A simple Monte Carlo based optimisation model to determine image contrast in an imaging system

D A Roberts¹, V N Hansen¹, J Seco², M G Thompson³ and P M Evans¹

¹ Joint Department of Physics, The Institute of Cancer Research and The Royal Marsden NHS Foundation Trust, Downs Road, Sutton, Surrey, UK
² Massachusetts General Hospital, Harvard Medical, Boston, USA
³ Elekta Limited, Crawley, UK

Whilst a radiotherapy imaging system can be modeled accurately using full Monte Carlo simulations a quicker method is required for system optimisation. Here we present a Monte Carlo based optimisation model that takes a radiation spectrum and detector response curve as inputs and predicts contrast for a particular imaging system. The model consists of two parts. The first part looks at the interaction of mono-energetic beams with phantoms of various bone and water compositions. In particular the scatter and primary components emerging from the phantom are analysed. The second part models the response of a detector to various mono-energetic beams. Weighting of the phantom simulations with a linac spectrum results in the prediction of the scatter and primary components incident on an imaging device. Subsequent application of a detector response curve yields the scatter and primary signals in the imager. This technique has been applied to standard 6 and 4MV linac spectra as well as an experimental low atomic number (Z) target configuration to determine various imaging parameters. In particular it has been used to determine the contrast with various detector, phantom and linac spectra combinations. Use of the model shows significant benefits in using a detector with a reduced metal plate thickness for the low Z beam for thin, 5.8cm phantoms that approximate the head and neck region. Whilst contrast can be doubled using the low Z beam and standard MV imager over the current 6MV system, a further improvement in contrast is predicted when using a detector without a metal plate.