Master's programme Medical Physics TU Dortmund
- Master thesis -

Topic: **Modelling the relative biological effectiveness of ions for cell irradiation based on a beam quality parameter**

Nowadays, a rapidly increasing number of ion therapy facilities are established worldwide to cure cancer. Compared to conventional photon therapy, protons or carbon ion beams show advantages, first, in terms of their inverted physical dose distribution along the penetration depth which allows higher dose delivered within the tumor volume and decreased dose in tumor-surrounding organs. And, furthermore, in terms of the higher relative biological effectiveness (RBE), since ions are more effective in cell killing than photon irradiation. This effectiveness has been found to be variable: a decreasing ion velocity results in an increase in RBE. The RBE of carbon irradiation has been studied for decades resulting in multiple variable-RBE models used for clinical patient treatment. For clinical proton therapy, on the other hand, RBE is currently modelled with a fixed value of 1.1. However, a growing number of clinical reports is providing evidence for the variability of the proton RBE and its consideration may improve future patient treatment.

Data analysis of cell irradiation experiments with ions shows the potential of a simple bio-mathematical model describing the RBE regardless of the ion type. That may allow for transferring available clinical knowledge from carbon irradiation to proton therapy or potentially other types of ion radiotherapy. A better description of the microscopic dose distribution on the cell level is needed to further investigate and test the proposed RBE model, and can be obtained using Monte Carlo beam transport simulations (TOPAS in this project).

The aim of this thesis is threefold; first, TOPAS simulations for mono-energetic ion beams are conducted and different measures to characterize beam quality with a simple parameter are investigated based on both theoretical and experimental material. After establishing an optimal measure for beam quality, second, the student will explore experimental setups applied to irradiate cells under clinically relevant conditions using a spread-out Bragg peak (SOBP) and implement them with the TOPAS simulation tool. Subsequently, precise simulations of the beam quality parameter for these experiments will be performed. Third, the validity of the proposed RBE model also for cell irradiation experiments within an SOBP, which is closer to the clinical situation, will be tested. Testing will be based on data-driven analysis of a database containing a variety of experimental cell response data. The tools established in this project will further boost the investigation of the mentioned RBE model and of radiobiological dose response in clinical ion therapy in general.