identify in which crystal the scintillation event takes place but also can provide information about the depth of interaction of the gamma along the vertical length of the crystal. In the module the light output of the crystals is related to the vertical position of the interaction point and it is proved that the DOI can be reach using a single side readout. The different configurations are tested and compared to obtain the best DOI resolution.
Conclusions: A innovative PET module is developed and tested and shows high performances according with a spatial resolution less then 1.5 mm and a DOI resolution of about 4 mm FWHM obtained using a single side readout.

Keywords: Positron Emission Tomography, Depth of Interaction, high resolution module

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Fast Beam Profile Monitors for Microbeam Radiation Therapy

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Microbeam Radiation Therapy (MRT) is a novel, promising technique for X-ray therapy [1]. The proposed treatment consists of intense, highly collimated, parallel arrays of X-ray beams of widths between 20 and 100 μm and separations between 100 and 400 μm generated by synchrotron radiation and suitable microslit collimators. Due to extremely high dose rate (up to 20 kGy/sec), a fast and reliable monitoring system is essential, but extremely challenging to construct, as it must cope with the high intensity, as well as very steep intensity gradients within the microscopic dimensions of the beams.
In order to meet the requirements, the 3DMiMic collaboration has designed and fabricated 10 μm thick silicon strip beam monitors. Several strip layouts have been produced for simultaneous monitoring of the full array of microbeams.
Tests using both single channel and multichannel readout at the ESRF biomedical beam-line ID17 demonstrate that the detector and readout system work well and constitutes a viable system for coping with the challenge [2].
In this presentation we will give details of the sensor design and results obtained from the tests at the ID17 beam-line. 2D response scans and time evolution studies of the sensor performed with an X-ray microprobe at the ID21 beam-line will also be presented.

Keywords: Micro-beams, Silicon sensors, X-rays.

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Improved proton stopping power ratio estimation for a deformable 3D dosimeter using Dual Energy CT

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Purpose: The highly localized dose distribution in proton therapy (PT) makes this treatment modality sensitive to organ motion and deformations. E.g. in proton pencil beam scanning interplay effects may be significant, resulting in dose degradations. Due to the complexity of PT dose delivery, investigations of the consequences of motion and of motion mitigation strategies may benefit from use of 3D dosimetry. A new family of silicone-based 3D dosimeters is currently being developed. These dosimeters can be moulded into anthropomorphic shapes and can be deformed during beam delivery, which allows for simulation of organ motion and deformation.
Treatment planning with protons is based on CT scans of the patient anatomy and a conversion of the HU for the tissue to a stopping power ratio (SPR) relative to water. To ensure that the same procedure can be performed for the dosimeter it must be verified that its SPR is estimated correctly from its HU. The aim of this study was therefore to investigate if the use of Dual Energy (DE) CT and dedicated DE calibrations can improve the calculation of the SPR for the dosimeter compared to use of Single Energy (SE) CT together with the stoichiometric calibration method.
Method: The dosimeter was CT scanned with a Dual Source CT scanner (Siemens Somaton Definition Flash). First a CT scan was obtained in SE mode with a tube voltage of 120 kVp, and this scan was used in the stoichiometric calibration. Next a set of CT scans was obtained in DE mode with a tube voltage pair of 80/140Sn kVp (Sn: 0.4 mm extra tin filtration); this CT image set was used for SPR calculation with two published DE calibrations. The $CTDI_{vol}$ of the two scanning modes was set to be the same (~20 mGy).
A thin slab of the dosimeter material was placed in a water tank and irradiated with a 60 MeV proton beam. The range of the protons was measured with and without the dosimeter intersecting the beam to determine the range difference. The SPR of the dosimeter was calculated from its thickness and the range difference.
Results: The two DE calibration methods both gave an estimate of SPR_{est} = 1.01, whereas the SE stoichiometric calibration estimate was SPR_{est} = 1.10. From the range measurements, the SPR of the dosimeter was calculated to be SPR_{meas} = 0.97. The measured SPR did not fall on the stoichiometric calibration curve of the reference tissues (Figure; the high content of silicon makes the dosimeter not tissue equivalent). The dosimeter was found to have a HU corresponding to bone (CT number = 135 HU) but a SPR corresponding to fat.

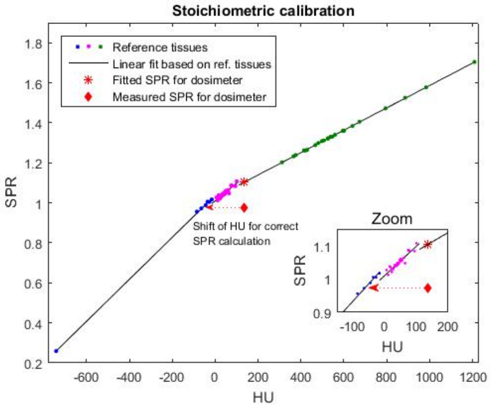

Figure: Stoichiometric calibration curve. The HU shift for the dosimeter needed for a correct SPR estimation based on the curve is indicated with a red arrow.

Conclusion: The stoichiometric method overestimates the measured SPR by 13%. Using DE this error is reduced, to an overestimation of 3%. If the stoichiometric method is used for the 3D dosimeter its HU must be corrected in the treatment planning system.

Keywords: Stoichiometric calibration method, Dual Energy CT, 3D dosimetry

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Organizational response of the hypothalamus and pituitary to external beam radiation

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Purpose: Hypothalamic-pituitary axis (HPA) dysfunction is a dose-dependent sequela of brain irradiation. Meta-analysis of studies on non-pituitary central nervous system tumours performed by Appelman-Dijkstra et al. [*The Journal of Clinical Endocrinology & Metabolism*, 8, 2330 (2011)] found estimated doses of 25-97 Gy to the HPA and 0.54 prevalence of pituitary deficiency. However, no included study reported the site-specific doses to the hypothalamus or pituitary. As the hypothalamus is thought to be more radiosensitive than the pituitary, greater understanding of the structural organization and normal tissue tolerances of these two structures is necessary to better describe the relationship between HPA radiation dose and secondary insufficiency. The purpose of this study is to characterize the radiation dose to the HPA in adults treated for non-pituitary brain tumours.

Materials/Methods: Twelve patients, 3 males and 9 females, have been enrolled in our prospective VoxTox study that will continue to recruit until 2017. Primary diagnoses included meningioma (7), pineal tumor (3), and glioma (2). Patients were treated with TomoTherapy® and received 50-60 Gy to the tumour bed in 30 fractions. Digital Imaging and Communications in Medicine radiotherapy data, including dose cubes, contours and planning imaging, were retrieved from TomoTherapy® archives using an in-house software and imported into ProSoma virtual simulation software. Quality assurance of hypothalamus and pituitary contours was performed. Parametrisation of dosimetric data from planning computed tomography scans was used to determine mean radiation doses to the hypothalamus and pituitary separately. Dose volume histogram data were exported to Matlab®. Equivalent uniform doses (EUDs) for a parallel structure (*a*=1) and serial structure (*a*=20) were calculated utilizing a freely available program and normal tissue tolerance parameters for the lung and spinal cord, respectively.

Results: The mean radiation doses to the hypothalamus and pituitary were 35 Gy and 34 Gy, respectively. Serial and parallel EUDs for each patient are presented in Figure 1. The mean EUDs for *a*=1 and *a*=20 were 30 Gy (range 14-52) and 33 Gy (range 19-52), respectively, for the hypothalamus and 29 (range 8-46) and 31 Gy (range 8-46), respectively, for the pituitary. The mean difference between serial and parallel EUD values was 3 Gy for both the hypothalamus and the pituitary.

Conclusions: The organization of the hypothalamus and pituitary into serial or parallel structures may not be predictive of HPA response to radiation. Future studies are necessary to isolate the dose-volume effects of these two organs.

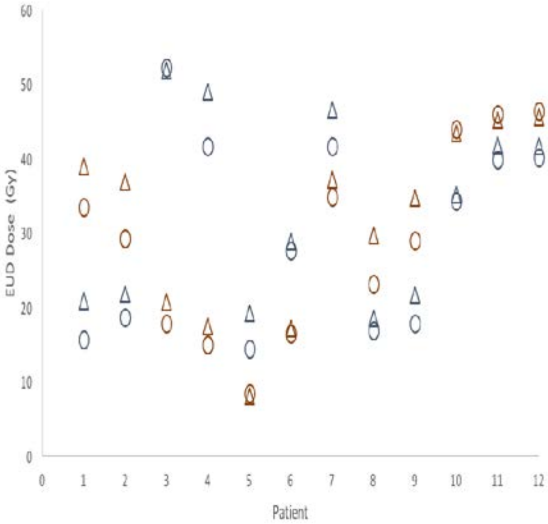

Figure 1. EUD doses to the hypothalamus (blue) and pituitary (red) are presented for parallel (circle) and serial (triangle) structures for each patient.

Keywords: brain tumours; pituitary; hypothalamus

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Response-based Bayesian Network Approaches for Adaptive Radiotherapy of Non-Small Cell Lung Cancer (NSCLC)

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Purpose: In NSCLC radiotherapy, personalized radiation treatment is intended to deliver an appropriate amount of dose to control the tumor while reducing radiation-induced toxicities such as radiation pneumonitis, esophagitis, carditis. The outcomes of radiation treatment may depend on radiation dose and patients' physical, clinical, biological and genomic characteristics before and during the course of radiotherapy. We intend to find hierarchical biophysical relationships influencing the observed outcomes from retrospective data and develop practical Bayesian Networks (BN) for adaptive radiotherapy of the NSCLC.

Materials/methods: Our study includes 79 NSCLC patients treated on prospective protocols under IRB approval. In addition to dosimetric information, each patient had 179 features from five categories including clinical factors (10) (e.g., age, KPS), cytokines before (30) and during (30) the treatment course, microRNAs (49), and single-nucleotide polymorphisms (SNPs) (60). A large-scale Markov blanket based on the HITON algorithm is employed for selecting relevant biophysical predictors of outcomes. The corresponding BN structure is obtained using the hill-climbing algorithm implemented in the R programming environment.