PhD Thesis title: 'Key Data for the Reference and Relative Dosimetry of Radiotherapy, Diagnostic and Interventional Radiology Beams'

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ABSTRACT:
Accurate dosimetry is a fundamental requirement for the safe and efficient use of radiation in medical applications. International Codes of Practice, such as IAEA TRS-398 (2000) for radiotherapy beams and IAEA TRS-457 (2007) for diagnostic radiology beams, provide the necessary formulation for reference and relative dosimetry, as well as the data required for their implementation. Research in recent years has highlighted the shortage of such data for radiotherapy small photon beams and for surface dose estimations in diagnostic and interventional radiology, leading to significant dosimetric errors that, in some instances, have jeopardized patient's safety and treatment's efficiency.

The aim of this thesis is to investigate and determine key data for the reference and relative dosimetry of radiotherapy and radiodiagnostic beams. For that purpose the Monte Carlo system PENELOPE has been used to simulate the transport of radiation in different media and a number of experimental determinations have also been made. A review of the key data for radiotherapy beams published after the release of IAEA TRS-398 was conducted, and in some cases the considerable differences found were questioned under the criterion of data consistency throughout the dosimetry chain (from standards laboratories to the user). A modified concept of output factor, defined in a new international formalism for the dosimetry of small photon beams, requires corrections to dosimeter readings for the dose determination in small beams used clinically. In this work, output correction factors were determined, for Varian Clinac 6 MV photon beams and Leksell Gamma Knife Perfexion ^{60}Co-ray beams, for a large number of small field detectors, including air and liquid ionization chambers, shielded and unshielded silicon diodes and diamond detectors, all of which were simulated by Monte Carlo with great detail.

Backscatter factors and ratios of mass energy-absorption coefficients required for surface (skin) determinations in diagnostic and interventional radiology applications were also determined, as well as their extension to account for non-standard phantom thicknesses and materials. A database of these quantities was created for a broad range of monoenergetic photon beams and computer codes developed to convolve the data with clinical spectra, thus enabling the determination of key data for arbitrary beam qualities.

Data presented in this thesis has been contributed to the IAEA international dosimetry recommendations for small radiotherapy beams and for diagnostic radiology in pediatric patients.

References to author publications that relate specifically to the dissertation:

I. Benmakhlouf H and Andreo P 2011 Ten years after: Impact of recent research in photon and electron beam dosimetry on the IAEA TRS-398 Code of Practice, in Standards, Applications, and Quality Assurance in Medical Radiation Dosimetry (IAEA Int. Symp. 2010) Vol. 1 (Vienna: International Atomic Energy Agency) 139-152

II. Benmakhlouf H, Bouchard H, Fransson A and Andreo P 2011 Backscatter factors and mass energy-absorption coefficient ratios for diagnostic radiology dosimetry Phys. Med. Biol. 56 7179-7204

III. Benmakhlouf H, Fransson A and Andreo P 2013 Influence of phantom thickness and material on the backscatter factors for diagnostic x-ray beam dosimetry Phys. Med. Biol. 58 247-260

IV. Benmakhlouf H, Sempau J and Andreo P 2014 Output correction factors for nine small field detectors in 6 MV radiation therapy photon beams: A PENELOPE Monte Carlo study Med. Phys. 41 041711 1-12

V. V. Omar A, Benmakhlouf H, Marteinsdottir M, Bujila R, Nowik P and Andreo P 2014 Monte Carlo investigation of backscatter factors for skin dose determination in interventional neuroradiology procedures, in Physics of Medical Imaging (San Diego, Feb. 2014) Vol 9033 (Bellingham: International Society for Optics and Photonics) 1-8

VI. Benmakhlouf H, Johansson J, Paddick I and Andreo P 2015 Monte Carlo calculated and experimentally determined output correction factors for small field detectors in Leksell Gamma Knife Perfexion beams Phys. Med. Biol. 60 3959-3973