AbstractID: 6824 Title: A semi-analytical model of biological effectiveness for treatment planning in light ion radiotherapy

Purpose: To formulate a fast and accurate model to predict the biological effectiveness of light ion beams along their penetration depths in tissue, for their applications in radiotherapy.

Method and Materials: A simple model of light ion Bragg peaks is used in conjunction with a detailed probabilistic model of the subsequent biological processes in individual cells. The physical model takes into account energy loss, its straggling, and the reduction of primary particles' fluence due to nuclear reactions, but products of these reactions are not followed at all. The biological model takes into account the stochastic nature of individual particle traversals through a cell nucleus, distinguishes between two classes of DNA lesions of different severity, and can also account for cellular repair success probabilities.

Results: The simple physical model enables to correctly represent the Bragg peaks of protons and light ions up to carbon. Deviations from experimental depth-dose distributions occur for heavier ions at higher incident energies due to the neglect of nuclear reaction products. However, fragments play only a minor role with respect to biological effects of ion beams. Cell survival along the beam penetration depth for light ions up to carbon and with ranges in water up to approx. 15 cm, predicted with the combined physical and biological model, is in excellent agreement with experimental data.

Conclusion: This work indicates the potential applications of the present biological model in treatment planning in radiotherapy. Further improvement might be expected if a full Bragg peak model is incorporated. The semi-analytical nature of the present scheme enables advanced calculations that are necessary for truly biological optimization in light ion radiotherapy, including the optimization of multiple-port intensity modulated radiotherapy with ion beams and maximization of complication-free tumor cure.