AbstractID: 13349 Title: High-performance dose calculation for proton radiotherapy using GPU

Purpose: To investigate the feasibility and the potential speed gain of GPU accelerated dose calculation for proton pencil beam algorithms with heterogeneity correction and to offer solutions to obstacles in implementing our algorithm.

Method and Materials: We implemented our in-house proton dose calculation system on an NVIDIA GTX 280 graphic card and an Intel Xeon 2.83 GHz processor using the Compute Unified Device Architecture environment. Several key techniques and strategies were employed in order to optimize the performance of the GPU code. (1) Modified the scaling algorithm used to calculate lateral spreading of the proton beam in the presence of tissue inhomogeneities. (2) Used an incremental ray tracing algorithm to reduce the memory requirement for each ray allowing for better parallelization. (3) The penalty of massive non-coalesced memory reads required for convolution/superposition was alleviated by texture fetching. (4) Parallel algorithms such as reduction and prefix sum were implemented on GPU to help avoid data transfer between the CPU and GPU memory. The performance of both implementations was evaluated on a prostate clinical case.

Results: With no loss in accuracy, the dose calculation time per beamlet with our GPU implementation ranges from 200 – 500 ms compared to 15 – 40 s on CPU. Approximately 80 times speed gain is achieved for various number of convolution/superposition steps.

Conclusions: GPU-based proton dose calculation is feasible with adapted algorithms and proper implementation techniques. Close to two magnitude of performance gain can be achieved with typical hardware. We believe GPU-based fast dose calculation can reduce the routine treatment planning workload as well as provide a feasible solution to the realization of online adaptive intensity modulated proton therapy.