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# Evaluation of a radiotherapy electron contamination deflecting system

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**Abstract**

The combination of a clinically useable neodymium iron boron rare earth magnetic deflector with a clinically viable thin walled helium bag which could be placed over a patients skin has shown that it could be very effective in reducing unwanted skin dose to radiotherapy patients by the removal of unwanted lepton contamination from the entry beam while not affecting dose at depth or beam symmetry. Results have shown that up to 70% of existing dose applied to the patients skin which causes damage could be removed by the tested devices. The magnetic deflectors characteristics for interference with linear accelerator electronic components and field strengths that a patient would be exposed to are also tested. 

*Keywords:* Electron contamination; Surface dose; Skin sparing; NeFeB magnets; Helium bag

## 1. Introduction

In the push for conformal radiation therapy, reduction of dose to all areas not associated with tumor tissue is imperative. One aspect of this could be the removal of unwanted skin dose while retaining the tumor dose. Removal of electron contamination from a clinical linear accelerator or cobalt-60 machine has been achieved by various methods (Biggs and Russell, 1983; Nilsson, 1985; Rao et al., 1988; Ling and Biggs, 1979; Butson et al., 1996) for a long period to time. Devices such as electron filters made from high atomic number material can reduce electron contamination but are limited in their application clinically due to their opaqueness and sometimes by beam hardening. Other devices including electromagnets which sweep electron contamination away from the treatment field are not considered clinically useable due to their size or weight. This note reports on the dose reducing characteristic of two devices, a neodymium iron boron magnetic deflector and a helium bag system which could be used clinically if skin sparing is needed during radiotherapy. Before clinical trials of the magnetic device can begin, any effects which could affect a patient during clinical treatment must be tested. The magnetic fields a patient is exposed to by the magnetic deflector has been tested in this report along with the effects on measuring ionization chambers.

## 2. Materials and methods

The *helium bag system* which is placed directly over the phantom is constructed from 0.05 mm thick plastic with thin wire edges and a valve. Wire edges were

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inserted firstly to add weight to the device and secondly so the device could be molded to form an irregular patient shape if required. Thus the bag can easily conform to the treatment area. A release valve was used to pump and then hold helium inside the bag. Yorke et al. (1985) have previously found that helium can be used to eliminate production of electron contamination in the air column. Our experiments have furthered this work by using a helium bag which could be used clinically over an irregular shaped patient.

The *neodymium iron boron magnetic deflector* consisted of two banks of NdFeB ceramic magnets dimensions $30 \times 5 \times 5$ cm, that were placed in a custom made holder to fit directly under the block tray holder on the accessory mount of the machines head (Butson et al., 1996). Neodymium iron boron magnets have a magnetic energy approximately 16 times greater than ferromagnetic devices. The magnetic deflectors weight including the frame and attachment bracket is approximately 12 kg.

Effects of magnetic fields on measuring chambers were tested by placing the chambers in solid water at depth beyond the range of electron contamination and increasing the field strength of the magnetic deflector with the same applied dose measured.

The two devices were placed together on a Varian 2100C linear accelerator. Photon beam measurements were made using an Attix Model 449 parallel plate ionization chamber, and a PTW thimble ionization chamber in a solid water (Constanitinou et al., 1982) stack phantom. The chambers were connected via a triaxial cable to a Keithley model 2540 electrometer at 300 V bias voltage. Percentage dose build up curves were measured on the central axis for various beam configurations and energies. The reduction in skin dose were calculated by comparing normal percentage build up dose curves with the same curves measured when the two devices were placed in the beams path. Predicted skin dose reductions quoted are calculated using the phantom skin dose reductions measured for the same field size and clinical treatment setup as for individual patients currently on treatment in our radiotherapy center.

Magnetic field strengths produced by the magnetic deflector were measured using a Daley electronics Pty Ltd Teslameter T-22A. The meter was placed at various distances equal to patient separations from the magnetic deflector to measure magnetic fields produced. For comparison, fields near other common electronic devices in a radiotherapy department (such as computer monitors, kV generators, etc.) were tested.

## 3. Results and discussion

Table 1 shows the effects of dose measurement from magnetic fields on two types of ionization chambers. As can be seen no distinguishable effects are seen with field strengths present at measurement sites. Thus we can assume all measured results are accurate within their own level of errors. An interesting point to note which could effect measured results is the leakage of helium gas from the bag which can then enter the ionization chamber used to measure results. By replacing the air inside the chamber with helium, you would effectively produce a lower charge reading due to lack of ionization events within the plate separation.

Fig. 1 shows the reductions in skin dose achievable with the introduction of the magnetic deflector and the helium bag system as a function of field size. Results are obtained by subtracting the measured percentage build up dose with the magnet and helium from open beam results. With the advent of linear accelerators and more conformal therapy procedures, skin dose and skin reactions are no longer a major problem in radiotherapy. However in certain instances, the treatment still requires a reduced skin dose for the greatest skin sparing effect. The magnetic deflector and helium bag systems are easily useable devices to reduce skin dose by up to 70% of its original value without effect-

Table 1
Effects on measured dose by magnetic fields for two types of ionization chambers[a]

| Field strength (T) | Chamber type/Measured dose per 100 cGy applied dose: Attix chamber | Thimble chamber |
|---|---|---|
| 0 | $100 \pm 1$ | $100 \pm 0.5$ |
| 0.02 | $99.8 \pm 1$ | $100.4 \pm 0.5$ |
| 0.05 | $99.7 \pm 1$ | $100.3 \pm 0.5$ |
| 0.1 | $99.9 \pm 1$ | $99.8 \pm 0.5$ |
| 0.2 | $99.5 \pm 1$ | $99.6 \pm 0.5$ |
| 0.3 | $99.6 \pm 1$ | $100.2 \pm 0.5$ |

[a] The field strengths attainable by the deflector produce minimal effect on dose measurement. No variations larger than the uncertainty of measurement were recorded.

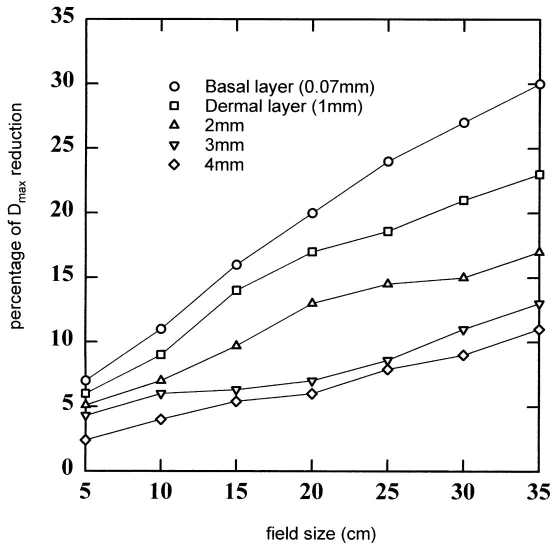


Fig. 1. The reductions in electron contamination dose achievable by the two devices. Results up to 70% of original dose to skin can be removed if necessary.

ing tumor dose or the need to redesign the treatment procedure.

Fig. 2 shows the field strengths of the magnetic deflector at distances comparable to patients separations with various configurations of the magnetic deflector. Also shown on this graph are measured magnetic field strengths at quoted distances from various devices in radiotherapy for comparison. By assessing the magnitude of the magnetic field around a patient during radiotherapy we can alleviate any concerns raised by exposure to electromagnetic fields. The fields that would be experienced by the patient during a radiotherapy treatment using this device compares to the fields exposed to by sitting in front of an older computer screen for a similar period of time. A patient would normally not be any closer than 20 cm to the magnetic deflector thus reducing the applied field strength to the order of 0.02 T or less. In contrast a Magnetic Resonance Imaging (MRI) machine normally produces field strengths in the order of 0.4–1.5 T. We would recommend however that no patient with a pacemaker or similar device be treated using the magnetic deflector due to the high risk factors associated with any magnetic fields around these devices.

## 4. Conclusions

A combined skin dose reducing device which could be clinically useable has reduced basal cell layer dose by up to 70% without any effects of x-ray dose deposition or without major side effects caused by magnetic fields. The two piece system can be easily attached and

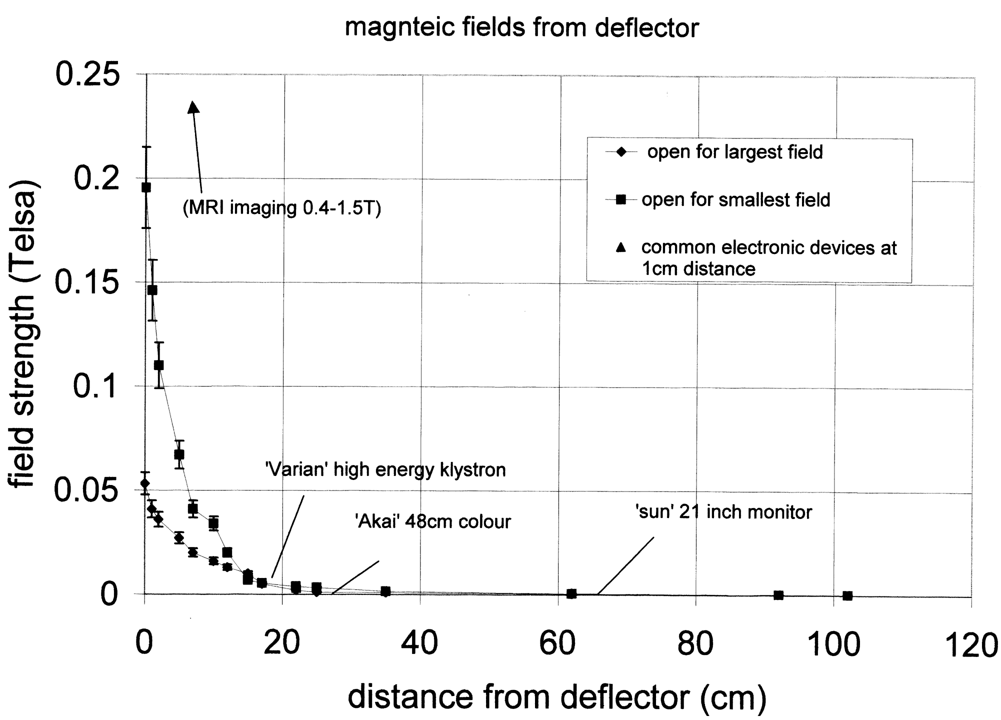


Fig. 2. The magnetic fields measured at distance from the magnetic deflector and compares this to various electronic devices.

removed from the accelerator and produced no change to tumor dose while removing unwanted skin dose caused by electron contamination.


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## References


Biggs, P.J., Russell, M., 1983. An investigation into the presence of secondary electrons in mega voltage photon beams. Phys. Med. Biol. 28, 1033–1043.

Butson, M., Wong, T., Law, A., Law, M., Mathur, J., Metcalfe, P., 1996. Magnetic repulsion of linear accelerator contaminates. Med. Phys. 23, 953–955.

Constanitinou, C., Attix, F., Paliwal, B., 1982. A solid water phantom material for radiotherapy X-ray and gamma ray beam ray calculations. Med. Phys. 9, 436–441.

Ling, C., Biggs, P., 1979. Improving the build up and depth dose characteristics of high energy photon beams by using electron filters. Med. Phys. 6, 296–301.

Nilsson, B., 1985. Electron contamination from different materials in high energy photon beams. Phys. Med. Biol. 30.

Rao, B., Prasad, S., Parthasaradhi, K., Lee, Y., Ruparel, R., Garces, R., 1988. Investigations on the near surface dose for three 10 MV X-ray beam accelerators with emphasis on the reduction of electron contamination. Med. Phys. 15, 246–249.

Yorke, Ling, Rustgi, 1985. Air generated contamination of 4 and 10 MV photon beams: a comparison of theory and experiment. Phys. Med. Biol. 30, 1305–1314.