

Measuring the Fluence of Clinical Electron Beams

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The incident fluence on the patient is greatly affected by the various collimator components on the path of the beam. It is therefore important to measure and characterize these fluence perturbations, which alter the dose distributions. In addition, the incident fluence information is needed as input for the treatment planning algorithms, which are presently inferred from the dose measurements.

The magnitude of electron fluence for patient treatments is very low and it difficult to assess directly. Therefore, a specially designed fluence-meter is required. Of all the detection methods, an ion-implanted semiconductor detector with an ultra-thin depletion layer is the most suitable.

We have shown that the energy deposited in an ultra-thin detector, with no window, is directly proportional to the incident fluence of clinical electron beams, including the small contribution of gamma-rays. The main reasons for this concept are that (L/p) of silicon is essentially constant over the spectrum of any clinical beam and these beams are almost mono-energetic.

Our detector is calibrated against a flat Faraday cup and can provide a measure of true electron fluence, with almost no energy and directional dependence. Calibrations are done in a vacuum chamber, where the chamber and the measuring electronics are connected to the accelerator ground. In the calibration setup, a pipe collimation system is used to create a mono-directional beam, so that $\Phi = \Phi(\text{planar})$. Geometrical calculations and films are used for making quantitative analysis of the beam impinging on the detector and the cup. The precision of the calibrations is better than 1%.

Since the calibration factors of the detector are the same on two different linacs, once a detector is calibrated, it can measure electron fluence on any clinical machine. Fluence output and profiles, and $d\Phi/d\Theta$ of a variety of cones and blocks are measured. The measured surface fluence values conform to the expected shape of the depth-fluence curves. It is demonstrated that the directional discrimination of the electrons can also be made. The scattering perturbation of this angular measurement system is calculated to be around 0.6%.