

The Improvement of Therapeutic Photon Beam Quality with Electric Field

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INTRODUCTION

Accurate knowledge of the distribution and amount of contamination electrons, arising from the gantry head at the surface and in the first few centimeters region of tissue, is essential for the clinical practice of radiation oncology. These electrons deteriorate the buildup in the radiation field compared with a pure photon field. In this study, the reduction of contamination electron in a therapeutic radiation photon beam have been investigated. The contamination electrons can be separated out by a special device. This device called Sweeper removes contamination electrons and positrons, henceforth called leptons, affecting the photon beam.

METHODS

All experiments were performed with a 15 MV photon and 6, 9 MeV electron beams from a linear accelerator (Clinac 1800 Varian). The Sweeper applied with a double focus electric field (8×10^5 V/m) from a great number of fine strings may remove leptons only but virtually never attenuates the intensity of photon. The Sweeper consists of four parallel string planes fixed in a rectangular hollow ($25.0 \times 25.0 \times 2.2$ cm³) Lucite frame of $30.0 \times 30.0 \times 2.2$ cm³ in dimension shown in Fig. 1. Each string plane is made of 41 stainless steel

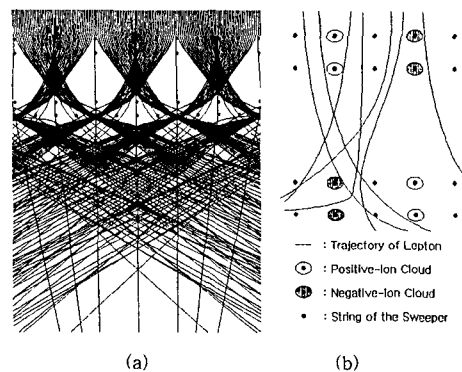


Fig. 1. a) The ideal configuration of tracks of lepton in the strong double focalized electric field from a great number of fine strings (2×10^{-4} m diameter) is simulated with SIMION 3D Version 6.0 software. b) The positive and negative charges ionized by photon are forced to drift towards the strings of anodes and cathodes under the strong electric field. These charges represent shape of clouds around strings.

wires of 2×10^{-4} m in diameter and each wire is spaced 0.48 cm apart and biased at 0.0 Volt every other wire and at 4.0 kV and -4.0 kV sequentially between neighboring 0.0 Volt wires. Upper two planes are 0.4 cm apart each other vertically and separated from lower two by 1.4 cm and lower two planes have the same structures as the upper two planes, except that high voltages of lower planes are applied in the opposite way. In this method, charged leptons can be doubly focused optically in passing through two different sets of asymmetric electric fields. Configuration of tracks of lepton path in this structure of electric fields are simulated with SIMION 3D simulation program of Version 6.0 software.

RESULTS and DISCUSSION

The curve A1 represents the relative surface dose for the photon beam as a function of field size without both Sweeper and copper plate. The B1 shows the relative surface dose from partially elimination of the leptons with a copper filter of thickness of 0.27 g/cm^2 . The difference between A1 and B1 increases linearly with field size. In this case, the larger field size, the more leptons are eliminated by the copper plate. Such a deviation in relative surface dose is mainly due to the reduction of leptons in the photon beam. The A2 represents the relative surface dose with electric field on the Sweeper, B2 for using both copper plate and Sweeper with electric field. B2 is almost identical with A2 which are obtained by the Sweeper only with electric field. This means that there are no more leptons removed by copper filter since the Sweeper had already removed most of leptons in the photon beam shown in Fig. 2.

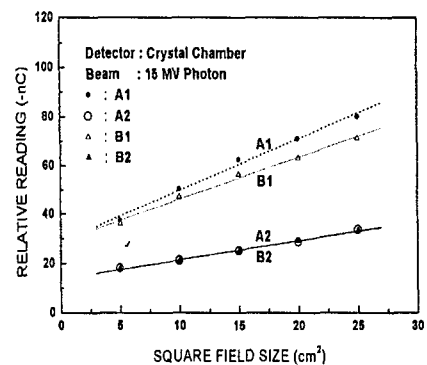


Fig. 2. The Sweeper can remove the most of leptons in the photon beam and also copper plate can remove partly leptons.

CONCLUSIONS

There are considerable leptons in a 15 MV photon beam, so that when photon beam is filtered by a Sweeper with electric field, it can eliminate a large fraction of the leptons. Whether the photon beam is filtered or not, the changes in relative surface dose with field size variation are due to the changes of the relative quantity of leptons in the photon beam. Therefore, the photon beam with the elimination of leptons by the Sweeper should have better beam quality for the treatments of tumors in radiation therapy.