Purpose: Monte Carlo (MC) simulation is commonly considered as the most accurate dose calculation method in radiotherapy. However, its efficiency still requires improvement for many routine clinical applications. The goal of this work is to develop a GPU-based MC dose calculation package, gDPM. It utilizes the parallel computation ability of a GPU to achieve high efficiency, while maintaining same particle transport physics as in the original DPM code and hence simulation accuracy.
Methods: The gDPM code is implemented on GPU architecture under CUDA platform. In GPU computing, divergence of execution paths between threads can considerably reduce the efficiency. Since photons and electrons undergo different physics and hence attain different execution path, we design a simulation scheme where photon transport and electron transport are separated to partially relieve the thread divergence issue. High performance random number generator and hardware linear interpolation are also utilized. We have also developed various components to account for fluence map and linac geometry, so that gDPM can be used to compute dose for real IMRT or VMAT treatment plans. The gDPM is tested for its accuracy and efficiency in both phantoms and realistic patient cases.
Results: In all cases, the average relative uncertainties are less than 1%. Dose difference between CPU and GPU results is less than 3% of maximum dose in over 98% high dose region. A t-test is also performed and the dose difference is not statistically significant in over 98% high dose region. Speed up factors of 57.3~75.5 have been observed using an NVIDIA Tesla C2050 GPU card against a 2.27GHz Intel Xeon CPU processor. Dose calculation for a real IMRT head-and-neck plan and a VMAT prostate plan can be finished in 48sec and 46sec, respectively.
Conclusions: The gDPM package has achieved high computation efficiency on GPU without losing accuracy.

Funding Support, Disclosures, and Conflict of Interest:

This work is supported in part by the University of California Lab Fees Research Program. GPU cards are partly provided by NVIDIA.