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Comparison of a novel Schottky diamond diode with reference detectors for dosimetry of flattening filter free beams

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Purpose: The aim of this work is to investigate the characteristics of a novel synthetic single crystal diamond detector (SCDD) under irradiation in Flattening Filter Free (FFF) photon beams. FFF beams show peculiar dosimetric properties, due to the absence of the flattening filter in the treatment head, arising interest from a clinical point of view thanks to the characteristic dose delivery and reduced treatment times. The most important differences with conventional beams are the bell shaped profile, the increased dose rate and dose per pulse, reduced leakage and out-of-field dose and a softer spectral distribution. The high dose rate achievable with FFF beams (up to 24 Gy/min for the 10MV FFF beam) makes of particular interest to study the SCDD response.

Materials and Methods: The properties of the SCDD, developed at "Tor Vergata" Rome University, were evaluated in comparison with a p-type silicon diode (PFD-3G Scanditronix Wellhöfer) and an ionization chamber (CC13 Scanditronix Wellhöfer). Measurements were performed in a Varian True Beam STX accelerator unit for square field sizes ranging from 1 x 1 cm^2 to 40 x 40 cm^2. Output factors, lateral field profiles, and percentage depth dose profiles were acquired; linearity with dose and dose rate dependence were evaluated too. The diamond device was operated at zero bias voltage under irradiation with 6MV FFF and 10MV FFF beams.

Results: Percentage depth dose curves obtained with the diamond detector are in good agreement within the experimental uncertainties with the ones from the other dosimeters for both energies. Lateral beam profile measurements show a good accordance with the silicon diode profiles down to the 2 x 2 cm^2 field when acquiring the signal with the detector axis parallel to the beam axis. For smaller field sizes , lower penumbra values can be obtained with the SCDD positioned horizontally (i.e. detector axis orthogonal to beam axis, Fig.1). The spatial resolution of the SCDD is then confirmed to be comparable to that of the silicon diode. The SCDD dose linearity was tested from 5MU to 2500MU (~0.04-23 Gy) observing a relative deviation between experimental and fitted data less than 0.5% for all data, except a 1% for the 6FFF at 5MU (Fig. 2). The dose rate dependence was studied in the range 400-1400 MU/min (0.08 MU/pulse) for the 6MV FFF and 400-2400 MU/min (0.13 MU/pulse) for the 10 MV FFF. The percentage deviation of the measured charge/MU respect to the one at 400MU/min is below 0.5% for all dose rates. A good agreement can be observed in the OF measured with the SCDD and others detectors for intermediate fields. PFD overestimates OF for very large fields while CC13 underestimates for fields below 3x3cm^2 (Fig 3).

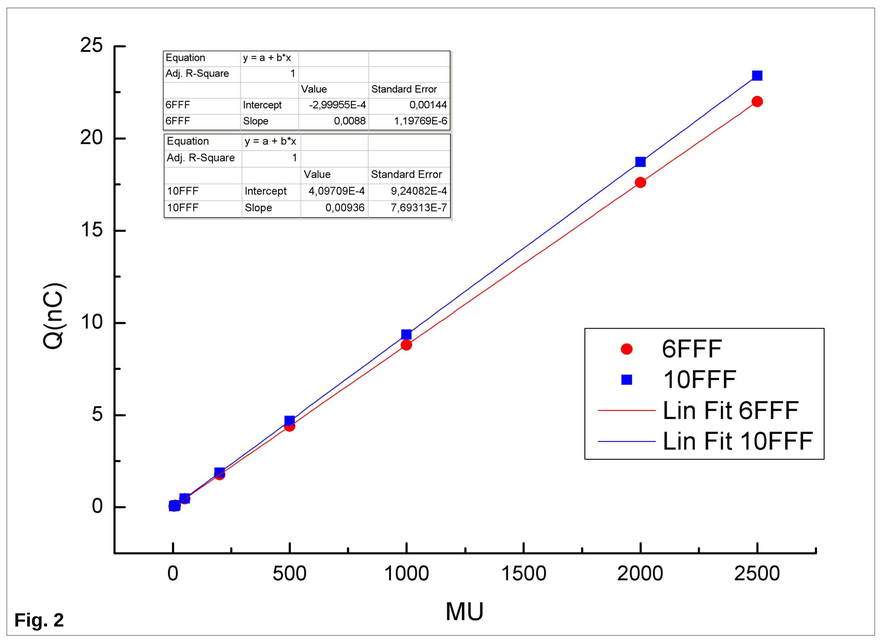

Fig. 2

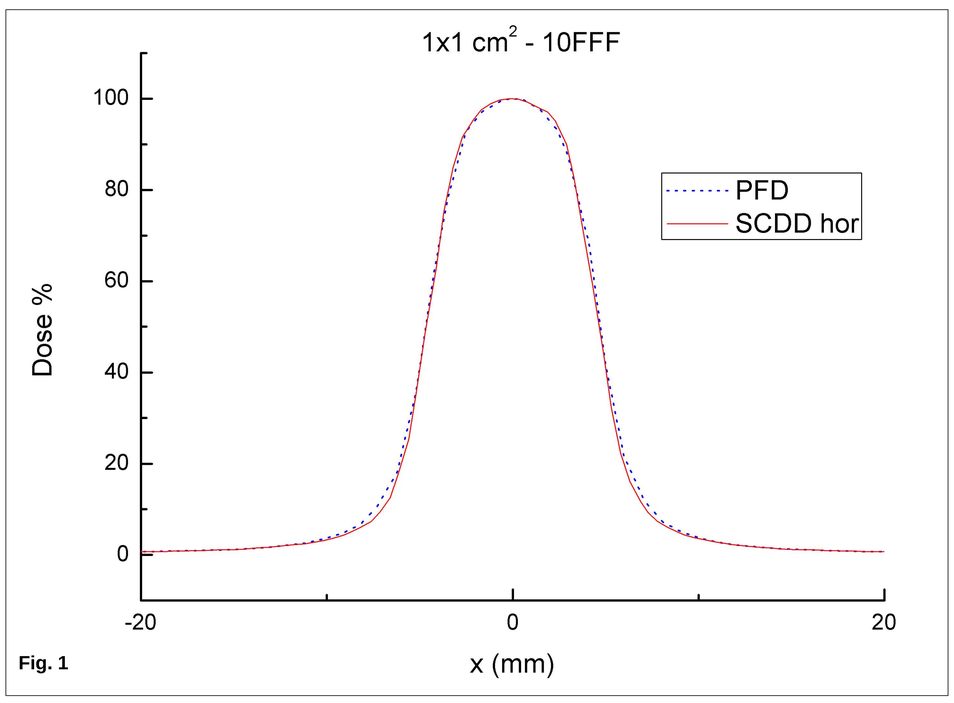

Fig. 1

Figure1: 1x1 cm^2 beam profile for 10MV FFF, a slightly lower penumbra can be noticed for horizontal SCDD.
Figure2: SCDD dose linearity measured for 6 MV and 10 MV FFF beams.
Figure3: OF measured for a 10 MV FFF beam. A good agreement can be seen for intermediate fields. Silicon diode (PFD) overestimates for very large fields and ionization chamber (CC13) underestimates below 3x3cm^2.

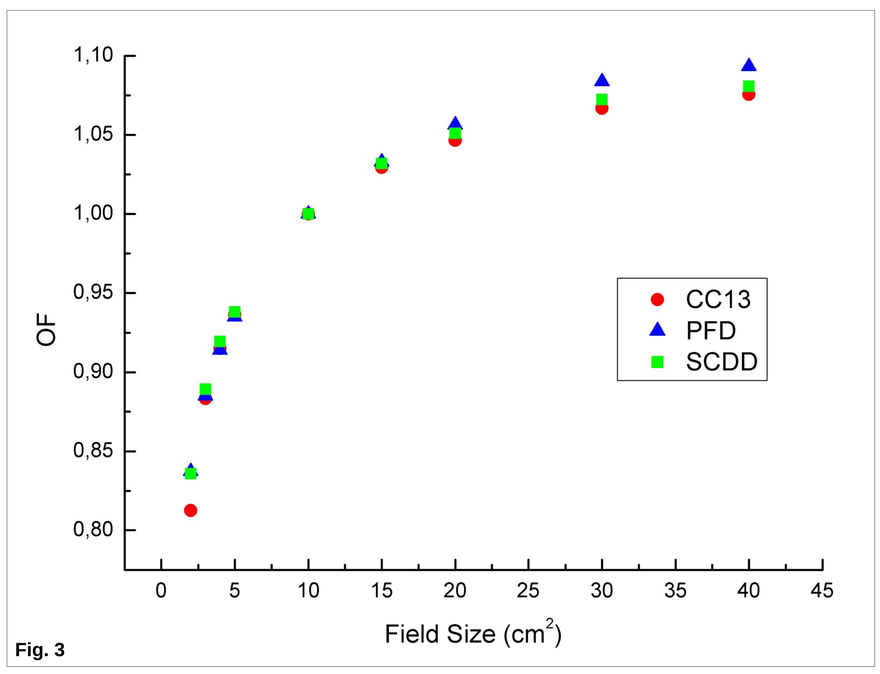

Fig. 3

Conclusions: The characteristics of this single crystal diamond diode have been studied under FFF conditions. The obtained results indicate that the investigated synthetic diamond-based detector is a suitable candidate for dosimetry in advanced radiation therapy including VMAT and IMRT with FFF beams, down to small fields.

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