Orientation Dependent Performance of a Microsilicon Detector In Small Field Dosimetry

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INTRODUCTION

Accurate small field dosimetry is strongly influenced by detector volume averaging, density effects, and perturbations. Solid state detectors such as microSilicon and microdiamond have been shown to be well-suited for small-field dosimetry due to their minimal correction with field-size $\left(k^{f_{clin},f_{msr}}_{Q_{clin},Q_{msr}} \approx 1.0\right)$, however, limited data exist on the impact of detector orientation and measurement depth. This study evaluates orientation dependent differences in field output factors (FOFs) and beam profiles for small fields to support more consistent and accurate clinical implementation.

METHOD

A PTW microSilicon detector was evaluated in face up and edge on orientations on a Varian TrueBeam linear accelerator. FOFs were measured for field sizes from 0.5 × 0.5 cm² to 10 × 10 cm² using 6 MV and 6 MV flattening filter free (FFF) beams at 100 cm source to axis distance and depths of dmax, 5 cm, and 10 cm in water. In plane and cross plane beam profiles were acquired using a water scanning system. Measured FOFs were compared between orientations and benchmarked against Monte Carlo (MC) simulations. Orientation dependent full width at half maximum (FWHM) and penumbra were analyzed to assess spatial resolution.

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RESULTS

Detector orientation produced clinically relevant differences for sub centimeter field sizes. For a 0.5 × 0.5 cm² field, the face up orientation underestimated FOFs by 5–6% relative to the edge on configuration. Orientation dependent differences decreased with increasing field size and were less than 0.5% for fields ≥1.5 × 1.5 cm². Compared with MC simulations, the edge on orientation showed closer agreement across all field sizes, remaining within 3% even for the smallest field. Profile analysis demonstrated superior spatial resolution in the edge on orientation. Face up measurements exhibited 3–10% FWHM narrowing and 6–11% penumbra underestimation, with increasing effects for smaller fields and greater depths.

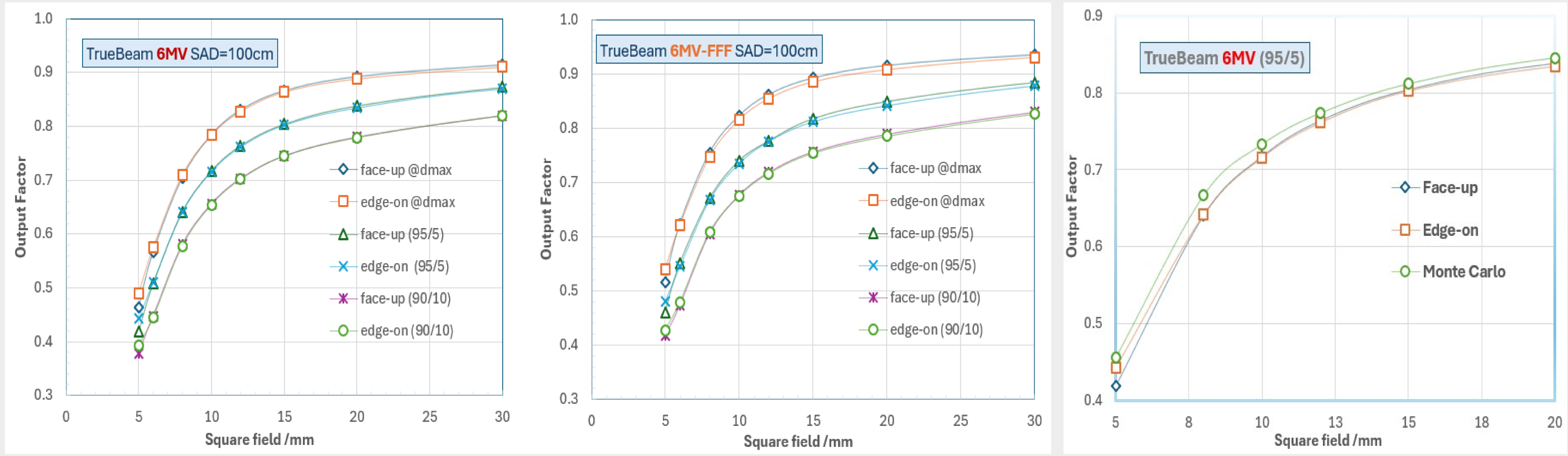

Fig. 1 (a) TrueBeam 6MV @ face-up &edge-on, (b) TrueBeam 6MV-FFF @ face-up & edge-on, (c) FOF of face-up, edge-on and MC.

Field (mm²)	5	8	10	12	15	20	30	50	100
Face-up	0.419	0.640	0.717	0.764	0.804	0.838	0.873	0.922	1.000
Edge-on	0.442	0.641	0.716	0.761	0.802	0.834	0.870	0.919	1.000
Face-up vs Edge-on (%)	-5.61	-0.13	0.20	0.37	0.24	0.47	0.36	0.23	0.00
Monte Carlo	0.456	0.662	0.733	0.774	0.812	0.846	0.883	0.931	1.000
Face-up vs MC (%)	-8.11	-3.26	-2.17	-1.27	-0.93	-0.86	-1.19	-1.02	0.00
Edge-on vs MC (%)	-2.96	-3.13	-2.37	-1.63	-1.17	-1.32	-1.55	-1.25	0.00

Table I FOF of face-up, edge-on and Monte Carlo for nominal fields from 0.5x0.5 to10x10 cm² for TrueBeam 6MV at 5cm depth & SSD=95. Difference between face-up vs edge-on measurements, face-up vs MC and edge-on vs MC simulations.

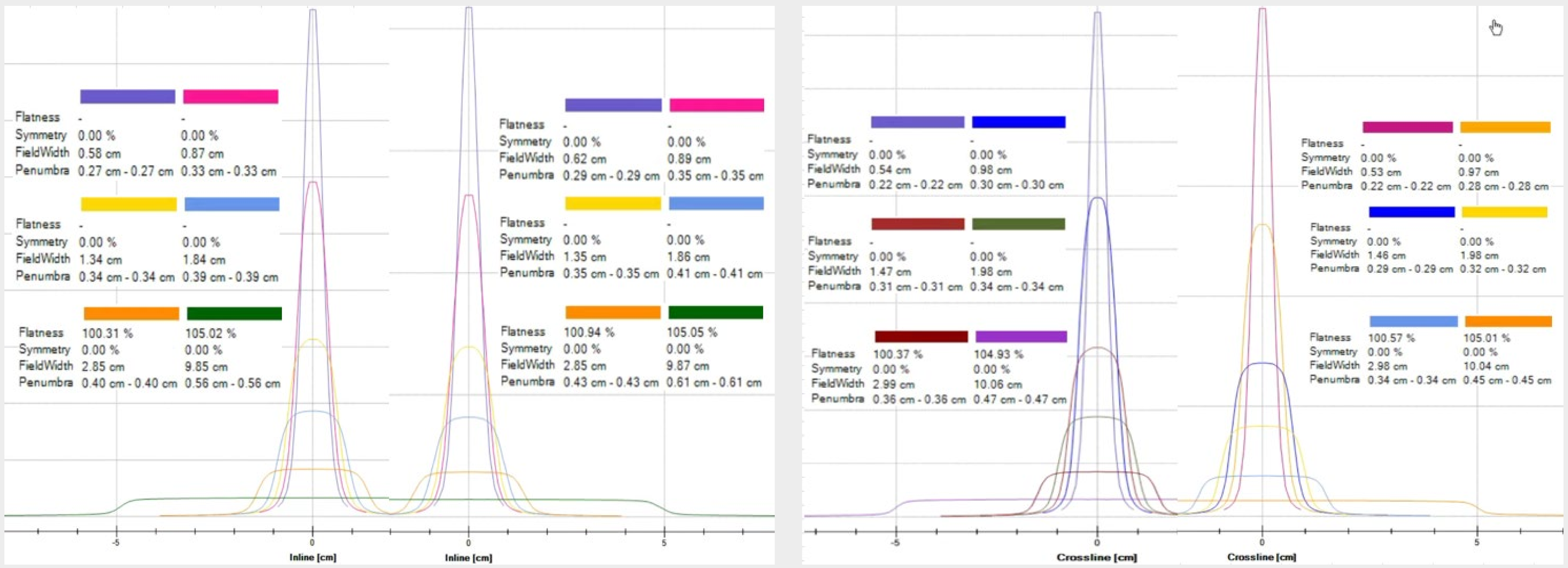

Fig. 2 FWHM and penumbra for profiles scanned at Inline (I) & Crossline (II) of fields from 0.5x0.5 to10x10 cm² for TrueBeam 6MV (5cm/ 95cm).
Notes: left sides of both Inline and Crossline profiles are in face-up and right sides are in edge-on orientations

CONCLUSIONS

The edge on orientation is preferred for microSilicon detectors in small field dosimetry, providing improved agreement with Monte Carlo simulations and more accurate beam profile characterization. The face up orientation may be acceptable for fields ≥1 × 1 cm² but introduces systematic underestimation in sub centimeter fields, underscoring the need for orientation specific standardization in small field reference measurements.

REFERENCES

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