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Application of a primary-standard level calorimeter for absolute dosimetry in monoenergetic proton radiation therapy (pMBRT) beams

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Using TRS-398, primary standard level dose measurements for calibrating ionisation chambers are currently realised in a 60Co beam. The upcoming UK IPEM Code of Practice for Proton Radiotherapy will provide a new protocol for the direct calibration of ionization chambers in a proton beam using the NPL Primary Standard Portable Calorimeter (PSPC) reducing the uncertainty on reference absorbed dose measurements by approximately 50%. In this study, an exploratory investigation was conducted to determine if is possible to apply the PSPC to proton minibeam radiotherapy (pMBRT) for primary standard level dosimetry.

Measurements were conducted at Institut Curie, utilising the PSPC, which was irradiated with a 100 MeV monoenergetic proton beam. The calorimeter core (16 mm diameter) was positioned at the isocentre, at 2 cm water equivalent depth. Monte Carlo derived correction factors were determined using TOPAS v3.6 to convert the measured dose to graphite core, to dose to water; using phase space data scored before the collimator (Figure1).

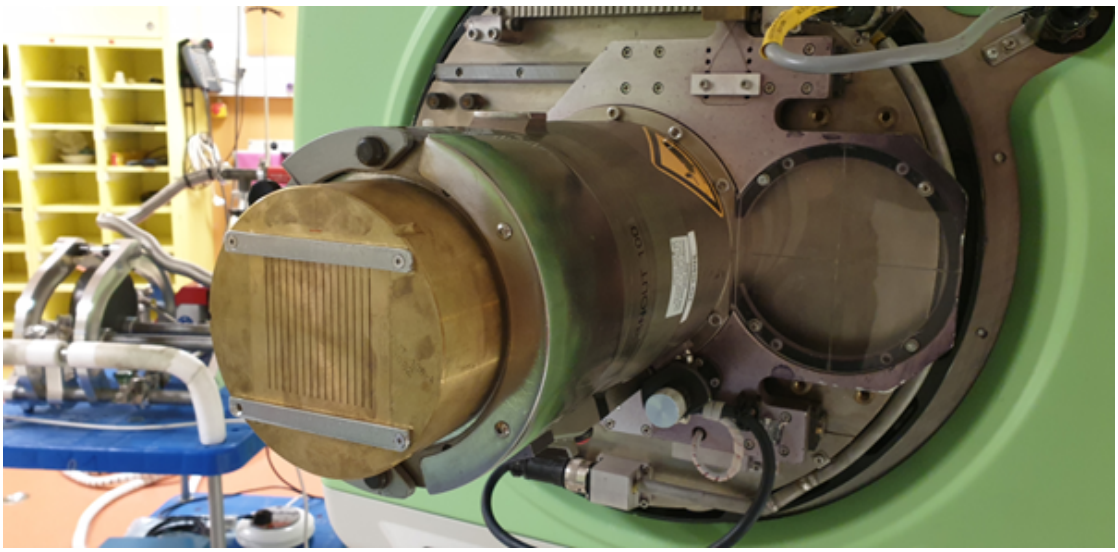

Figure 1: Figure1: Photograph of brass collimator, with machined fifteen 5 cm x 400 □m long slits, 4 mm pitch.

The PSPC was able to measure radiation- induced temperature rise (Figure2) in both quasi-adiabatic and isothermal modes. However, the pMBRT dose profile introduces large uncertainties associated with the position of the PSPC (Figure3). Additionally, experimental variations in alignment of the collimator introduce further uncertainty with lowered repeatability.

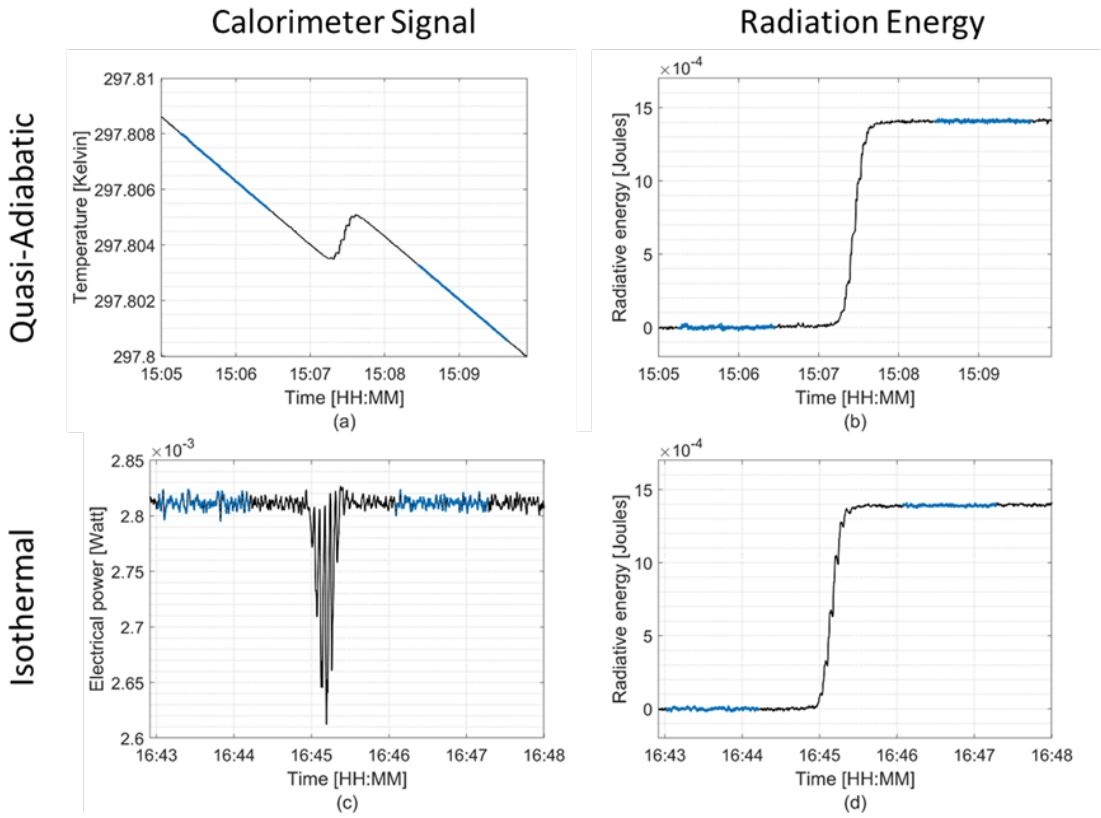

Figure 2: Figure2: Two sets of PSPC analysis in pMBRT beam deliveries.

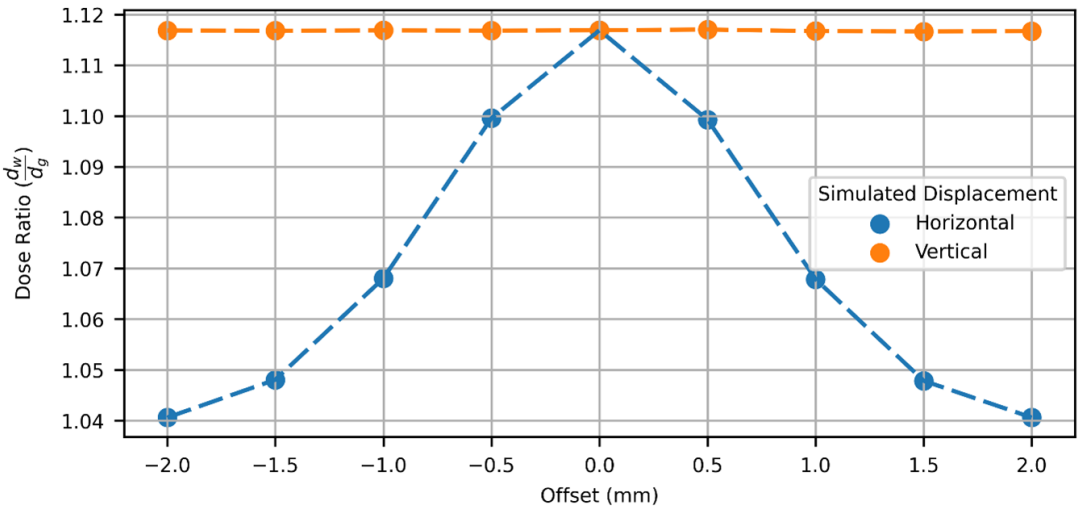

Figure 3: Figure3: Variation in dose to water simulations due to lateral PSPC core displacement.

Primary standard level dosimetry in pMBRT is possible with sufficient signal-to-noise ratio observed in raw data, however with significantly larger uncertainties than clinical proton beams. Additional research is ongoing to analyse and simulate collected Spread-Out Bragg peak pMBRT data, and the viability of other calorimeters for pMBRT dosimetry.

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