Performance Comparison of a Plastic Scintillation Detector and Various Detectors for Small Field Dosimetry in High-Aspect-Ratio Rectangular Fields

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INTRODUCTION

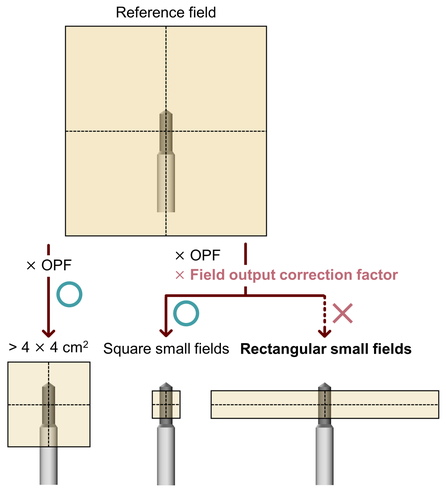

Fig. 1. Flowchart illustrating the current scope of field output correction factors.

Background

- TPS commissioning (e.g. Eclipse) requires beam data for a wide range of field sizes, including **high-aspect-ratio rectangular fields** formed by independent jaw settings (e.g. 1 × 40 cm²).
- Jaw geometry asymmetrically affects lateral charged particle equilibrium and source occlusion along each axis; rectangular-field behavior **cannot be inferred from square-field data alone** (Fig. 1).
- Field output correction factors for square small fields are tabulated in IAEA TRS-483[1] and IPEM Report 103[2], but **none exist for rectangular small fields**, and detector responses in these geometries **have not been systematically quantified**[3,4].

Purpose

- This study characterized clinically relevant small-volume detectors across high-aspect-ratio rectangular fields, using a **near-perturbation-free plastic scintillation detector (PSD) as a physical reference**.

METHODS AND MATERIALS

- OPFs were measured for rectangular fields (**one jaw set to 1, 2, 3, or 4 cm; the orthogonal jaw varied from 1 to 40 cm**) on a Varian TrueBeam Edge linac at 6-MV and 10-MV FFF (Fig. 2).
- Five detectors were evaluated (Table 1), with the HYPERSCINT PSD as reference.
- OPFs were **normalized to 4 × 4 cm²**; deviations relative to the PSD were quantified, and the stem effect was assessed for the chambers.

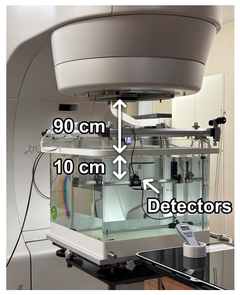

Fig. 2. Measurement geometry.

Table 1. Physical properties of the detectors used in this work.

	Type	Sensitive volume	Radius / Dimensions (mm)	Sensitive materials	Wall materials
HYPERSCINT RP-200	Plastic scintillation	0.8 mm³	0.5 / 1	Proprietary polyvinyl toluene mix	Proprietary plastic
microSilicon (60023)	Shielded silicon diode	0.03 mm³	0.75 / 0.018	p-Type silicon	RW3
microDiamond (60019)	Synthetic diamond	0.004 mm³	1.1 / 0.001	Diamond	RW3
Pinpoint 3D (31022)	Ion chamber	0.016 cm³	1.45 / 2.9	Air	PMMA, graphite
Semiflex 3D (32021)	Ion chamber	0.07 cm³	2.4 / 4.8	Air	PMMA, graphite

RESULTS

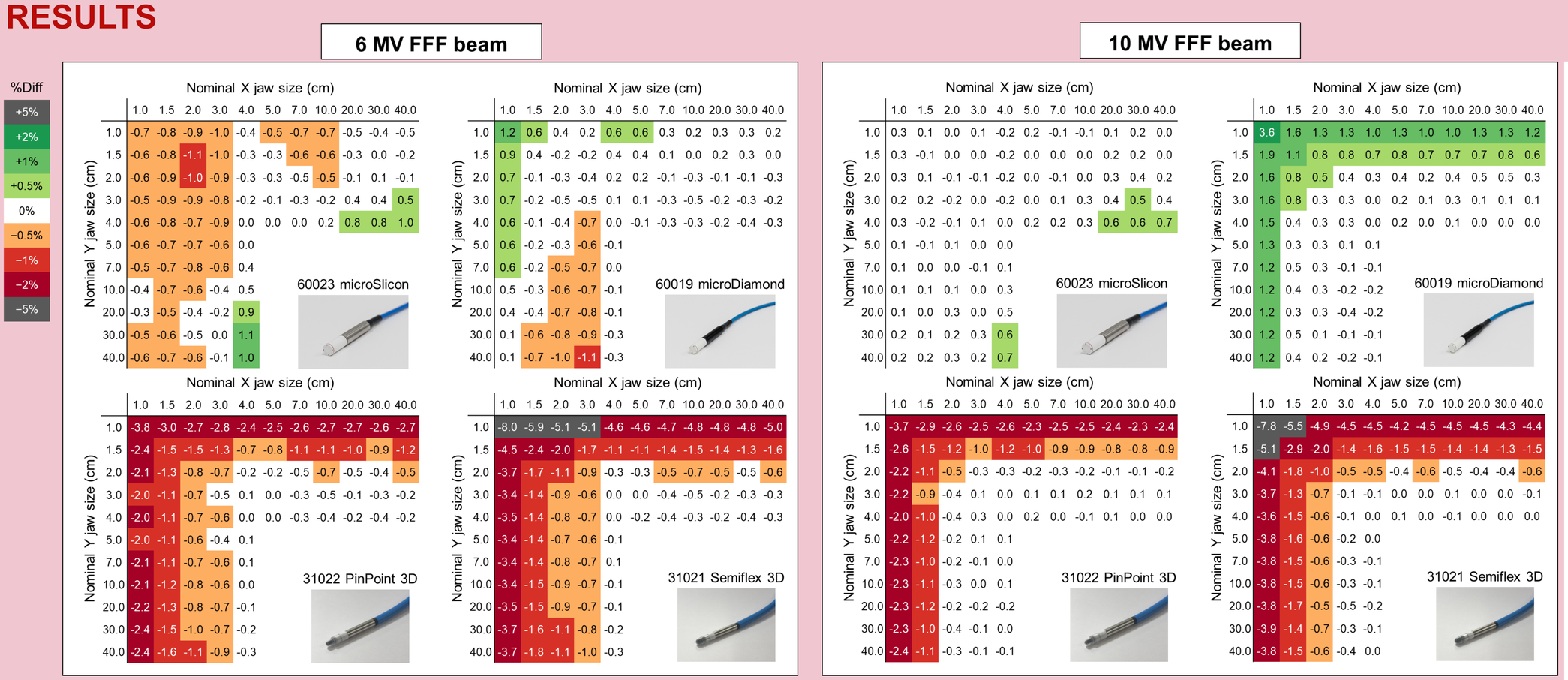

Fig. 3. Deviations of measured OPFs relative to the HYPERSCINT PSD in 6-MV and 10-MV FFF beams. Data were normalized to the 4 × 4 cm² field. For the PinPoint 3D and Semiflex 3D chambers, detector orientation was adjusted according to the field size.

- For fields **larger than 2 × 2 cm²**, all detectors agreed **within 1.1%** at both energies.
- The microSilicon diode agreed most closely with the HYPERSCINT PSD.
- The microDiamond deviated up to +3.6%.
- The PinPoint 3D chamber deviated up to −3.8%, with a stem effect of up to 1.3%.
- The Semiflex 3D chamber deviated most (−8.0%), with minimal orientation dependence (~0.2%).
- The combined standard uncertainty of the OPFs was below 0.6% (k = 1) for all detectors.

DISCUSSION

- Detector response varied with aspect ratio, reflecting sensitive volume geometry and material composition.
- The **microSilicon** stayed near-reference across all aspect ratios, indicating minimal volume-averaging and energy dependence.
- The **microDiamond** deviation at 1 × 1 cm² agreed with previous reports[5], confirming the validity of the present measurement approach.
- The **PinPoint 3D** stem effect indicates that detector orientation must be optimized for the field geometry; the **Semiflex 3D** shows an under-response that exceeds 5%, making it unsuitable without dedicated correction

CONCLUSIONS

- The **microSilicon diode** showed the highest agreement with the HYPERSCINT PSD across rectangular fields from 1 to 40 cm, **confirming its suitability for high-aspect-ratio rectangular fields**.
- Detector-specific correction data for rectangular small fields are essential for accurate TPS commissioning, as square-field correction factors alone are insufficient for non-square field configurations.

REFERENCES

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