

Characterization of a new plastic scintillator detector system for small field dosimetry

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Purpose:

Cutting-edge radiotherapy treatments (RT) require the use of increasingly smaller fields sizes. Therefore, it is essential to use detectors with appropriate collecting volumes and well understood dependence on energy, dose and dose rate.

In this work, Exradin W1 (Standard Imaging), a new plastic scintillator detector system (PSD), has been characterized and tested both in small and standard radiation fields.

Material and Methods:

The small size PSD (1 mm diameter, 3 mm length, 0.0024 cm³ sensitive volume) signal was analysed by SuperMAX (Standard Imaging) electrometer. All measurements were executed in 3D water phantom (Sun Nuclear). An Elekta Synergy Linac provided a 6 MV photon beam.

Short term stability, dose linearity and reading dependence on dose rate had been tested for 10x10 and 4x4 cm² fields.

Profiles and Percentage Depth Dose (PDD) measurements were performed for fields ranging in size from 1x1 to 25x25 cm².

Output Factors (OF) were measured for fields ranging from 0.6x0.6 to 40x40 cm².

PDD, profiles and OF results were compared to other detectors measurements with well-established commercial usage: EDGE Diode (Sun Nuclear) for small fields (up to 4x4 cm² fields) and Semiflex (PTW) ionization chamber for standard fields.

Energy dependence was analysed comparing W1 readings with measurements performed with a calibrated ionization farmer-type chamber (Exradin A19) for 6, 10, 15 MV photon beams.

Results:

W1 short term measurements showed a good stability: standard deviations are 0.5 % and 0.2 % for 10x10 and 4x4 cm² fields respectively.

PSD dose linearity has been verified ($r_2 \approx 1$); dose rate readings from 37 to 700 MU/min showed a 1% maximum variation for both analysed fields.

Profiles obtained by PSD are in agreement with those scanned by EDGE diode with 0.4 mm maximum penumbra variation for 1x1 cm² field; the comparison with profiles scanned by the Semiflex ionization chamber (IC) shows a 1.7 mm maximum penumbra difference for 25x25 cm² field.

W1 Full Width at Half Maximum (FWHM) measurements had a maximum difference of 0.3 mm for 1x1 cm² field scanned with EDGE diode and 0.2 mm for 25x25 cm² field obtained with IC.

For small fields, PDD measurements performed with PSD exhibit a 2% maximum difference in the fall-off region in comparison with EDGE diode (fig. 1a).

For standard fields, the comparison between PSD and IC showed a 1.9% maximum discrepancy.

OF values (fig. 1b), evaluated by W1 PSD and compared to those acquired by diode and IC, showed mean differences of 1.7% and 0.5% respectively.

W1 readings dependence on photon beam energy is within 1.7%.

Conclusion:

As suggested by the results obtained, W1 PSD could be used in relative dosimetry for all fields sizes (0.6x0.6 to 40x40 cm²). We think this scintillator could constitute a valid detector for small fields dosimetry.

Keywords:

Plastic scintillation detector, small-field dosimetry, output factors.