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First demonstration of real-time in-situ dosimetry of x-ray microbeams using a large format CMOS sensor

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Microbeam radiotherapy is a novel type of radiotherapy in which narrow beams of radiation (typically less than 500 μm) are spatially fractionated, delivering a non-uniform distribution to the target tumour volume. Due to the very high dose gradients involved, new dosimetric techniques are required for translation into clinical practise. Current real-time beam monitoring is typically performed using 1 dimensional silicon strip detectors or wire chambers, with 2D beam information measured offline using radiochromic film (requiring a minimum of 24 hours to self-develop).

Using a bespoke x-ray microbeam generator at the Technical University of Munich, Germany, the newly developed vM1212 detector was exposed to a variety of microbeams (220 kV, nominal slit widths 0 - 100 μm) for evaluation for in-vivo real time verification. The sensor evaluated is a large format CMOS sensor with a 50 μm pixel pitch and an active area of approximately 6 x 6 cm^2, and was chosen for the investigation due to its predicted radiation tolerance and high spatial resolution. 1 cm of water equivalent bolus build-up was placed on top of the sensor to make the results clinically relevant for comparison with other measurement techniques.

The vM1212 detector was assessed by changing the collimator slit width (and thus microbeam FWHM) mid-irradiation. For each frame that was captured, a Python script identified each of the fifty-one microbeam peaks, allowing a Gaussian function to be fitted in order to extract the relevant beam parameters. Microbeam FWHMs of 130 −190 μm could be measured in this manner in addition to temporally monitoring other basic parameters such as the radiation intensity. More advanced parameters could be calculated as the tungsten slits within the microbeam collimator opened and closed such as the rate of change of FWHM; the peak-valley-dose-ratio (PVDR); and the sub-pixel movement of each microbeam peak.

This work demonstrates the potential of radiation hard CMOS sensors for 2D in-vivo real-time monitoring of FWHM, intensity and position in x-ray microbeam radiotherapy.

Submission declaration

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