3-D dosimetry readout techniques

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Abstract. This invited technical review will discuss the numerous options available for making 3-D measurements of radiation dose, including both the physical principles underlying them and the potential sources of error involved.

One of the joys of being involved from the very beginning in the DOSGEL and IC3Ddose conference series has been the opportunity to follow the evolution of the different imaging modalities. Back in 1999, Magnetic Resonance Imaging (MRI) was the method of choice, thanks to Gore and Kang's seminal publication [1] and the work of the early "gel pioneers" [2-4]. Its popularity waned somewhat as it became clear that the level of technical understanding and careful experimentation required to obtain good results were non-trivial. In the 1990s and early 2000s access to MRI equipment for radiotherapy was also problematic, but now, with the advent of true MRI-guided radiotherapy and the possibility of real-time, MR-based 3-D dosimetry [5], it is perhaps set for a renaissance.

At the time of that first DOSGEL meeting in Kentucky, optical computed tomography (CT), although first described in 1996 [6], still felt very much like the "new kid on the block". Subsequently, the relatively low bar to entry into the field, in terms of scanner cost, led to significant innovation from a number of research groups and commercial companies, making this a dynamic and exciting area to work in. By the second DOSGEL meeting in 2001, x-ray CT as a readout technique had also already become an established field of work [7, 8], and the ubiquity and relative ease of access to hospital CT scan were encouraging signs.

Many physical properties are capable of being used to record radiation dose. So, along with these three stalwarts of the gel dosimetry field, other techniques have emerged — sometimes briefly, sometimes in a more sustained fashion — and each has its own unique advantages and problems. I will provide a brief introduction to each of the techniques, but the archives of the DOSGEL and IC3Ddose conferences, as well as previous review articles (e.g., [9]) provide a wealth of information for the interested reader to explore further.

An important initial distinction to make is the difference between 3-D methods that involve *integrating* dosimeters coupled with a two-step measurement (in which a sample is first exposed to radiation that causes a change in its physico-chemical properties, and then subsequently imaged); and *real-time imaging*, where the dosimeter gives off an instantaneous signal, captured by the imaging device, that corresponds to the radiation dose absorbed. Historically, the DOSGEL conferences focused on integrating dosimeters and these methods will be examined first. With the change in conference title to IC3Ddose, came the acknowledgement that 3-D dosimetry involved other types of method and these will be presented subsequently.

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References
[1] Gore J and Kang Y 1984 *Phys. Med. Biol.* **29** 1189
[2] Appleby A *et al* 1987 *Med. Phys.* **14** 382
[3] Olsson L E *et al* 1989 *Phys. Med. Biol.* **34** 43
[4] Schulz R *et al* 1990 *Phys. Med. Biol.* **35** 1611
[5] Lee H J *et al* 2018 *Phys. Med. Biol.* **63** 045021
[6] Gore J *et al* 1996 *Phys. Med. Biol.* **41** 2695
[7] Hilts M *et al* 2000 *Phys.Med. Biol.* **45** 2559
[8] Trapp J *et al* 2001 *Phys. Med. Biol.* **46** 2939
[9] Baldock C *et al* 2010 *Phys. Med. Biol.* **55** R1