

Swift ions in radiotherapy: Treatment planning with TRiP98

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Since 1997 GSI operates a successful pilot project treating tumours in the head and neck region with scanned beams of swift carbon ions. In collaboration with the DKFZ Heidelberg, the Radiological University Hospital Heidelberg, and the FZ Rossendorf more than 400 patients have been treated so far. In order to exploit the unique physical and radiobiological properties of ion radiation, a dedicated treatment planning system (TPS) is mandatory.

This contribution will summarize the current capabilities of GSI's TRiP98 TPS as well as future challenges and developments.

Beam-modelling:

The complexity of interactions of ion beams heavier than protons with living matter makes it difficult to provide purely experimental base data sets for treatment planning.

Hence one has to rely on sufficiently accurate - and fast - calculations to obtain base data such as depth dose distributions and particle spectra.

We have incorporated semi-empirical model calculations for various ions such as ^{12}C and ^3He , and will continue to do so with further species such as ^7Li and ^{16}O .

Radiobiology:

For all ions heavier than protons the inclusion of radiobiological effects, i.e. RBE, survival rates, biologically effective dose, into regular treatment planning is indispensable. Since ab-initio calculations are so far neither reliable nor computationally feasible, we use the versatile LEM model for the planning of all irradiations. Recent developments include clustered single strand breaks, improvements for low-LET radiations and calculations sped up by a factor up to 100 without sacrificing accuracy or versatility of the model.

Verification:

TRiP98 has built-in procedures to predict the non-linear response of cells as well as solid-state detectors when exposed to complex ion radiation fields. Such detection systems, like radiographic films and TLDs are still widely used and are superior to ionization chambers under certain circumstances, e.g. to verify irradiations under presence of motion.

Biological Dose Optimization:

The conventional - and reasonably fast - approach to obtain conformation of biological dose distribution to the target is to optimize ion fields from different directions singly.

For cases where even better conformation - and accounting for organs at risk - are desired, methods of simultaneous multiple field optimization have been implemented. This was possible with the much faster biological algorithms. The technique was verified by means of biological dosimetry.

Future Developments:

One of the main future tasks is 4D treatment planning, to support irradiation under presence of motion of both, the scanned beam as well as the target. The necessary enhancements are currently being built into TRiP98, including biological effects.

First results from experimental verifications are very encouraging.