Theme: Physics

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Abstract Title: Development of an In-House Dose Verification Software Utilizing Log Files and OpenCL GPU Computing for Patient-Specific Quality Assurance in Carbon-Ion Radiotherapy

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Background / Aims:

The first carbon-ion radiotherapy (CIRT) facility in Taiwan began operation in May 2023 at Taipei Veterans General Hospital. To address time-consuming patient-specific quality assurance (PSQA) measurements, we developed and validated in-house software using log file and OpenCL-based GPU computing to efficiently reconstruct delivered doses.

Subjects and Methods:

The in-house software, developed in Python, employed a triple-Gaussian pencil beam model incorporating integral depth dose (IDD) and beam size measurements obtained during commissioning. Beam transport was calculated by accounting for increases in spatial and angular variance with distance due to multiple scattering. Extensive matrix operations were accelerated using PyOpenCL for GPU computation. The accuracy of the software was validated using an optimized volume from our treatment planning system (VQA-Hitachi). Measured depth-dose curve from an Advanced Markus chamber was compared with calculations from both VQA and the in-house software. Furthermore, 2D dose distributions from clinical cases were compared between OCTAVIUS 1500XDR measurements and in-house software calculations using the log files. The gamma index analysis evaluated whether the passing rate exceeded 90% using 3 mm/3% criteria.

Result:

Average depth-dose differences before the distal fall-off were 1.8% ± 1.1% (measurement vs. VQA) and 1.1% ± 0.4% (measurement vs. in-house software), with maximum differences of 3.1% and 1.5%, respectively. The passing rates of the local gamma index, excluding dose regions below 10% of the maximum, were 99.1% for prostate and 99.2% for pancreas cases. In the example shown in Figure 1, the GPU computation time was approximately 1/52 of that of the CPU, and the gap further increased as the number of spots increased.

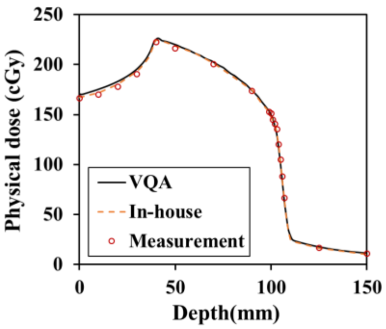

Figure 1. Depth-dose curve.

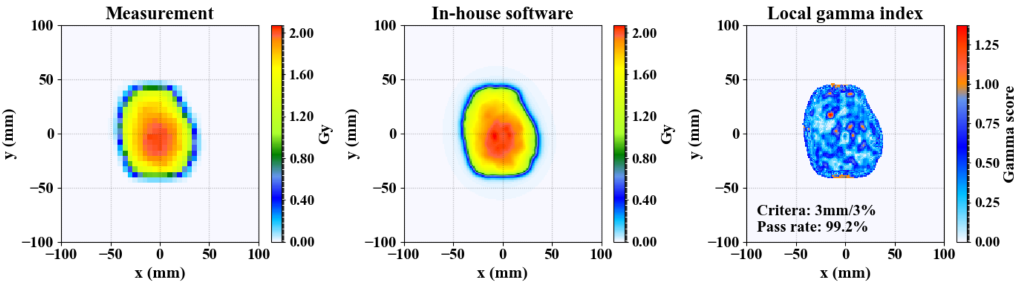

Figure 2. 2D dose distribution comparison.