Magnetic Field Effects On Radiation Dose Distribution

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Joint Imaging/Therapy Symposium - MR-Guided Radiotherapy,
AAPM 51st Annual Meeting, Anaheim, CA
July 29th, 2009

Interaction of the external beam-derived secondary electrons with magnetic fields

- Brief historical review.
- Non-uniform magnetic fields.
- Uniform MRI fields and tissue density effects.
- Treatment planning issues.
- Engineering trade-offs.
- Conclusions.

1976 McIntyre patent

Improved Monte Carlo codes

- 1978 Ralph Nelson introduced magnetic field transport to EGS3.
- 1984 Alex Bielajew developed improved method to incorporate both E and B fields in EGS4 user codes.
- AAPM Farrington Daniels Award for a paper on dose enhancement due to charge storage in electron-irradiated phantoms.
Bielajew longitudinal B-field plots

20 MeV electron pencil beams

0 Tesla

6 Tesla

20 Tesla

6 MeV photon beam transport in transverse B-field

0 Tesla

1.5 Tesla at 90°

Leonard Reiffel patent

Approached by a third party who implied that there was a patent with a method for achieving proton-like dose distributions with a photon beam combined with a magnetic field to shape the secondary electron cloud

Depth dose for X-rays and protons

Depth in Tissue (cm)
Inventor himself claimed only 40% dose enhancement

Dose deposition in transverse B-field
Electron Return Effects

Ralph Nelson EGS5 result

Dose Deposition
Tissue density compensation using opposed beams

Magnetic field vs. image quality


5-field lung treatment plan – 2 fields are 180° apart

CT

1.5T MRI
B-field/beam axis/patient axis orientations

University of Utrecht group and Viewray have the treatment beam transverse to the B-field which is aligned along the rotation axis.

Dr Fallone’s group have the beam transverse to the B-field and both are transverse to the rotation axis.

Stanford have the treatment beam parallel to the B-field and both are transverse to the rotation axis.

Engineering trade-offs in combined MRI-RT Systems

• Performance tradeoffs re magnetic field orientation and field strength are complex.
• Three leading university groups pursuing widely different approaches.
• Good situation!

Acknowledgements

• The speaker would like to thank Ralph Nelson for many helpful discussions, teaching him the basics of Monte Carlo modeling, and for running the B-field transport examples shown.

Thank you for your attention