3021 GPU-acceleration of GEANT4-based Monte Carlo Simulations for Radio Therapy

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Purpose/Objective(s): A porting of the main compute intensive kernel of the GEANT-4 Monte Carlo (MC) code on a single instruction multiple data (SIMD) architecture has been realized.
Materials/Methods: The implementation is based on the C programming language and the CUDA toolkit of the GPU (graphic processing unit) . The most challenging part is the implementation of the stepping kernel and the interaction kernels for continuous and discrete physical processes. This was achieved by parallelizing the Mersenne Twister random number generator, a dedicated technique for particle process calculations, and a dynamic load balancing during processing. Furthermore, we extended GEANT4 by a CT geometry package in order to directly load CT voxel models.
Results: A speed-up of a factor 10-30 compared to a single core CPU has been observed in our first prototype implementation using a NVIDIA GTX 8800 graphics card. As illustration and for verification of correct implementation, depth dose curves in a water phantom are presented.
Conclusions: By this prototype we can show that an efficient implementation of MC techniques on GPUs is feasible. We expect that by further optimizations of the code, additional substantial speed-up could be realized and thus such a GPU-based installation could yield comparable performance as PC-clusters.

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