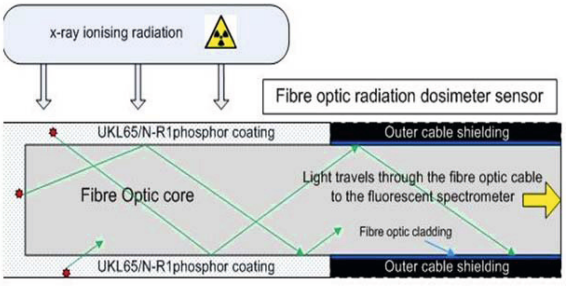
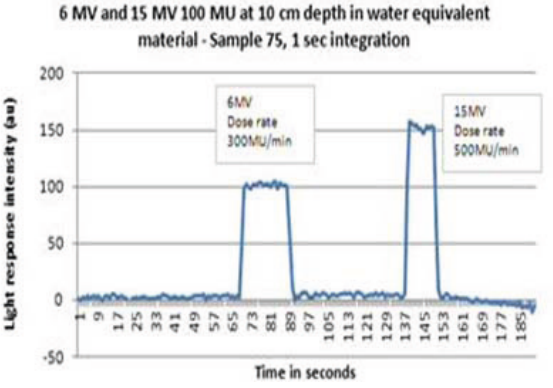
calculated 191.7cGy. The error in film measurement increases from 1.4cGy to 2.2cGy if a single film is used instead of a 5-film sample.
Conclusions: Submillimeter point dose measurement with EBT2 film is shown to be very accurate. Signal extraction from such a small spatial area allows for accurate measurement in small-fields, steep dose gradients, and non-flattened beams.
References:
1. Gafchromic EBT2 Self-Developing Film for Radiotherapy Dosimetry, ISP White Paper, Revision 1, February, 2009.

PO-0763
Optical fibre radiation detector for radiotherapy dosimetry
P. Woulfe[1], D. McCarthy[2], S. O'Keefe[2], E. Lewis[2], J. Cronin[1]
[1]*Galway Clinic, Department of Medical Physics, Galway, Ireland Republic of*
[2]*University of Limerick, Optical Fibre Sensor Research Centre, Limerick, Ireland Republic of*

Purpose/Objective: An optical fibre sensor for use in radiotherapy dosimetry is presented. The sensor is based on a scintillating material coated plastic optical fibre (POF), which emits visible light when exposed to low level ionising radiation. The incident level of ionising radiation can be determined by analysing the observed emission spectra. The work presented reports on the design of the sensor and the stability of the sensor during measurement of incident x-ray energy. Initial testing of the sensor on a Linac is presented, demonstrating the suitability of such a sensor for a range of radiotherapy dosimetry applications, including the area of small field dosimetry.
Materials and Methods: A 1 metre PMMA (Polymethyl Methacrylate) plastic optical fibre of 1mm diameter is prepared.The optical fibre cable end was polished, an epoxy resin and hardener mix,containing the scintillation material, was then encapsulated around the fibre cable end using an injection method and allowed to set. The radiation source used was a Siemens Artiste, with a water equivalent phantom of varying depths. The sensor was connected to a fluorescent spectrometer using a 19 meter long POF cable. The spectrometer and a computer for analysing the resultant optical signal were located at the control console. The optical fibre coated with a scintillation material fluoresces when subjected to ionising radiation. Upon scintillation, the low level light permeates the fibre optic cable end and the spectrometer placed at the distal end of the POF cable measures the received optical signal. The amount of radiation incident on the sensor is directly related to the measured intensity of the received spectrum at the preselected wavelengths. The spectrometer detects and records low level light from the sensor and detects any changes in optical intensity levels that are recorded via LabVIEW software.



Results: The optical fibre sensor was initially tested for its response to 100MU (Monitor Units,where 1MU = 1cGy when SSD (surface to source distance) is 100cm at a depth of Dmax.) at 6MV photon energy using a 1.5cm build-up. The peak intensity of the received fluorescent signal, at 544nm, was monitored. During irradiation the sensor demonstrates a stable response and then returns to its original off state when the radiation stops. The sensor was then tested at repeated radiation doses of 100MU at 15MV to test for the stability of the optical fibre sensor at repeated exposures.



Conclusions: The optical fibre sensor was investigated for its response to known incident radiation exposure patterns, repeatability and stability of measurement. The sensor demonstrated excellent response to a wide range of exposure conditions including different levels of ionising energy, dose rates and exposure duration. The results show that the sensor is capable of realtime, accurate and repeatable radiation dose measurements with a maximum variance of ± 2% from a Linac.

PO-0764
Evaluation of EBT3 films for use in clinical photon and proton beams
S. Reinhardt[1], M. Hillbrand[2], J.J. Wilkens[3], W. Assmann[1]
[1]*Ludwig-Maximilians-University, Physics Department - Medical Physics, Garching, Germany*
[2]*Rinecker Proton Therapy Center, Radiooncology, Munich, Germany*
[3]*Klinikum rechts der Isar TU München, Department of Radiation Oncology, Munich, Germany*

Purpose/Objective: Radiochromic films such as Gafchromic EBT or EBT2 offer an excellent spatial resolution which is beneficial for dose verification in highly conformal radiation therapy such as IMRT or proton therapy. Recently, a new generation of these films, EBT3, has become available. As composition and thickness of the sensitive layer are the same as for the previous EBT2 films, a similar dosimetric performance is expected, in particular with respect to the known energy dependence of the films. The side orientation dependence, which is reported for EBT2 films, has been eliminated in EBT3 films by a symmetric layer configuration.
Materials and Methods: The general EBT3 film characteristics such as read-out orientation dependence and post-exposure darkening growth are evaluated and compared to EBT2 films. Film response has been investigated in clinical photon and proton beams. The energy dependence of both, EBT2 and EBT3 films, has been studied for low proton energies (<=20MeV) as predominating in the vicinity of the Bragg peak but also up to a maximum energy of 200 MeV.
Results: In general, EBT3 show a comparable performance to EBT2 films, moreover, orientation dependence with respect to film side is completely eliminated in EBT3 films. Response differences of EBT2and EBT3 films are of the same order of magnitude as batch-to-batch variations observed for EBT2 films. Photon and proton exposure show similar response for both generations of EBT films. Depth dose measurements show an under-estimation of dose by up to 20 % in the Bragg peak region for both types of film.
Conclusions: EBT3 and its precursor EBT2 have similar dosimetric performance and can, thus, be applied to dose verification in IMRT in the same way. Dose under-response in the Bragg peak region has to be taken into account if films are to be applied for dose verification in proton therapy.

PO-0765
Dosimetry audit of TPS performance
W. Bulski[1], K. Chelminski[1], J. Rostkowska[1]
[1]*The Maria Sklodowska-Curie Memorial Cancer Center, Department of Medical Physics, Warsaw, Poland*

Purpose/Objective: In the radiotherapy Treatment Planning Systems (TPS) various calculation algorithms are used (Pencil Beam Convolution PBC, analytical anisotropic algorithm AAA, Monte-Carlo). The accuracy of dose calculations has to be verified. Numerous phantom types and detectors are proposed to verify the TPS calculations by dosimetric measurements. A heterogeneous cubic-shape phantom has been designed for this purpose within a Coordinated Research Project of the IAEA.

Materials and Methods: The heterogeneous phantom was developed in the frame of IAEA Coordinated Research Project. The phantom consists of frame made with polystyrene and bone or lung equivalent inhomogeneity slabs. Special inserts allow to position TLD capsules within the polystyrene below the bone or lung material and also within the lung equivalent material. Additionally, there are inserts that allow for positioning the ionization chamber and films in the phantom. This enables comparisons of the doses calculated by TPSs for specific treatment fields in specified points with the measurements performed with various detectors. The comparisons were performed for a number of TPS (Eclipse from Varian, XiO, from CMS, Oncentra MasterPlan from Nucletron, Panther from Prowess, PrecisePlan fromElecta, Pinacle from Philips) and for a number of linear accelerators (Varian, Siemens, Elekta) in several radiotherapy departments in Poland in the framework of the Quality Assurance Audit programme in Poland.
Results: Seven Polish radiotherapy centers (of 28 in total) were audited. Six different TPSs and eleven calculation algorithms were examined. Generally, most of the results obtained with TLD and ionizing chamber were within 5% tolerance. Differences between doses calculated by TPSs and measured with TLD did not exceed 4% for bone equivalent and polystyrene materials. Under the lung equivalent material, on the beam axis the differences were lower than 5% whereas inside the lung material, off the beam axis – in some cases were about 7%.
Differences of doses measured with ionizing chamber under polystyrene and bone or lung equivalent materials were lower than 5%, whereas inside the lung material the difference was 5,2%.
Conclusions: The comparison of results for calculations and the measurements allow for the detection of limitations of TPS calculation algorithms. The audits performed with the use of heterogeneous phantom seem to be an effective tool for detecting the errors in basic data configuration and the TPS performance at the audited radiotherapy departments.

PO-0766
Small beam dosimetry using diamond devices
F. Marsolat[1], N. Tranchant[1], D. Tromson[1], M. Le Roy[2], F. Moignau[2], C. Bassinet[3], C. Huet[3], S. Derreumaux[3], G. Boisserie[4], A. Lisbona[5]
[1]*CEA LIST, LCD, Gif sur Yvette, France*
[2]*CEA LIST, lnhb, Gif sur Yvette, France*
[3]*IRSN, PRP-HOM/SDE/LDRI, Fontenay-aux-Roses, France*
[4]*Pitié Salpêtrière Hospital, Radiotherapy Department, Paris, France*
[5]*René Gauducheau Cancer Treatment Center, Radiotherapy Department, Nantes, France*

Purpose/Objective: Recent developments of new therapy techniques using small beams, such as stereotactic radiotherapy, require new detectors to precisely determine the delivered dose. The dosimeter has to be as close as possible to tissue equivalence and exhibit a small detection volume compared to the size of the irradiation field, because of the lack of lateral electronic equilibrium. Characteristics of single crystal diamond (tissue equivalent material Z=6, high density) make it an ideal candidate to fulfill most of the small beam dosimetry requirements.
Materials and Methods: We developed single crystal diamond dosimeters (SCDDo) with a small detection volume (<0.4 mm^3). The Monte-Carlo code PENELOPE (parallelized version) was used to optimize the encapsulating material and electrodes of our diamond detectors, in order to obtain a tissue equivalent detector. Response time, stability and repeatability of the detector were tested under Co^{60} source irradiation. SCDDo dose profile, depth dose and output factor measurements, were performed for small beams using two stereotactic systems: Varian Clinac 2100 C linear accelerator with micro MLC m3 and a Novalis TX linear accelerator. These measurements were compared to different detectors, both active and passive: diode, micro-LiF (TLD), EBT2 radiochromic film, PinPoint ionization chamber.
Results: SCDDo presents an excellent spatial resolution for dose profile measurements, due its small detection volume. OFs obtained with SCDDo are very satisfactory from 0.6 x 0.6 cm^2 to 10 x 10 cm^2 field sizes, compared to PinPoint ionization chamber which underestimates OF values in small beam.
Conclusions: SCDDo respects the small beam dosimetry requirements (tissue-equivalence, small detection volume). The absorbed dose measurements obtained with this device are very satisfying compared to the results obtained with the existing devices and to the literature.

PO-0767
Characterization of a radiochromic dosimeter: The chemical structures
P.S. Skyt[1], G.V. Jensen[2], I. Wahlstedt[3], J.B.B. Petersen[1], L.P. Muren[1], J.S. Pedersen[2], P. Balling[4]
[1]*Aarhus University Hospital, Dept. of Medical Physics, Aarhus C, Denmark*
[2]*Aarhus University, Interdisciplinary Nanoscience Centre (iNANO) and Dept. of Chemistry, Aarhus C, Denmark*
[3]*Aarhus University, Dept. of Physics and Astronomy, Aarhus C, Denmark*
[4]*Aarhus University, Dept. of Physics and Astronomy and Interdisciplinary Nanoscience Centre (iNANO), Aarhus C, Denmark*

Purpose/Objective: Radiochromic dosimeters are promising within radiotherapy due to the ability to measure dose distributions in 3D with high resolution. However, the response to irradiation is low compared to clinical relevant dose levels. Improvements of the dose response may be found through knowledge of the chemical structure of the dosimeter. In this study we therefore examined the nanoscale structures in a radiochromic dosimeter that was based on a leuco malachite green dye and the surfactant sodium dodecylsulfate (SDS) suspended in a gelatin matrix.
Materials and Methods: The original dosimeter formulation investigated consisted of 6 % (w/w) gelatin that formed the volume of the 3D dosimeter, 50 mM sodium dodecyl sulfate (SDS) was added as surfactant, 5 mM trichloroacetic acid as initiator, 0.37 mM leuco malachite green (LMG) as active component and 80 mM trichloromethane was added to dissolve the LMG. Small-angle x-ray scattering was then used to investigate the structures of a range of compositions of the dosimeter by omitting different components of the dosimeter formulation.
Results: When omitting gelatin ellipsoidal micelles of SDS were formed with a core radius near 15 Å and shell thickness near 7 Å (figure 1).Gelatin significantly changed the micelles to a cylindrical shape with around three times lower core radius and four times larger shell thickness, which indicates that the gelatin is present in the shell and the outer part of the core.

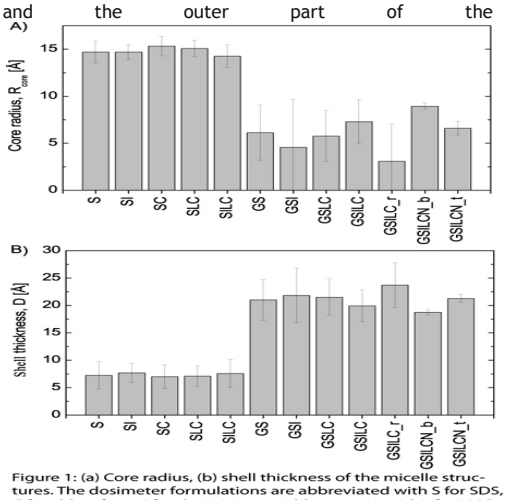


Figure 1: (a) Core radius, (b) shell thickness of the micelle structures. The dosimeter formulations are abbreviated with S for SDS, C for chloroform, I for the initiator trichloroacetic acid, L for LMG and G for gelatin. The extension, _r, is the irradiated dosimeter while _b and _t is the bottom and top phase of the dosimeter added salt, respectively.

Conclusions: It was possible to measure the individual dosimeter components effect on the chemical structures of the dosimeter. Using knowledge of the chemical structure, it might be possible to construct an improved dosimeter with a clinical relevant dose response by modifying the chemical composition and thereby the micelle structures.

PO-0768
Localization methodology for water-equivalent plastic scintillation detectors using surrogate fiducials in CT
R.J. Kudchadker[1], L.S. Wootton[1], A.K. Lee[2], A.S. Beddar[1]
[1]*The University of Texas MD Anderson Cancer Center, Department of Radiation Physics, Houston TX, USA*
[2]*The University of Texas MD Anderson Cancer Center, Department of Radiation Oncology, Houston TX, USA*

Purpose/Objective: To quantify the accuracy of a method to localize the sensitive volume of water equivalent *in-vivo* plastic scintillation detectors (PSDs) on Computerized Tomography (CT) images. PSDs when inserted in patients cannot be directly visualized on CT images