An on-line kilovoltage (kV) imaging system has been implemented on a medical linear accelerator to improve radiotherapy treatment verification. A kV x-ray tube is mounted on the accelerator at 90 degrees to the megavoltage (MV) source and shares the same isocenter. Nearly identical CCD-based fluoroscopic imagers are mounted opposite the two x-ray sources. The advantage of kV imaging for on-line localization is being studied. The performance of the kV and MV systems are characterized to provide quantitative support to the conclusions of these studies.

A spatial frequency-dependent linear systems model is used to predict the detective quantum efficiencies (DQEs) of the two systems. Each is divided into a series of gain and spreading stages. The parameters of each stage are either measured or obtained from the literature. The model predicts the system gain to within 15% of measured gain for the MV system and within 12% for the kV system. The systems' noise power spectra and modulation transfer functions (MTFs) are measured to construct the measured DQEs. X-ray fluences are calculated using modeled polyenergetic spectra. The model predicts zero-frequency DQEs of 0.9% and 11% for the MV and kV systems, respectively. Measured DQEs agree well with these predictions. The model reveals that the MV system is well optimized, and is x-ray quantum noise limited at a frequency of zero. The kV system is sub-optimal, but still yields superior image quality to the MV system due to it's higher primary detector MTF and the inherently higher contrasts present at kV energies.

Supported in part by the NCI CA 66074.