AbstractID: 11296 Title: Monte Carlo Calculations of Microscopic Dose Enhancement Factor for Gold Nanoparticle-aided Radiation Therapy

Purpose: To quantify the energy deposition due to photoelectrons from gold nanoparticles on a micrometer scale and to calculate the corresponding microscopic dose enhancement factor during *Gold Nanoparticle-Aided Radiation Therapy* (GNRT).

Method and Materials: The Monte Carlo code EGSnrc was modified to obtain the spectra of secondary electrons from atoms of gold and molecules of water under photon irradiation of a tumor infused with 0.7 wt. % gold. Six different photon sources were used: ^{125}I, ^{103}Pd, ^{169}Yb, ^{192}Ir, 50kVp, and 6MV x-rays. Treating the scored electron spectra as point sources within an infinite medium of water, the event-by-event Monte Carlo code NOREC was used to quantify the radial dose distribution, giving rise to gold and water electron dose point kernels. These kernels were applied to a scanning electron microscope (SEM) image of a gold nanoparticle distribution in tissue. Treating each pixel in the image as a point source of gold or water emitting secondary electrons, the dose at each point was calculated, enabling the determination of the microscopic dose enhancement at each point.

Results: For the lower energy sources ^{125}I, ^{103}Pd, ^{169}Yb, and 50 kVp, the secondary electron fluence was increased by as much as two orders of magnitude, leading to a one-to-two order of magnitude increase in the electron dose point kernel over radial distances up to 50 μm. The dose was enhanced by 100% within 5 μm of the nanoparticles, and by 5% as far away as 30 μm.

Conclusion: This study demonstrates a remarkable microscopic dose enhancement due to gold nanoparticles and low energy photon sources. Given that the dose enhancement exceeds 100% within very short (5 μm) distances from the nanoparticles, the maximum radiobiological benefit may be derived from active targeting strategies that concentrate nanoparticles in close proximity to the cancer cell and/or its nucleus.