Spectroscopic characterization of low dose rate brachytherapy sources

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The low dose rate (LDR) brachytherapy seeds employed in permanent radioactive-source implant treatments usually use one of two radionuclides, ^{125}I or ^{103}Pd. The theoretically expected source spectroscopic output from these sources can be obtained via Monte Carlo calculation based upon seed dimensions and materials as well as the bare-source photon emissions for that specific radionuclide. However the discrepancies resulting from inconsistent manufacturing of sources in comparison to each other within model groups and simplified Monte Carlo calculational geometries ultimately result in undesirably large uncertainties in the Monte Carlo calculated values.

This dissertation describes experimentally attained spectroscopic outputs of the clinically used brachytherapy sources in air and in liquid water. Such knowledge can then be applied to characterize these sources by a more fundamental and metro logically-pure classification, that of energy-based dosimetry. The spectroscopic results contained within this dissertation can be utilized in the verification and benchmarking of Monte Carlo calculational models of these brachytherapy sources.

This body of work was undertaken to establish a usable spectroscopy system and analysis methods for the meaningful study of LDR brachytherapy seeds. The development of a correction algorithm and the analysis of the resultant spectroscopic measurements are presented. The characterization of the spectrometer and the subsequent deconvolution of the measured spectrum to obtain the true spectrum free of any perturbations caused by the spectrometer itself is an important contribution of this work. The approach of spectroscopic deconvolution that was applied in this work is derived in detail and it is applied to the physical measurements. In addition, the spectroscopically based analogs to the LDR dosimetry parameters that are currently employed are detailed, as well as the development of the theory and measurement methods to arrive at these analogs. Several dosimetrically-relevant water-equivalent plastics were also investigated for their transmission properties within a liquid water environment, as well as in air.

The framework for the accurate spectrometry of LDR sources is established as a result of this dissertation work. In addition to the measurement and analysis methods, this work presents the basic measured spectroscopic characteristics of each LDR seed currently in use in the clinic today.