

**Purpose:** To develop a method for reliably unfolding the true spectra of clinical photon beams using simple depth-ionization measurements, and to validate the method using other independent spectral measurements.

**Methods and Materials:** An accurate and flexible functional form to represent photon spectra is developed and benchmarked against a comprehensive set of 68 realistic spectra. A monoenergetic depth-ionization kernel is generated using EGSnrc. Electron contamination is included using a validated one-parameter model. Depth-ionization measurements are performed on a Vickers research linac for three energies (10, 15, 20 MV) and three targets (Be, Al, Pb). The Vickers electron beam parameters are independently known to 0.4%, and its spectra have been previously measured using a NaI detector (i.e. the true spectra are known). Measurements are also performed on clinical beams (Elekta Precise 6, 10 and 25 MV) both on- and off-axis to extract off-axis softening. Independent transmission measurements are performed on the same two machines using multiple detectors with different energy responses and multiple attenuating materials to improve energy differentiation. Experimental and Monte Carlo methods are used to correct for attenuator scatter, polarity and beam instabilities.

**Results:** Spectra unfolded from depth-ionization data agree well with those unfolded from transmission data and with previous NaI measurements. Electron contamination is reproduced within 1% of the maximum dose. Photon spectra from electron beams with more than 5% mean energy difference are resolvable. Off-axis softening can be extracted.

**Conclusions:** Despite the ill-conditioned nature of spectral unfolding, this study shows that when the full potential of the new approach is used, it is possible to unfold the true photon spectra from basic clinical measurements without prior knowledge of the linac head or incident electron beam. The proposed method is a significant improvement over the 'self-tuning' approach that is currently being used in beam commissioning.

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