Title: Accurate small field dosimetry through optical CT scanning of radiochromic gels

Trainee Name: Kurtis Dekker

Supervisor(s): Dr. Jerry Battista, Dr. Kevin Jordan

Structured Abstract:

Introduction: Measuring small radiation fields using “point” detectors is a challenge in clinical medical physics. Due to these fields’ small size and peaked distribution, partial volume effects and small positioning errors can lead to large dosimetric errors. Additionally, the detector material itself perturbs the travel of secondary electrons, and has a non-negligible impact on dosimetry at small field sizes. The use of 3D gel dosimeters for small field measurement is attractive, as geometric uncertainties are avoided and gels are water-equivalent. However, stray light in some optical CT designs resulted in cupping artifacts and loss of dosimetric accuracy. This motivated us to design and build a scanning-laser optical CT system with high accuracy and sufficient speed for practical clinical applications, which we previously reported [1]. Here, we demonstrate the use of this scanner for accurate small field dosimetry.

Methods: Our custom optical CT system [1] was used to image a 15 cm diameter radiochromic dosimeter [2] that was irradiated with 4 jaw-defined small fields (6 MV photons, field sizes: 3x3, 2x2, 1x1, 0.6x0.6 cm). Optical CT reconstruction was performed using GPU-accelerated filtered backprojection and iterative techniques. Beam profiles and percent depth dose (PDD) curves were extracted from reconstructed data using MATLAB, and compared to Monte Carlo simulations performed using input parameters based on machine commissioning data.

Results: Small field beam profiles and PDD curves showed excellent agreement with Monte Carlo simulation data. PDD curves, normalized at 5 cm depth (a trusted location in the gel dosimeter), agreed within 2% at all positions, including the buildup region. Beam profiles showed minor discrepancies which were attributed to collimator positioning. Our results show no stray light artifacts, indicating that the scanner effectively rejects scattered photons.

Conclusions: The ability to simultaneously measure field size, central axis dose, PDDs and beam profiles (at a range of depths) for multiple small fields within a single dosimeter was demonstrated. This has the potential to accelerate small field dosimetry, and gives us confidence in using our system for clinically relevant dosimetry tasks such as multi-focal radiosurgery dose verification.

References:
[1] Dekker et al., Phys. Med. Biol., vol. 62, no. 7, p. 2636, 2017.
[2] Jordan et al., J. Phys. Conf. Ser., vol. 847, p. 012009, 2017.