in-vitro cell survival experiments after photon or ion irradiation. For each radiation quality in the PIDE-Database, the corresponding ICS distributions (ICSD) were calculated with the PTB Track structure code (PTra) [4, 5] for specific nanodosimetric parameters, such as size, shape and material composition of the specified target volume (STV), as well as its distance and direction with respect to the particle beam.

Results: Nanodosimetric quantities were calculated from the aforementioned ICSDs (i.e. the mean ionisation cluster size \( M_i \), or the cumulative probability distribution \( F_\text{I} \) of ICS, given the probability that an ICS of K or larger is produced in the target volume). The ascertained correlations to the biological data will be presented.

Conclusions: The database application is a useful resource for investigating the range of validity of the nanodosimetric approach.

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Proposal of thermal neutron detector stability for peripheral dose estimation in clinic at a novel neutron facility

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Purpose/Objective: This work aims to design a stability verification system for thermal neutron detectors, based on the characterization and implementation of a fixed neutron fluence beam from a 3 MV tandem facility. The goal would be to minimize the noticed loss of sensitivity with accumulated dose in time and the constancy of the physical-chemical deposition of TNRD detector. This will guarantee a correct behavior of these detectors for peripheral neutron dose estimation \([1]\) in clinical environments when using photon beams over 8 MV.

Materials and Methods: Neutron beams can be obtained by means of the \(^7\)Li(p,n) and D(d,n) reactions, setup shown in Figure (a). TNRD (Thermal Neutron Rate Detector) \([2]\), as most of the neutron detectors are mainly sensitive to the thermal component but photon presence can disturb the signal. Preliminary tests (detector-source distances and angles, plastic material thickness and photon rejection) were performed with epithermal neutron beam (0-100 keV neutron energy) following a quasi-Gaussian distribution by means of the \(^7\)Li(p,n), with proton energy near-threshold, in order to have an appropriate neutron thermal fluence. With this information, several Monte Carlo simulations have been carried out to propose an optimal solution.

Results: As expected, tests showed that photon contribution increases when getting closer to the beam and thermal neutron signal increases when a thicker polyethylene block is used while decreases with distance. Thus a compromise between these aspects has to be found in order to ensure an acceptable noise-signal ratio. A solution based on the D(d,n) reaction at \(E_D=500\) keV \([3]\) was found with MCNPX simulations. Figure (b) shows the simulated normalized neutron flux integrated over the cell, with the dimensions of the TNDR. One million neutrons can be achieved with 1 hour irradiation using 500 nA deuterium current, polyethylene thickness of 2 cm, 2.1 cm distance between TNDR and neutron production target and the detector perpendicular to the beam.

Conclusions: Periodic measurements in a reference neutron facility should be considered to ensure thermal neutron detectors accuracy. The proposed setup added to the tandem facility, could be an adequate system to perform periodic stability measurements for this type of devices. The neutron spectra obtained from the D(d,n) reaction and polyethylene moderator may fulfill the requirements. Additional future measurements will be performed to verify the viability of the facility for neutron detectors stability verification and to study the possibility to establish as future calibration procedures.

Ref.

\([2]\) Radiat Prot Dosim 2014;161(1–4), 241–244.
\([3]\) Nuclear Data Tables 1973;11(7), 569-619.

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Investigation of new phantom materials for QA in deep hyperthermia treatments

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Purpose/Objective: The University Clinic Erlangen is equipped with phased array deep hyperthermia treatment devices. The implemented antennas in the hyperthermia applicator transmit steered radio waves to heat the target. Since the characteristics of the antenna can be varied due to adjustments of the device, QA measurements of the equipment are necessary. Generally, a phantom filled with a muscle-equivalent gel is used for the verifications. A mixture of water, TX 150 and NaCl was used for the standard phantom in Erlangen. This mixture, however, includes air bubbles (arising from the short pot life), that lead to massive artefacts. Moreover, only one measurement can be accomplished within 24 hours, as the material disperses the heat very fast in the phantom, yet the heat dissipates slowly into the surrounding air. Concerning these negative characteristics, investigations on a new phantom material were carried out.

Materials and Methods: The phantom material should mimic the muscle in terms of permittivity $\varepsilon_r$ and conductivity $\sigma$. The characteristics of muscle in the frequency range of 100 MHz are $\varepsilon_r \approx 66$ and $\sigma \approx 0.71$ S/m [Andreuccetti 1997]. The dielectric properties of seven different possible phantom recipes were measured with a Vector Network Analyzer (Rohde & Schwarz, Munich, Germany) with open-ended coaxial probes [Bobowski 2012]. Possible thickening agents (Rohde & Schwarz, Munich, Germany) with open-ended coaxial probes [Bobowski 2012]. Possible thickening agents were TX 150, PNC 400, gelatin or agar. NaCl, ethylene glycol and sugar were used to change conductivity and permittivity, respectively. Afterwards, the thermal properties were investigated using a BSD-2000/3D/MR (BSD Med. Corp., Salt Lake City, UT, USA) combined with a Magnetom Symphony 1.5T MRT (Siemens, Erlangen, Germany). Since the thermal properties of the PNC 400 phantoms (either pure or mixed with agar) proved themselves most similar to the standard TX 150 phantom in the MR thermometry images, further investigations were therefore performed with PNC 400. Various properties of the recipe were changed to ease the fabrication and to decrease the air bubbles, such as the order of the blended materials, the temperature during stirring and the amount of PNC 400 and ethylene glycol.

Results: The standard recipe with TX 150 resulted in measured dielectric properties of $\varepsilon_r \approx 80$ and $\sigma \approx 0.5$ S/m. The new PNC 400 phantom gave measured properties of $\varepsilon_r \approx 90$ and $\sigma \approx 0.5$ S/m and $\varepsilon_r \approx 70$ and $\sigma \approx 0.2$ S/m for PNC 400 plus agar. We found that by heating pure water up to 85°C, adding the other ingredients followed by PNC 400 gave promising results regarding the number of air bubbles, transparency and thermometry response. The drawback is the same long cool-down time as of the standard phantom.

Conclusions: The dielectric properties of the first investigated recipes were not completely in line with the muscle properties. But PNC 400 mixtures with different NaCl, ethylene glycol and sugar fractions and further measurements of the dielectric properties will result in a better standard phantom.

EP-1366
Comparison of Gafchromic EBT, EBT2 and EBT3 radiochromic films when used with flat bed scanners
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Purpose/Objective: Dosimetry films have certain advantages over matrices of diodes or ionization chambers because their high spatial resolution and flexibility in the use with a number of tissue equivalent phantoms for dosimetry in radiotherapy. Radiochromic films are easier to handle than radiographic films because they do not require processing after irradiation. Since Gafchromic EBT films were released, two other generations, EBT2 and EBT3, became available. The purpose of this study was a comparison of physical properties of the three generations of Gafchromic films and their performance when used with flat bed scanners.

Materials and Methods: The EBT, EBT2 and EBT3 films were cut to obtain 5 cm × 10 cm samples. The samples were exposed to UV radiation of sunlight and to Co-60 radiation and 6MV and 15 MV X-ray beams from the Varian Clinac2300 linac. During X-ray irradiation the reference conditions were used. The exposed films were scanned with two types of EPSON flat bed scanners: PERFECTION V750 PRO and EXPRESSION 10000XL. The colour separation (red, green and blue) was performed to obtain digital images. The response curves of three types of films for different radiation energy, orientation of scanning and two types of scanners were generated and compared in each of colour channel. The orientation effect for each film type and for each scanner was evaluated as well as energy dependence and UV sensitivity.

Results: For all colour channels the EBT films show much higher sensitivity to UV radiation compared to EBT2 and EBT3 being the least sensitive. The sensitivity of the EBT films to X-rays is also the highest in respect to EBT2 and EBT3. Each type of films shows similar orientation effect for both scanners. There was no energy dependence observed for any of the film type in the examined energy range (Co60 and 15MV X-rays).

Conclusions: The reduction of sensitivity to UV radiation in subsequent generations of Gafchromic films was in correlation with lower sensitivity for high energy X-rays. Lower optical densities of EBT2 and EBT3 films may increase uncertainties during the dose measurements compared to the former EBT films. The Gafchromic films are a useful tool for pretreatment dosimetry verification of complex radiotherapy dose distributions (IMRT, VMAT etc.).

EP-1367
Characterization of a new plastic scintillator detector system for small field dosimetry
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Purpose/Objective: Cutting-edge radiotherapy treatments (RT) require the use of increasingly smaller fields sizes. Therefore, it is essential to use detectors with appropriate collecting volumes and well understood dependence on energy, dose and dose rate. In this work, Exradin W1 (Standard Imaging), a new plastic scintillator detector system

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