Status of the TRiP98 Treatment Planning System *

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Dose Optimization Algorithms

Various iterative algorithms to solve the dose optimization problem have been investigated in recent years [1]. The BFGS method as well as the popular Levenberg-Marquardt minimization (LMM) have now been integrated in the upcoming TRiP98 production version. Figure 1 shows that for problem sizes we usually encounter in ion beam radiotherapy, i.e. free parameter numbers up to and above 70000, text book wisdom (LMM and BFGS) tends to loose against the much simpler gradient based methods (steepest descent, SD, and conjugated gradients, CGFR).

Multi-material beam modelling

In ion beam treatment plans all tissue is treated as water, and even obvious deviations like lung or bone are only accounted for their influence on penetration depth. In particular bone, however, might have a different transport characteristic due to its significantly different elemental composition. To this end, materials other than water have been introduced in the TRiP98 transport model. Figure 2 shows a comparison with experimental data [2]. Whereas ”spongious bone” data agree with density scaled water as well as with preliminary transport calculations, deviations are seen for ”compact bone”, which are still under investigation.

New modalities

In view of upcoming irradiations with protons above 1 GeV, exploratory treatment plans have been performed for this new potential modality. Since at these energies the Bragg peak can no longer be used, cross fire techniques have to be implemented. A semi-empirical depth dose profile was constructed from the experimental data in [3]. As a proof-of-principle, figure 3 shows a planned four-field irradiation of a simulated tumour in the biophantom. The entrance dose is roughly 50% of the target dose.

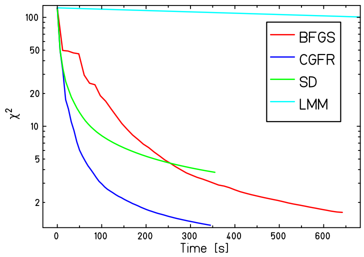

Figure 1: Convergence speed of optimization algorithms.

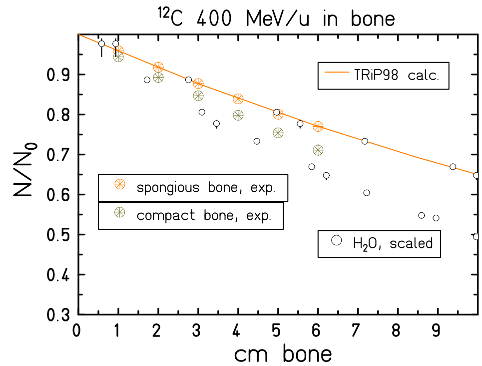

Figure 2: Primary beam attenuation in bone.

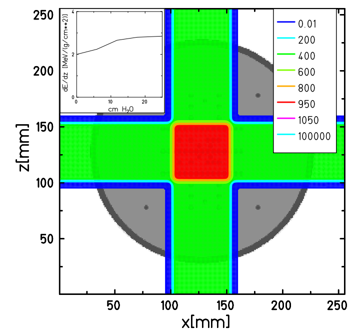

Figure 3: Treatment plan for 2.5 GeV protons. The assumed depth dose profile is shown in the insert.

Technical developments

With more demanding treatment plans, in particular high resolution CTs as well as 4D irradiations, the computational footprint of TPS calculations has dramatically increased in comparison to the initial TRiP98 version introduced in 1999. Thus the support of large (64bit) address spaces, large files and multicore CPUs have finally reached the production version. The underlying batch system (LoadLeveler) has been tuned accordingly.

References

[1] Horcicka M. et al., Phys. Med. Biol., 58 (2): 275-286 (2013)

[2] Eichhorn A., et al., GSI Report 2011

[3] Z.Yu, et al., J. Radiat. Res. 53(4): 620-627 (2012)

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