AbstractID: 6785 Title: Monte Carlo simulation and design of a carbon nanotube small-animal Micro-RT system

Purpose: To use Monte Carlo simulations to characterize the design and performance of a nanotechnology-based high spatial and temporal resolution small animal micro-RT system.

Method and Materials: The proposed micro-RT system uses carbon nanotube field emission technology to produce arrays of individually and electronically controllable x-ray pixels that can form spatially and temporally high resolution modulated irradiation. Combined with the existing carbon-nanotube field emission micro-CT, the future micro-CT-RT system promises a high spatial and temporal resolution image-guided irradiation system ideal for small animal research. Prospective designs for the micro-RT system were evaluated using EGSnrc-based Monte Carlo simulations. Design aspects studied included: 1) x-ray anode design, 2) collimator design, and 3) dosimetric considerations, including dose rate, inhomogeneity corrections, and the overlap effect of adjacent pixel beams.

Results: Anode studies indicate that reflective and transmission target designs produce similar dosimetric properties, finding dose rates of 40 cGy/min/mA/pixel are achievable at isocenter (10 cm SAD) for 2 mm x 2 mm pixels in a 3 cm diameter mouse model. For beam energies of 80-100 kV, photons below 20 keV must be filtered out to eliminate excessive surface dose for the mouse model. This filtration can be achieved using a tungsten transmission target 26 μm thick or a 2.5 mm Al filter with the reflective target. Dose overlap between adjacent x-ray pixels produces high or low dose spots for a single beam array direction. When opposing beam pair configurations are used, the dose inhomogeneity is reduced to negligible levels near isocenter and 20% near the surface.

Conclusion: Monte Carlo simulation studies are instrumental to the development of a novel micro-RT system. They are used to evaluate performance on different system designs without the cost of prototype fabrication. The Monte Carlo study verified basic dosimetric features of the intended micro-RT design.