

# **Development of Kilovoltage X-ray Dosimetry Methods and Their Application to Cone Beam Computed Tomography**

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The increase in popularity of pre-treatment imaging procedures in radiation therapy, such as kilovoltage cone beam computed tomography (CBCT), has been accompanied by an increase in the dose delivered to the patient from these imaging procedures. The measurement of dose from CBCT scans is complicated, as currently available kilovoltage dosimetry protocols are based on air-kerma standards and radiation detectors exhibit large energy responses at the low photon energies used in the imaging procedures. This work aims to provide the tools and methodology needed to measure the dose from these scans more accurately and precisely.

Through the use of a validated Monte Carlo (MC) model of the moderately filtered (M-series) x-ray beams at the University of Wisconsin Accredited Dosimetry Calibration Laboratory, dose-to-water rates were obtained in a water phantom for the M-series x-ray beams with tube potentials from 40-250 kVp. The resulting dose-to-water rates were consistent with previously established methods, but had significantly reduced uncertainties.

While detectors are commonly used to measure dose in phantom, previous investigations of the energy response of common detectors in the kilovoltage energy range have been limited to in-air geometries. The newly determined dose-to-water rates were used to characterize the in-phantom energy and depth response of thermoluminescent dosimeters and ionization chambers. When compared to previous investigations of the in-air detector response, the impact of scatter and attenuation of the photon beam by the water medium was found to have a significant impact on the response of certain detectors.

The dose to water in the NIST-traceable M-series x-ray beams was transferred to clinical CBCT beams and the resulting doses agreed with other dose-to-water measurement techniques. The dose to water in the CBCT beams was used to characterize the energy and depth responses of a number of detectors. The energy response in the CBCT beams agreed with the energy response in the M-series beams but the thermoluminescent dosimeters exhibited a change in detector response as a function of depth. Using the tools developed earlier in this work, the dose from clinical CBCT scans was measured in a custom-built pelvic phantom and compared to MC simulations of the dose.