Purpose: As multi-detector computed tomography (MDCT) scan is routinely performed for treatment planning in radiation oncology, understanding the characteristics of MDCT x-ray beam is essential to optimize scan protocols as well as to estimate patient dose. The purpose of this study was to characterize the x-ray beams of two commercial MDCT simulators with Monte Carlo (MC) simulations.
Methods: X-ray tube systems of two wide bore MDCT scanners (GE LightSpeed RT, LS and Philips Brilliance Big Bore, BB) were modeled in the BEAMnrc/EGSnrc systems. All the tube components were modeled: tungsten target, inherent filter, bowtie filter, and beam collimators. Three benchmark processes were performed to validate the MC models. (1) X-ray spectra comparison between MC and manufacturers' data, (2) Half-value layers (HVLs) between MC and measurements using aluminum sheets and multi-functional radiation detectors, (3) Lateral and axial beam profiles between MC and radiochromic film measurements To understand the scatter effect of the MDCT beams, scatter-to-primary energy fluence ratios (SPRs) were derived and the total SPR for each CT system was calculated with CTDI head and body phantoms..
Results: MC generated x-ray spectra agreed well with the manufacturer-specified data over the entire energy range. Effective photon beam energies for 120kVp beam were found to be (MC, vendor-specified): (60.8, 60.2keV) for LS scatter, and (65.4, 64.9keV) for BB scanner. MC-computed HVLs were found to be within 1% of the ion chamber measurements on average. The lateral and axial profiles between film and MC showed overall good agreement within 10% on average. The total SPR ranged from 3.5 to 4.9% for head phantom and from 7.1 to 11.1% for body phantom.
Conclusion: Complete characterizations of two MDCT scanners have been performed using the BEAMnrc/EGSnrc MC system. This information can be utilized to optimize scan protocols as well as patient-specific dosimetry for the MDCT systems.