Abstract ID: 16242 Title: Fast and accurate estimation of organ doses in medical imaging using a GPU-accelerated Monte Carlo simulation code

Purpose: To present a Monte Carlo (MC) x-ray transport simulation code that uses a massively parallel graphics processing units (GPU) to generate medical images of voxelized patient models and estimate organ doses.

Methods: We updated MC-GPU, a CUDA-based open-source code for the simulation of radiographic projections and CT, to include the capability to tally 3D dose distributions. Since electrons are not transported, deposited doses are assumed to be equivalent to photon KERMA. The validity of this assumption was investigated by comparing it with the general-purpose MC code PENELOPE in the simulation of a posterior-anterior chest examination with 1010, 60-keV x rays and a realistic female phantom with 1-mm voxels. The stability of the simulation in a 480-core GPU was also benchmarked using a sequential execution in a single CPU core. A utility to post-process the voxel doses and report average and peak organ doses and effective dose for the procedure (and their uncertainty) has been developed.

Results: The accuracy of the dose values generated by MC-GPU was successfully validated. Average relative differences in the doses from PENELOPE and MC-GPU executed in CPU and GPU were below 2%, in the expected range for statistical fluctuations. The simulation speeds were 46554 x rays/s with PENELOPE (electron transport disabled), 158216 x rays/s with MC-GPU in a CPU, and 5124867 x rays/s in a GPU (simulation time in the GPU: 32.5 minutes, 32-fold speedup compared to the CPU). The average and peak doses in breast and skin were estimated as 1.1 and 3.4 eV/g, and 1.7 and 15.6 eV/g per history respectively.

Conclusion: The presented code can estimate organ doses 110 times faster than a general-purpose MC code with comparable accuracy. A multi-GPU execution of MC-GPU has the potential to provide accurate organ doses in a CT scan in near real-time.