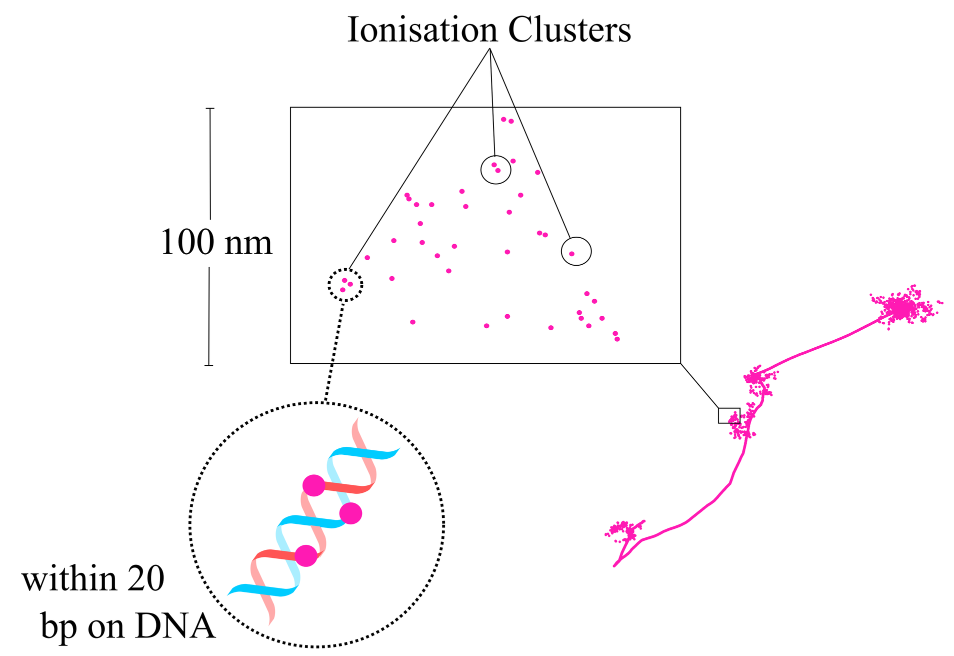
Relative Dose delivered as a function of depth. The red region representing the maximum relative dose delivered is lined up with the tumour :



A single proton track propagating through water - each colour represents a different particle or chemical species :



- The ionisation density of the track structure determines how severely the DNA inside the cells within the tumour are damaged.



- When the particle tracks damage the DNA severely enough, the cancer cells will deactivate causing the tumour to shrink.