Influence of Detector Sensitive Volume on Ionization Chamber Response for MR-Guided Particle Therapy

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Purpose

Online MR guidance in particle therapy can help achieve full exploitation of Bragg peak advantages as it offers fast imaging of unparalleled soft tissue contrast.

However, the presence of magnetic field affects the ionization chamber response impacting accurate dosimetry.

This study examined the influence of detector sensitive volume in the magnetic field (MF) effect on ionization chambers under the irradiation of proton, carbon and helium ion beams.

Materials and Methods

- Six thimble type ionization chambers (PTW, Freiburg, Germany)
- Sensitive volumes from 0.016 to 0.6 cm^3
- Measurements @ 2 cm WET
- MF: 0, 0.25, 0.5, and 1.0 T
- 10×10 cm^2 fields of 252.7 MeV protons, 220.8 MeV/u helium ions, and 402.8 MeV/u carbon ions.

The $k_{B,M,Q}$ factor was introduced to account for the MF effect on the chamber performance

$$k_{B,M,Q} = \frac{M_Q}{M_Q^B}$$

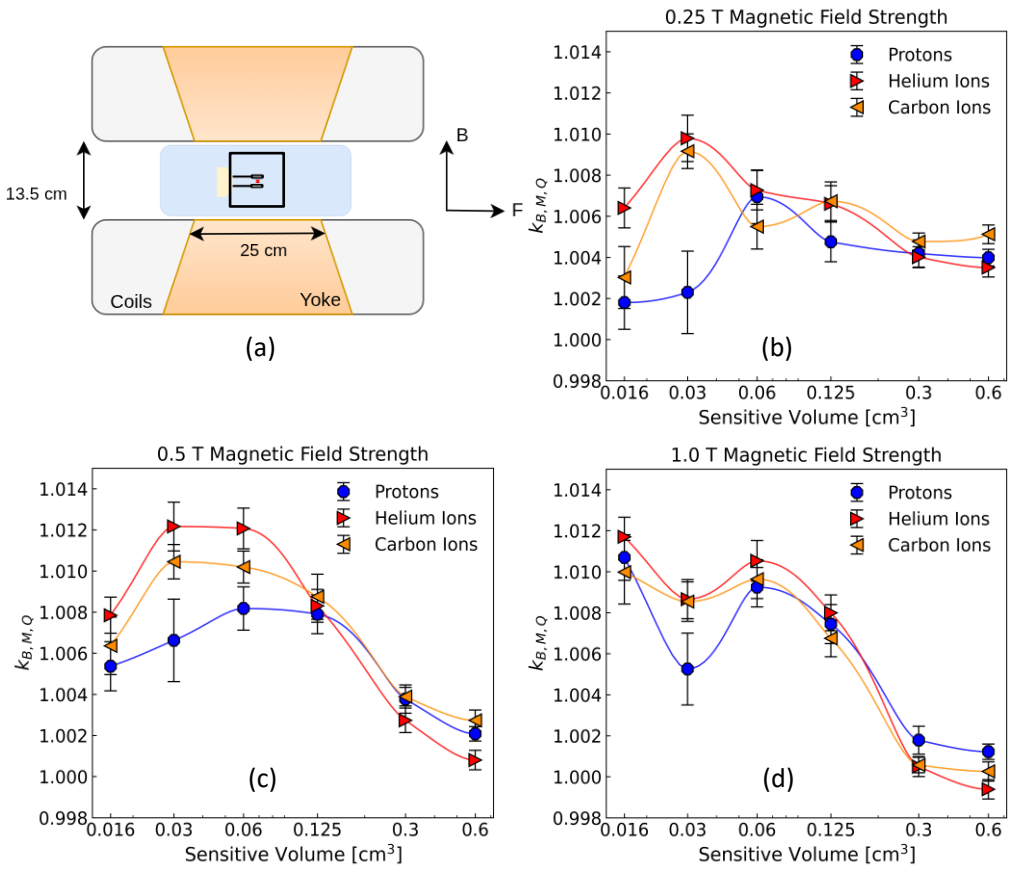

Figure 1: a) Sketch of the experimental set-up in beam's eye view. Two ionization chambers are used simultaneously. The radiation field is indicated by the black square. MF correction factor against detector sensitive volume for b) 0.25 T, c) 0.5 T, and d) 1.0 T.

Results

Sensitive volume influence is more prominent for larger detectors (≥0.06 cm^3).

- $k_{B,M,Q}$ values inversely related to the cavity size
- volume effect becomes stronger with MF

For smaller volumes (<0.06 cm^3) the $k_{B,M,Q}$ factor is more susceptible to changes in MF strength

- 0.25 and 0.5 T: increase up to 0.03 cm^3
- 1T: decrease at 0.03 cm^3

The trend appears to be independent of the particle type with the 0.03 cm^3 volume deviating slightly from the general behavior.

Conclusions

- MF effect not solely dependent on chamber sensitive volume

Further investigations are required to clarify the combination of chamber design properties that best describes the influence of cavity size.

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