

Treatment planning for the GSI radiotherapy

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Throughout the year 2000 our standard treatment planning software TRiP98 [1, 2] which went into production last year [3] was used in combination with the Voxelplan environment for the planning of all 32 patients [4]. Specific improvements on the software side were the introduction of inhomogeneous dose prescriptions, extensions of the beam model and addition of auxiliary functions.

Inhomogeneous dose prescriptions

One major user requirement was the possibility of prescribing partial fields with individually inhomogeneous dose distributions across the target volumes instead of a constant overall weighting of the single fields. The superposition of the partial fields should yield again a homogeneous biologically effective dose distribution. This task was basically solved by allowing to specify 3D dose weighting information. In a first step a weighting cube with a ramp-like dose gradient across the target volume is generated. The gradient should, but need not, be along the beam's eye-view of the irradiation field. Since we have to account for biologically effective dose the initial weighting prescription has to be modified in a second step according to the rules of nonlinear effective dose addition [5] thus yielding two complementary biologically effective 3D weighting distributions. Finally, these distributions are fed into our established single-field optimization procedures, which have been modified to cope with inhomogeneous dose prescriptions instead of a single value. Dose superposition, assessment and verification proceed as usual.

Extensions of the beam model

Our treatment planning code includes a refined and streamlined version of the YIELD beam model [6]. It has been further improved for ^{12}C primary particles by adapting the projectile fragmentation cross sections. It was found that in the vicinity of the Bragg peak heavy fragments were overestimated whereas light fragments were underestimated. This caused a slight overestimation of absorbed and of biologically effective dose beyond the Bragg peak. The improved beam model will be verified and included into the production version in 2001.

Although not verified for primary particles other than ^{12}C our beam model can preliminary be used for treatment planning of lighter projectiles - in view of the upcoming clinic facility. Exploratory calculations showed that there is probably no significant benefit in terms of the ratio of target to entrance (exit) dose for projectiles lighter than carbon, in contrast to other predictions [7].

Miscellaneous improvements

A raster scan path algorithm was introduced which handles irregular patterns of scanner positions - a prerequisite for scanner optimization for moving targets [8].

Another add-on is the evaluation of dose-volume histograms (DVHs) as "figures of merit". Traditionally they are calculated and assessed within the Voxelplan environment. However, with the future multi-field optimization

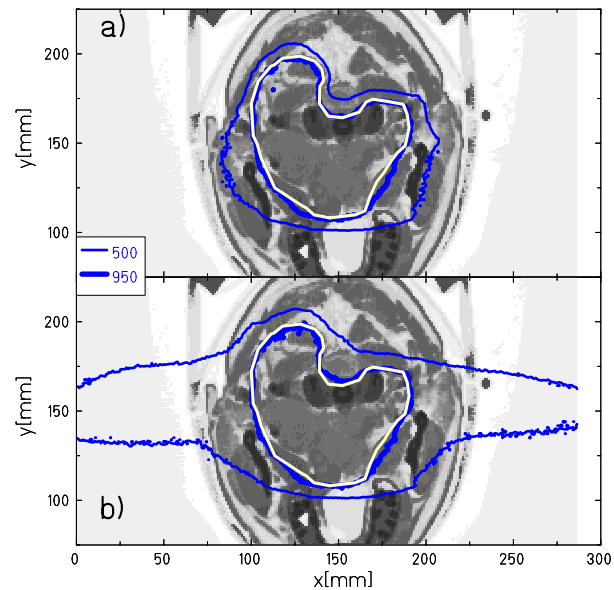


Figure 1: Patient plan with (a) 3 partial dose ramps and with (b) conventional opposing fields. Target as well as 50 and 95% isodoses are shown.

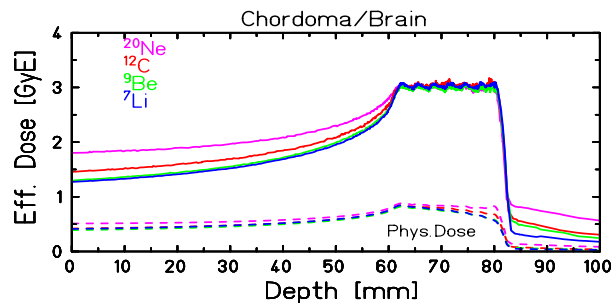


Figure 2: Biological dose profiles for various projectiles

in mind, DVH constraints will be necessary as objective functions for optimization already at the TRiP98 level.

Since the DKFZ CT scanner used since 1997 was replaced by a new one the Hounsfield calibration table had to be revised. Extensive measurements showed that reusing the old table would not lead to significant misalignments.

References

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