PhD Thesis title: 'A Quantitative Method for Reproducible Ionization Chamber Alignment to a Water Surface for External Beam Radiation Therapy Depth Dose Measurements'

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ABSTRACT:
Ionization chambers (ICs) are the most commonly used detectors for radiation therapy dose measurements. Typical IC measurements use cylindrical ICs in a water phantom and therefore require initial IC alignment to the water surface. This alignment has long been ignored and only recently has a qualitative governing recommendation been made. This thesis describes a reproducible methodology for quantitative ionization chamber water surface alignment. Depth-ionization measurements are taken with twenty-eight IC designs under varying conditions including, but not limited to, changes in scan direction, speed, and resolution, radiation beam type, field size, energy, and electron contamination. Measurements are acquired using standard radiotherapy accelerators in the Virginia Commonwealth University Department of Radiation Oncology and at the National Research Council of Canada, where a customized scanning system capable of better than 0.15 mm IC positioning precision is used. Measurements are also performed with standard commercial scanning equipment on the Accuray CyberKnife, a specialized radiosurgery-class accelerator. An analytical model is developed from basic principles to test the theoretical foundations of IC response near a water surface. The theoretical foundation is further validated via Monte Carlo simulation models that fully account for all details of the ICs used to take measurements. It is determined that the dose gradient as a function of depth is maximized when a given IC reaches the water surface when moving from depth in water. This effect is unchanged under all of the measurement scenarios tested. Measurements taken at 0.1 mm resolution for several seconds per point over several millimeters near the surface will yield a gradient peak that can be used for quantitative alignment. Using developed software, multiple scans at variant resolutions can be stitched into typical clinical scans so as not to significantly affect clinical measurement workflow. The recommended measurement method is developed in a format suitable for inclusion into a clinical protocol for depth-ionization measurement acquisition.

References to author publications that relate specifically to the dissertation:

Ververs, J. D., M. J. Schaefer, I. Kawrakow, J. V. Siebers., A method to improve accuracy and precision of water surface identification for photon depth dose measurements. *Med Phys* 2009; 36(4):1410-20