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Establishing a process for the use of thermoluminescence dosimetry (TLD) in radiotherapy – an approach concerning the entire range of diagnostic and therapeutic photon energies

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Nowadays, radiation therapy is characterized by dose escalations to the tumor and increased use of X-ray imaging in order to localize the tumor volume anatomically and to position the patient correctly according to the treatment beam. These circumstances claim highly accurate methods for the determination of absolute dose. TLD was chosen due to very good spatial resolution and thus the potential of precise 3D dose distribution detection both in phantoms and in vivo.

First of all, the complex process of handling TL-Detectors was facilitated by an enhanced calibration procedure. Therefore a phantom was created comprising up to 100 TL-Detectors at a time. The following calculation of calibration factors was aligned and yielded improved accuracy about ± 1% averaged over all detectors used. Furthermore, the software *'TLD Analyzer'* was developed as part of this thesis. With the *TLD Analyzer* calibration factors and doses can be calculated automatically, completing the improvement of the TLD process.

Anymore, this work was focused on determining the energy dependence of the TL output for TLD600 and TLD700 in order to define energy correction factors k_E for X-ray imaging beams. This was carried out in collaboration with the German secondary standard laboratory PTW Freiburg. The results lead to the conclusion that the k_E-values provided in the German DIN protocol for TLD ought to be adapted. The k_E-values determined in this work were tested for different photon energies at an X-ray tube mounted at a linear accelerator. The standard deviation of reproducibility was 1.16...3%. Measuring imaging dose for patient positioning purposes (IGRT) in an anthropomorphic phantom served as an example for delineating the energy correction. CBCT's were delivered to different body regions with dose values between 5 mGy and 25 mGy per fraction. Accumulating this dose over all fractions (due to daily position verification) a dose bath is brought about, which is no longer negligible and ought to be considered in the dose prescription already during the treatment planning process. For this reason, more accurate Monte Carlo simulations are needed for any kind of X-ray tube along with dosimetrical commissioning methods like TLD - as long as alternative imaging methods e.g. MRI are still under investigation regarding IGRT.

Irradiating TL-Detectors with very high single doses supralinear behavior becomes another important property of the TL signal. This work was concentrated on the dosimetrical determination and mathematical description of the supralinearity. The specified interpolation models work very well for irradiation doses up to 70 Gy. The irradiation of cell cultures in the lower dose range up to 4 Gy and an *in vivo* experiment with doses in the medium and high dose ranges up to 70 Gy served as test cases. The resulting dose values calculated from the TL signal together with the supralinear correction function $k_N(D_{irr}, D_{TL})$ were adequate with a propagated standard deviation between ± 1.5 % and ± 2.4 %. Regarding the *in vivo* experiment, it has to be stated that the trial was an unprecedented method to measure dose *in vivo* and convinced with complete success. Concluding the determined dose values and the corresponding deviations are satisfying. In order to achieve dose values, which are more representative for the dose delivered to the tumor itself, the idea occurred to let the tumor grow around the TL-Detector in a future trial.