Purpose: While intensity-modulated proton therapy (IMPT) has great potential to deliver highly conformal tumoricidal dose to targets whilst minimizing dose to nearby organs-at-risk, IMPT optimization is very time consuming and memory extensive due to finer dose grids and a large number of energy layers used compared to intensity-modulated radiation therapy (IMRT). In this presentation, for the first time, a new approach is introduced to speed up the IMPT treatment planning through application of parallel computing with Graphic Processor Units (GPUs).

Methods: Parallel computation with GPUs, which are affordable and can be plugged in a workstation easily, is potentially a good way to improve the computation efficiency. In our approach, we used the standard quadratic objective function to optimize the intensity map of beamlets. The objective function and gradient equations, which are the most time consuming parts of the optimization, were calculated with GPUs. We compared the computation time of optimization done by an Intel® Core™ i7 CPU and that by the same CPU accelerated by GPUs (TESLA C1060). The influence matrix was pre-calculated before optimization with an in-house proton pencil beam dose calculation engine. Two clinical cases were studied: one base-of-skull (BOS) case (clivus chordoma) and one prostate case (adenocarcinoma). The dose volume histogram (DVH) data for the tumor and critical organs were derived for comparison of optimization results generated by CPU and GPUs.

Results: For the BOS case, application of GPUs for the optimization and overall gained 54 and 36.5 times speedup. For the prostate case, application of GPUs for the optimization and overall gained 69 and 28.5 times speedup.

Conclusions: The application of GPUs for the parallel computing of IMPT treatment plan optimization can dramatically improve the computation efficiency. The optimization time can be reduced from typically half to one hour to only several minutes.