Evaluation of Multiple Detectors Under UHDR Electron Beams

Racell Nabha[1,2], Iris Apale[1,2], Séverine Rossomme[3], Marlies Boussaer[1,2], Mark De Ridder[1,2], Thierry Gevaert[1,2]

(1) Department of Radiotherapy, UZ Brussel, Vrije Universiteit Brussel, Brussels, Belgium (2) Research Centre for Digital Medicine, Vrije Universiteit Brussel, Brussels, Belgium (3) Dosimetry department, IBA, Louvain-la-Neuve, Belgium

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Introduction

Reliable dosimetry under ultra-high dose rate (UHDR) is critical for translating FLASH radiotherapy into clinical practice. Conventional ionization chambers may suffer from recombination effects, whereas solid-state diodes and diamond detectors promise faster and potentially more accurate readings. This study presents initial measurements comparing multiple detector types across varying Flashknife delivery parameters.

Materials and Methods

Irradiations were performed using the FLASHKNiFE (Theryq, France) system with a 10 cm diameter circular field. A FlashDiamond (fD), a SiC prototype diode, Razor diode, and a prototype PPC05 were used and a consistent buildup thickness was applied. Four irradiation configurations were evaluated, of which three were in the FLASH mode and one in the conventional mode. All beam parameters are summarized in Table 1. Dose-related quantities i.e. average dose rate (ADR) and dose per pulse (DPP) were estimated using the fD detector and based on the pulse repetition frequency (PRF), pulse width (PW) and number of pulses. Detectors' response to varying number of pulses and across the full range of PW and PRF was also investigated.

Table 1. Beam parameters used for the four irradiation configurations.

Config.	PRF (Hz)	PW (µs)	# Pulses	Dose (Gy)	ADR (Gy/s)	DPP (Gy)
1 (FLASH)	300	3	2	4.05	1213.8	2.02
2 (FLASH)	100	1	6	4.07	81.3	0.68
3 (FLASH)	300	1	6	4.05	242.7	0.67
4 (Conv)	10	1	-	4.04	0.1	-

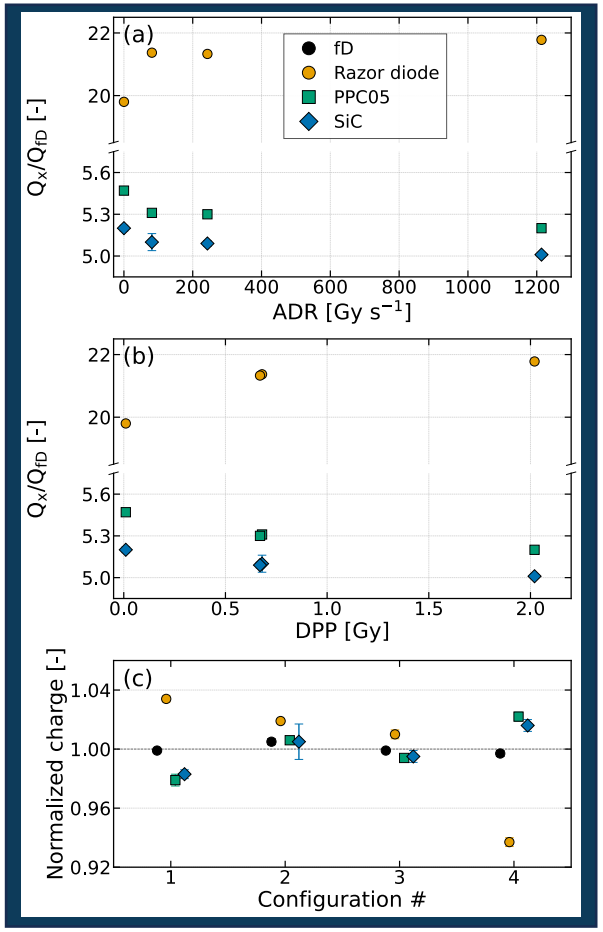

Figure 1. Relative detector (Razor diode, prototype PPC05 and SiC) charge normalized to the fD charge as a function of ADR (a) and DPP (b). Normalized detector charge relative to each detector's mean across the four irradiation configurations (c). Error bars represent one standard deviation from repeated measurements.

Results and Discussion

Figure 1a-b compare detectors' responses relative to the fD reference as functions of ADR and DPP. Figure 1c shows detectors' responses across four irradiation configurations, normalized to their mean charge. Except for the Razor diode in configuration 4, all detectors were stable within 3% of their mean (0.98–1.03). Stability was observed across all configurations, with RSDs of ~3.6% (Razor diode), ~1.8% (PPC05), and ~1.3% (SiC), indicating limited influence of ADR and DPP on output. The Razor diode showed a systematic decrease with decreasing DPP and ADR, consistent with silicon diode studies reporting reduced sensitivity at lower dose rates, possibly due to charge recombination.

Conclusion

Preliminary findings showed that most of the investigated detectors demonstrated stable responses with minimal dependence on beam parameters, supporting their suitability for UHDR dosimetry, and motivating further work on absolute dose verification, extended characterization, and broader UHDR assessment for FLASH clinical translation.