Determination of the Bremsstrahlung Spectra of High-Energy Medical Linear Accelerators using a Simpson Iteration Technique

The determination of the x-ray energy spectrum produced by linear accelerators has received increasing attention due to the use of model based three-dimensional treatment planning. High-energy x-ray spectral reconstruction from transmission data was investigated by utilization of the Simpson iterative numerical technique, and the results were compared to the energy spectra used in the ADAC Pinnacle treatment planning system. Although previous works have used this technique, no experimental investigation had been performed for energies above 10-MV due to the limitations of lead and aluminum as attenuators at high energies.

In this work, graphite was used as the attenuating material to measure the transmission data and to determine the modal energy. The average energy was measured separate from the graphite transmission measurements using tissue maximum ratio (TMR) data obtained from solid water. The Simpson technique uses the measured graphite transmission data to iteratively unfold the shape and fluence rate of the photon spectrum, with the modal and average energies used as physical constrains.

Energy spectra were generated for Varian 6/100 and 2100C/D 6-MV photon beams to test the consistency of the measured data and to validate the Simpson technique. An 18-MV photon spectrum for a Varian 2100C/D was then successfully generated using this technique. The frequency of the modal energy for the 18-MV reconstructed spectrum was within 4% of the modeled 18-MV spectrum used in the Pinnacle treatment planning system.