Fabrication and calibration of superheated droplet detectors (SDDs) for neutron dosimetry

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Issue & objectives

Proton therapy is becoming one of the most attractive approaches in the treatment of cancer. Nevertheless, there is a major concern about the carcinogenic risk of secondary neutrons, which are inevitably present in proton therapy.

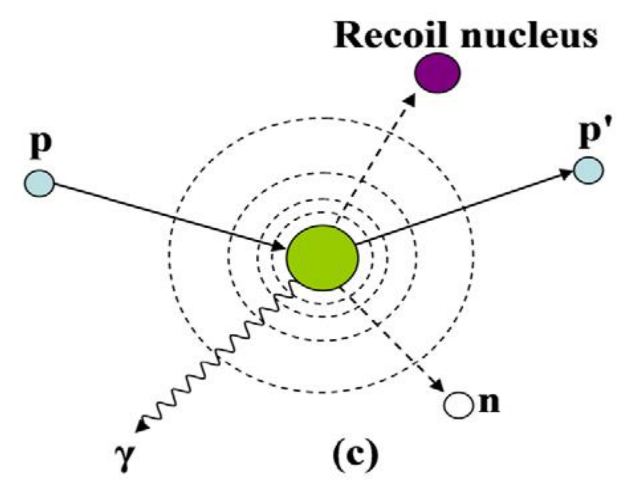

Figure 1: Removal of primary proton and creation of secondary particles via non-elastic nuclear interaction (p: proton, e: electron, n: neutron, γ: gamma rays) [1].

In order to measure the secondary neutron dose, commercial bubble detectors can be used. However, these detectors take a lot of space, are very expensive and have limited life time and therefore small SDDs need to be developed to measure the neutron dose in vivo by using a phantom.

This master's thesis aims to improve an existing fabrication protocol to achieve a stable detector to assess neutron doses in anthropomorphic phantoms during proton radiotherapy. Thereafter, the detectors must be characterized and a reproducible calibration method has to be sought.

Material & methods

A new fabrication protocol has been developed that must be followed very carefully.

Figure 2: Pressure reactor (left-hand side) used to fabricate the gel for the SDD (right-hand side).

An SDD consists of superheated liquid drops suspended in a visco-elastic gel. Due to the influence of neutrons the drops turn into bubbles. With piezo-electric sensors the acoustic waves that are associated with the generation of a bubble can be detected.

The SDDs are characterized by irradiating them with a ^{252}Cf neutron source and read through an acoustic detection system. Afterwards, registered pulses are analyzed through a software program to provide an objective analysis.

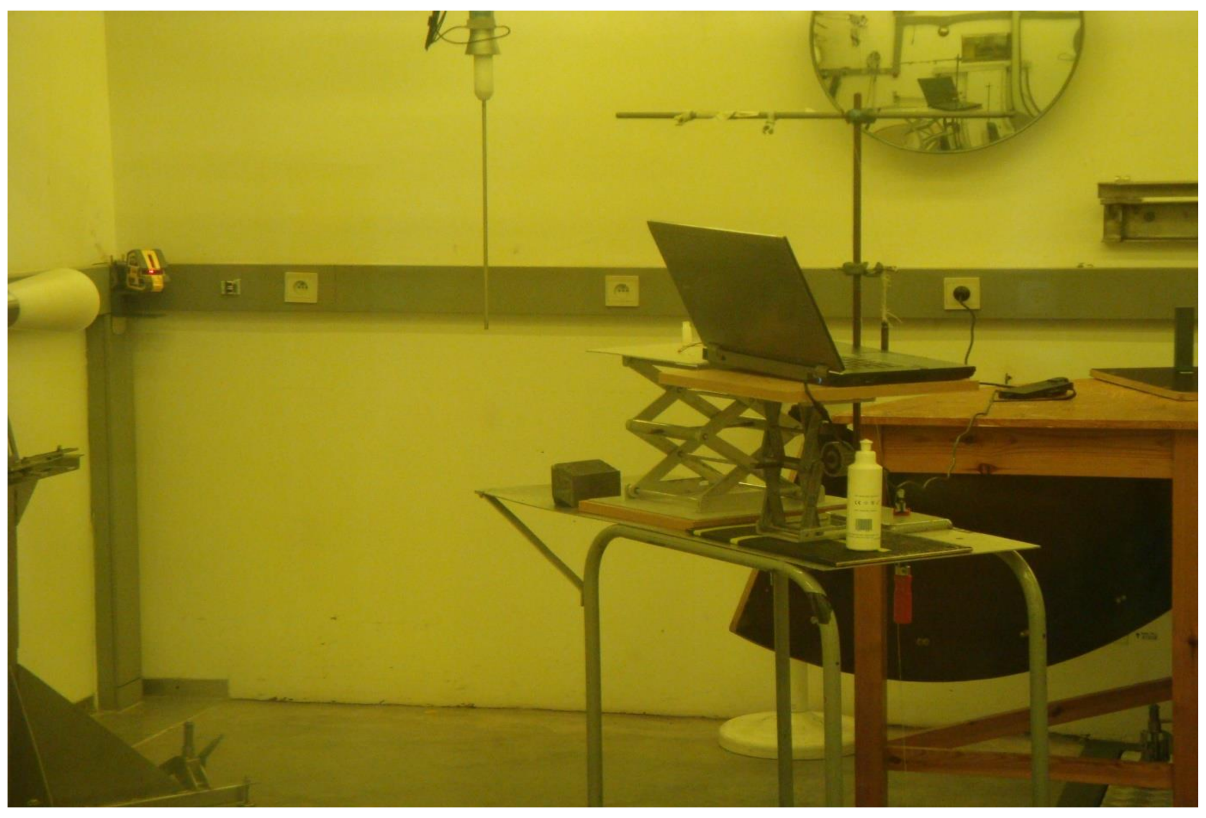

Figure 3: Calibration set-up, including the SDD, a laptop installed with the LabVIEW program and the ^{252}Cf source at the end of the rod.

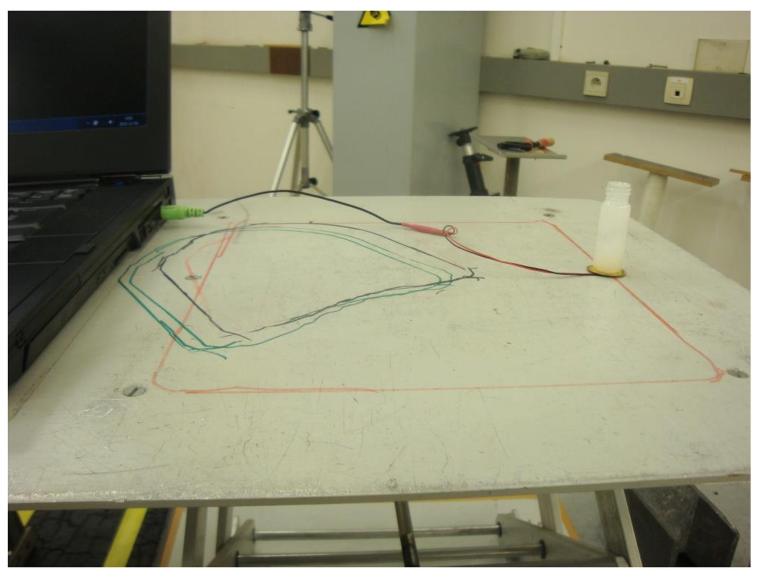

Figure 4: SDD resting on a piezoelectric microphone connected to a laptop.

Conclusion

To conclude, the SDDs must be manufactured by strictly following a dedicated protocol.

The sensitivity of the SDDs can be increased by increasing the amount of added Freon. However, these detectors are limited in sensitivity because of the limited volume.

Finally, it was concluded that the SDDs must be reset after each irradiation to obtain a constant response, by applying pressure on the vial containing the gel.

A reproducible calibration method was obtained by resetting each time and with the software analysis of the acoustic pulses.

Reference

[3] W. Newhauser and R. Zhang, "The physics of proton therapy", *Physics in Medicine and Biology*, vol. 60, no. 8, pp. R155-R209, 2015.

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