Purpose: To facilitate real-time dose calculation for online adaptive radiation therapy, we have implemented the Monte Carlo-based finite size pencil beam (FSPB) dose calculation algorithm on Graphics Processing Units (GPUs).

Methods: The FSPB dose calculation algorithm is based on the analytical kernel calculated from Monte Carlo simulations using the EGSnrc Monte Carlo code. This provides the benefit of Monte Carlo accuracy while the GPU implementation and the exponential kernel significantly reduces execution time. The GPU-based FSPB implementation was executed on the NVidia GTX480 GPU card. Both CPU and GPU versions of the FSPB algorithm were implemented operationally identically and benchmarked for accuracy and execution time. The dose calculation was performed in heterogeneous phantoms consisting of water, lung and bone slabs, and in clinical cases. The GPU-based FSPB implementation was compared with the CPU version and with a commercial treatment planning system for different situations including IMRT plans.

Results: The FSPB algorithm with heterogeneity correction and anisotropic analytical algorithm (AAA) in heterogeneous phantom and clinical treatment planning cases agree within 2%. The GPU implementation was found to be up to 477 times faster than the single threaded CPU while achieving identical result in terms of dosimetric accuracy. The GPU-based FSPB was close to six times faster than the AAA, with single beam calculations completed within 0.45 s for typical scenarios.

Conclusions: This work describes the implementation of a GPU-based FSPB algorithm for dose calculation in radiation therapy. The results demonstrated that the GPU-based FSPB algorithm can provide accurate 3D dose distributions in heterogeneous media in less than a second per beam for clinically relevant cases.

Funding Support, Disclosures, and Conflict of Interest:

This research is supported by CPRIT Individual Investigator Award RP110329.