Multi-points calorimeter using fiber Bragg gratings for small field dosimetry in radiotherapy

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INTRODUCTION

- Interest of fiber Bragg gratings (FBGs) dosimeters in radiotherapy (RT):
  - Submillimeter detection volume
  - Customizable spatial resolution
  - Multi-points dose measurement
  - Real- time data acquisition
- Purpose: characterize a multi-points FBGs dosimeter customized for small field RT dosimetry having a spatial resolution of 1 mm

METHODS

- Dosimeter specs : 30 co-located 1 mm FBGs (3 cm long)
  - FBG written with the phase-mask technique in 80 μm silica fiber
  - Embedded in a 0.60 cm diameter PMMA cylinder (30 cm length)
- Characterizations (Varian TrueBeam, 2000 MU, 600 MU/min):
  - Dose profile of a 2 x 2 cm^2 6 MV beam
  - Output factor for a 6 MV beam up to 30x30 cm^2
  - Energy dose response (6,18 MV and 6, 9 , 12, 15 MeV)
- Temperature correction: pre-irradiation and post irradiation temperature drift technique [1]

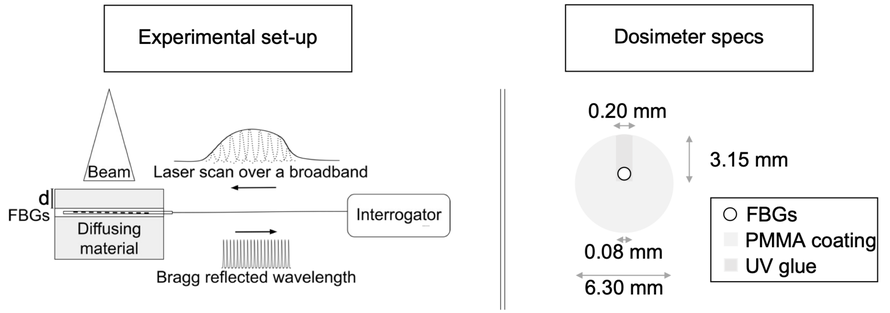

Fig 1 Experimental set-up including dosimeter specs. The laser beam is injected in the FBGs and the reflected wavelength is measured with the interrogator at 1 kHz (si155 interrogator, ENLIGHT software, Micron Optics)

RESULTS

Dose profile: over ± 0.9 cm, the mean and maximum relative difference are respectively 1.8% and 6.4% (Fig 2)

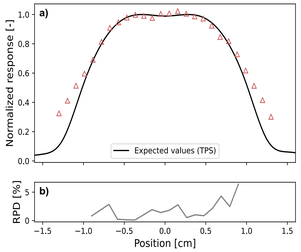

Fig 2 a) Dose profile measured with the FBGs dosimeter for a 2 x 2 cm^2 6 MV beam and its b) relative difference to the expected values calculated with the TPS. The distance surface to detector is 10 cm and the isocenter is placed on the detector.

Output factor: relative difference between is under 7% for every data point except for 2 x 2 cm^2 field that has a 15% gap (Fig 3)

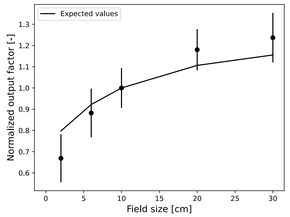

Fig 3 Output factor for a 6 MV beam. The distance surface to detector is 10 cm and the isocenter is placed on the detector. The expected values are measured with ion chamber and diodes.

Energy: the detector response is within 5% of the mean response for every tested energies (Fig 4)

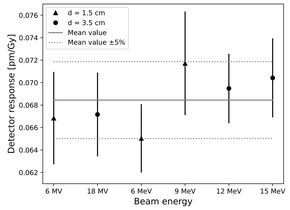

Fig 4 Detector energy dependency. In order to maximized the signal measured, the distance surface to detector is changed (1.5 or 3 cm), but the isocenter is kept at the surface in both cases. A 10 x 10 cm^2 field is used for photons and a 15 x 15 cm^2 field is used for electrons.

DISCUSSION

- This detector allows dose profile measurements for a 2 x 2 cm^2 field with a mean relative difference of 1.8% excluding the penumbra region
- It allows output factor measurements with a relative difference under 7% excluding the 2 x 2 cm^2 field which has a 15% gap
- The detector is also energy independent within a 5% range of the mean response

CONCLUSION

This type of detector could prove really useful for small field dosimetry, but also potentially for MRI-LINAC and FLASH since silica fibers are highly resistant to radiation and are already used for high dose range in the nuclear field

REFERENCE

[1] Lebel-Cormier, Marie-Anne, et al. "Real-Time Temperature Correction of Medical Range Fiber Bragg Gratings Dosimeters." Sensors 23.2 (2023): 886.