PhD Thesis Title: Quantitative Scintillation Imaging for Dose Verification and Quality Assurance Testing in Radiotherapy

Author: Irwin Isaac Tendler

Email: irwintendler1@gmail.com

Institution: Thayer School of Engineering, Dartmouth College, Hanover, NH

Supervisor: David Gladstone, Brian Pogue, Lesley Jarvis, and Gregory Sharp

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ABSTRACT:

This work outlines the development of a novel, imaging-based, method for conducting radiotherapy dose verification and quality assurance (QA) testing of therapeutic radiation apparatus. In an effort to reduce human error and optimize workflow, light emission from plastic discs and rods was used to track surface dose of patients undergoing Total Skin Electron Therapy (TSET) and conduct QA testing of linear accelerators (linacs) / irradiators, respectively.

TSET is a standard technique for treating skin lymphoma, however, the efficacy of this treatment is highly dependent on administration of uniform dose over the entire body. Thus, verifying dose homogeneity is important to ensuring therapeutic effectiveness. Conducting surface dose measurements during TSET is, unfortunately, a resource-intensive task that requires careful handling and tracking of dosimeters. The imaging system described in this work – light emitted from plastic discs attached to the skin surface is captured and converted to dose – can produce results remotely, without post-exposure processing, and in near real-time, Figure 1. In turn, the workflow for TSET-associated surface dosimetry is substantially streamlined when using scintillator dosimeters compared to current technologies (Optically Stimulated Luminescence

Detectors, OSLD). Additionally, scintillator imaging enables an automatic method for storing dosimetric and positional treatment information without any additional operator input. These improvements were made without sacrificing measurement accuracy.

In the case of QA testing of linacs or irradiators, point-measurements can often be time consuming. By imaging scintillator rods during TBI QA testing, the amount of time required to achieve results was minimized since 2D images containing dose distribution information were produced using single irradiations. This was accomplished at equivalent accuracy levels compared to OSLDs; additional comparison testing with ionization chambers was used to further verify accuracy of scintillator measurements, Figure 2. QA testing of MRI-linacs is all the more complicated since use of standard motorized devices in the presence of a strong magnetic field is not possible. Thus, scintillating rods were adapted for use in daily QA testing of an MRI-linac; this technology was able to complete AAPM TG-142 tests accurately and with sufficient sensitivity.

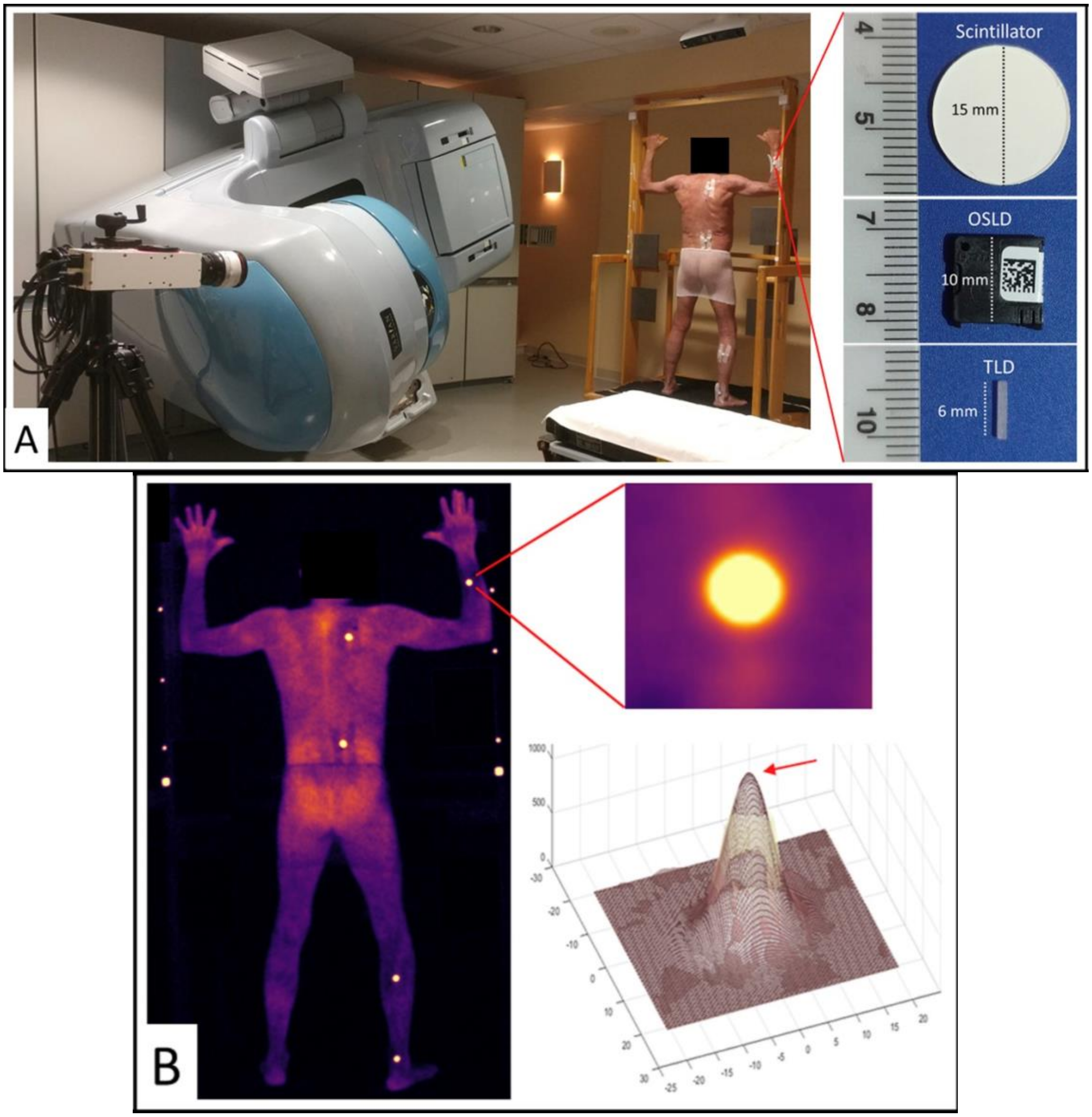

Figure 1: Room setup, dosimeter application, and comparison of image processing. (A) Photograph of a patient on a custom total skin electron therapy stand, linear accelerator, and intensified camera. Zoomed-in view of a dosimeter packet attached to a patient provides a close-up perspective on the face of a scintillator, optically stimulated luminescence dosimeter, and thermoluminescent dosimeter. Width dimensions are provided in mm. (B) Background-subtracted cumulative image of the patient from panel A. Zoomed-in view provides region of interest of scintillator used in image processing (upper right) and ellipse-convolved Gaussian fit to a single frame of the scintillation video. The red arrow points to the maximum amplitude value. (Tendler, *IJROBP*, 2019)

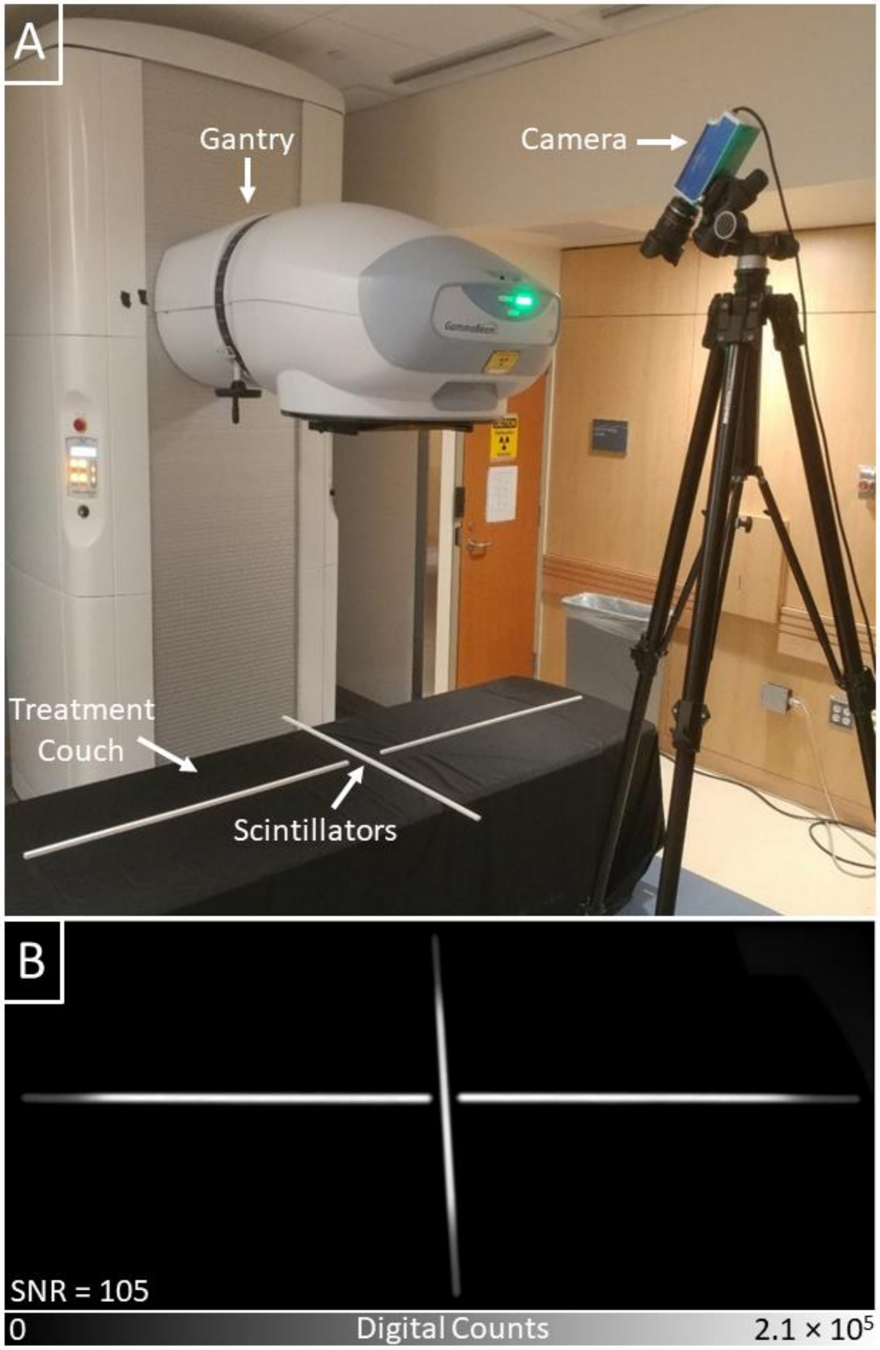

Figure 2: A) Imaging setup for field homogeneity, light-radiation field correspondence and symmetry testing featuring tripod-mounted camera, ^{60}Co irradiator, and scintillator dosimeters. B) Sample cumulative image (SSD = 174) from field symmetry and homogeneity testing, setup shown in (A), colorbar represents pixel intensities in digital counts (arbitrary units). SNR is also provided for this image. Two separate rods (2 x 1m) are used in the longitudinal direction, a single rod (1m) is used for the latitudinal axis. (Tendler, *Medical Physics*, 2019)

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