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Small field dosimetry in 1.5T MR-Linacs using plastic phantoms: an investigation of the effect of air gaps

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Background

In MR-Linac dosimetry using plastic phantoms and for a 10x10cm^2 field, small (~0.2mm) air gaps between a Farmer-type ionization chamber and plastic phantom could affect detector response by up to 1.6%, while larger effects are reported for small-cavity ionization chambers.[1-2] Thus, the aim of this study is to investigate the effect of small air gaps around a detector under small irradiation fields, using Monte Carlo (MC) simulations.

Materials & Methods

- Three ionization chambers (PTW Pinpoint 3D, IBA Razor nano, Exradin A26) were modelled in the EGSnrc MC package (Figure 1), based on blueprints made available by the corresponding manufacturers.
- All detectors were simulated at the isocenter (SAD=143.5cm), at a depth of 10cm inside an RW3 solid phantom, antiparallel to the magnetic field and perpendicular to the beam axis.
- Phase space files for the 1x1, 2x2 and 3x3 cm^2 of a Unity 1.5T/7MV MR-Linac (Elekta, UK) were provided by the manufacturer and used as the source models.
- Asymmetrical and symmetrical air gaps (thickness of 0.1, 0.3 and 0.5mm) were introduced around the detectors (Figure 1).
- The dose scored in each detector's air cavity was compared against the corresponding one for the zero-gap geometry

Results

Figure 2 presents the detector response normalized to the zero-air gap simulation.

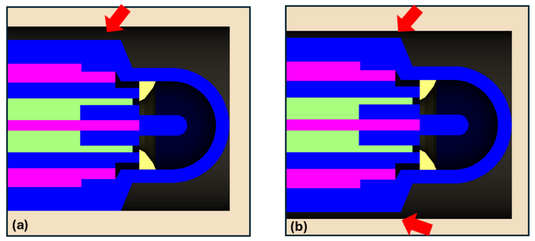

Figure 1: (a) Asymmetrical air gap around the ionization chamber. The air gap was modelled on the top of the detector, facing towards the source. (b) Symmetrical air gap homogenous around the detector. Black represents the air, and the yellow the dead volume of the ionization chamber, that is, air is not included in the scoring option. Red arrows indicate the air gaps.

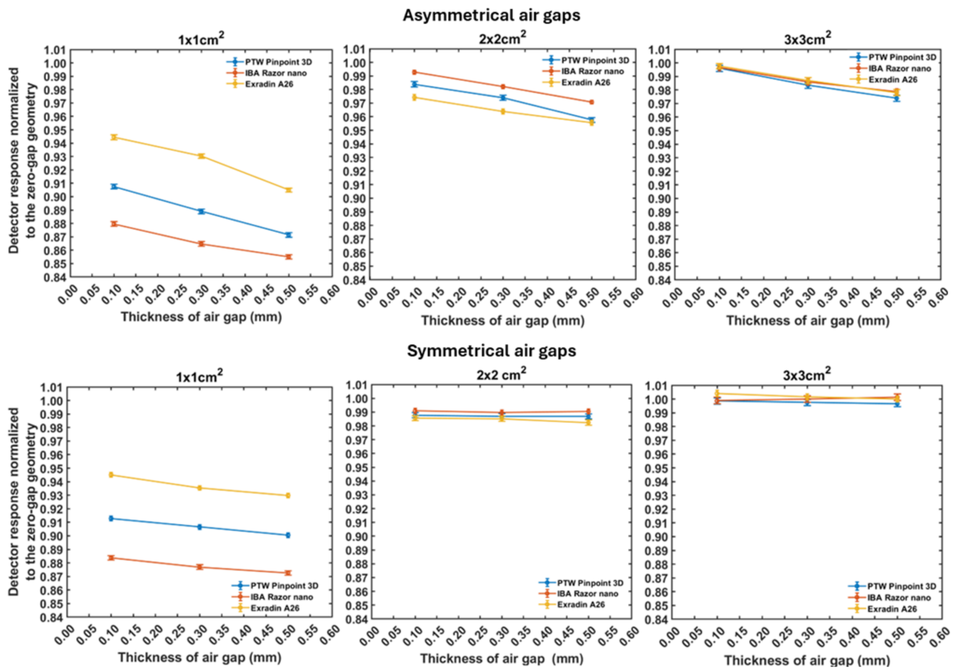

Figure 2: Relative dose normalized to the one scored in absence of air gaps for three ionization chambers and varying air gaps.

Conclusion

The presence of a small volume of air between the plastic phantom and the ionization chamber could significantly bias the detectors' response in a 1.5T MR-Linac.

References

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2. Margaroni V. et al. " Dosimetry in 1.5T MR-Linacs: Monte Carlo determination of magnetic field correction factors and investigation of air gap effect", Med. Phys., 50(2):1132-1148 (2023)

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