Magneto-radiotherapy: making the electrons conform

Heidi Nettelbeck
University of Wollongong, hn06@uow.edu.au

Michael L. Lerch
University of Wollongong, mlerch@uow.edu.au

George J. Takacs
University of Wollongong, gjt@uow.edu.au

Anatoly B. Rosenfeld
University of Wollongong, anatoly@uow.edu.au

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Heidi Nettelbeck, Michael Lerch, George Takacs and Anatoly Rosenfeld

Centre for Medical Radiation Physics, University of Wollongong, Australia

Introduction:

Magneto-radiotherapy is the application of magnetic fields during radiotherapy procedures. It aims to improve the quality of cancer treatment by using magnetic fields to alter the dose-deposition of secondary electrons in tissue. This work compares the performance of PENELOPE and EGS4 MC codes for magnetic fields applied to conventional photon beams. It also investigates the effect of a magnetic field on the electron spectrum and explores the novel idea of applying magnetic fields to MRT (Microbeam Radiation Therapy) for the treatment infantile brain tumours.

Method:

PENELOPE simulations were based on an EGS4 study by Li *et al.* (1) which investigated the effect of a slice of transverse magnetic field on different energy photon beams. The simulations were performed with magnetic field strengths of up to 20T applied to 6, 10 and 15MV photon beams to compare with those obtained with EGS4. Further simulations have been done to investigate how the presence of a magnetic field alters the electron spectrum.

Physical magneto-radiotherapy measurements were conducted at the ESRF (European Synchrotron Research Facility) in France, to study the effect of a *longitudinal* magnetic field on the dose-distribution of secondary electrons in MRT. These measurements were performed using a variety of magnetic field configurations and radiation detectors. MC simulations have also been done to support this work.

Results:

A *transverse* magnetic field produced a perturbation in the depth-dose profile of linac photon beams (Fig.1), particularly for magnetic field strengths greater than 2T. This perturbation arises from secondary electrons spiraling about the magnetic field vector, thus depositing their energy at shallower depths rather than further downstream. MC results reveal changes in the low-energy electron spectra of linac beams in the regions approaching and exiting the slice of magnetic field (7-9 cm depth), particularly for stronger magnetic fields.

In MRT, the presence of a *longitudinal* magnetic field had no effect on the dose-deposition. Further MC simulations are in progress to investigate whether this result can be explained by to the mean free path of the low-energy electrons being much smaller than their radius of curvature.

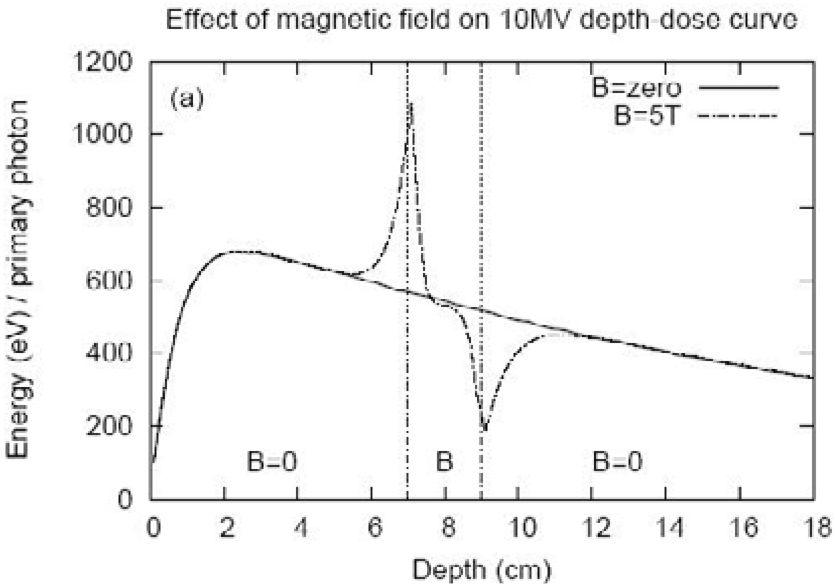

Figure 1. *PENELOPE 10MV depth-dose curve with zero and 5T magnetic field (7-9cm).*

Discussion and conclusions:

Magnetic fields applied to radiotherapy procedures can alter the dose-deposition of secondary electrons producing desirable therapeutic benefits such as the dose-perturbation effect (Fig.1) which could be manipulated to treat tumour regions close to critical structures. This is just one benefit that this innovative magneto-radiotherapy technique – a technique that makes the electrons conform.

References:

Li X et al. Conformal photon-beam therapy with transverse magnetic fields: A Monte Carlo study. Medical Physics 2001; 28(2):127-33.