Abstract ID: 16820 Title: Interactive 4D Proton Pencil Beam Dose Calculation using Shadie: A fast GPU-based Visualization Language

Purpose:Proton treatment planning for thoracic and gastrointestinal targets requires sensitivity to motion issues upstream from the distal surface of the defined disease site. Variations in radiological path length due to organ motion, both inter- and intra-fraction, can result in significant under- and over-shoot of the defined proton dose distribution due to the high radiological range sensitivity of particle beam radiotherapy. We describe a method for interactive exploration of this range sensitivity through direct, ‘on-the-fly’ dose recalculation using a GPU-based visualization language, Shadie.

Methods:Based on a python-like syntax, the GPU kernel is defined and recompiled by the Shadie language interpreter for CUDA code compilation. This kernel is evaluated directly in the rendering pipeline, coupling the display to the final, volume rendered patient anatomy. The size and/or number of spatial-temporal volumetric datasets is limited only by available GPU memory, allowing for kernel operations against multiple data sets simultaneously. A pencil beam proton dose calculation algorithm has been re-implemented using this shader language to allow real time recalculation of proton dose distributions. Interactivity of the volume rendered image is provided by exposing relevant treatment delivery variables to the user, including: beam range, modulation, couch and gantry angle, and source position. As these exposed variables are modified, the dose is continuously recalculated and displayed.

Results:The speed of the dose calculation engine allows for 4D visualization of both anatomy and dose distribution in a volume rendered environment. The flexibility of Shadie allows for easy adaptation to multiple visualization needs, including mean and standard deviation dose distribution maps as well as a cinematic mode where the dose is recalculated as the datasets are cycled through sequentially.

Conclusions:This tool may provide assistance when planning/reviewing treatment sites subject to temporal variability, allowing for deeper understanding of the dosimetric implications of organ motion.