Evaluation of a dense planar diode array for true composite SRS measurements

Saeed Ahmed[1,2], Geoffrey Zhang[2], Eduardo G. Moros[1,2], Vladimir Feygelman[2]

[1] Department of Physics, University of South Florida, Tampa, FL, USA

[2] H. Lee Moffitt Cancer Center and Research Institute, Tampa, FL, USA

INTRODUCTION

Stereotactic radiosurgery (SRS) is a single fraction high dose technique used for the treatment of multiple small lesions deemed to be surgically inoperable. The SRS treatments are very complex due to widely distributed targets, tight PTV conformality with steep dose gradients and non-coplanar arcs (beams). These treatments therefore, pose certain challenges for pre-treatment patient-specific dosimetric QA requiring high spatial resolution dosimeters suitable of measuring non-coplanar beams.

SRS MapCHECK (SMC) is a planar diode array (size 7.7 × 7.7 cm^2) with detector spacing of 2.5 mm intended for SRS true composite measurements. The device consists of 1013 diodes arranged in two face-to-face PCBs in such a way that the active area of the diodes are at the same plane. The SMC is used in a cylindrical head-like PMMA phantom (StereoPHAN). The depth of the diode array when installed in the phantom is 7.62 cm. The assembly can accommodate the couch angles up to ± 45°.

AIM

This study is aiming to evaluate a 2D detector array from Sun Nuclear Corp.) for SRS plan verification.

METHODS

- ***Parametric evaluation:*** SMC was installed inside the StereoPHAN phantom as shown in Figure 1, and was irradiated with a conventional 6MV and 6MVFFF beams from a Varian TrueBeam accelerator. After the array and absolute calibration of the dosimetry system performed, it was characterized for the angular dependence (axial, azimuthal and combination of gantry plus couch angles), dose rate dependence against and field size dependence against a standard detector (ion chamber or scintillator).

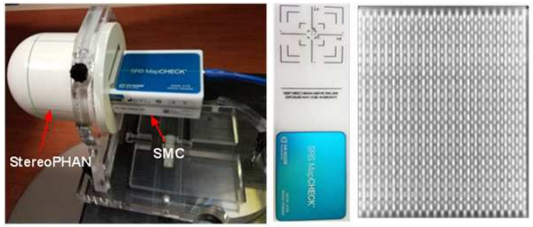


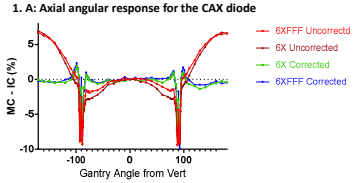
*Figure 1: **left panel:** SMC with StereoPHAN phantom**; middle panel:** SMC, and **right panel:** diode array showing the arrangement of the diodes.*

- ***SRS plan dosimetry:*** The phantom was scanned on a Big Bore scanner and two geometric plans named P1 & P2 each with 3 spherical targets were created. The maximum dimensions of the targets range from 0.5 to 1.3 cm. The targets and film were positioned in such a way that the film plane intersected at the center of each target. The isocenter was placed at the geometric center of the phantom. An additional 2cm diameter target was placed at isocenter for ion chamber normalization measurements . The Ion chamber dose was used to scale the film.
- Single isocenter VMAT plans were optimized using Pinnacle v. 14.0 with a 6MV and 6MVFFF beams thus giving four plans in total. Each plan had four arcs (2 without and 2 with couch rotation up to 30°). The dose was calculated with 2^0 control point increment and 2mm isotropic grid.
- GafChromic EBT-XD films were used for the measurements. Scanning was performed after 24h of irradiation using Epson flatbed 48 bit scanner. RIT113 v 6.6 was used. Digital Gamma analysis with 3%/1mm and 2%/2mm criteria with global error normalization and10% low dose threshold was performed at RIT.

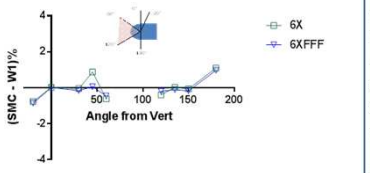
RESULTS

1. Angular response of SMC

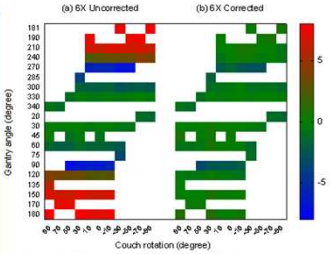
1. A: Axial angular response for the CAX diode



1. B: Azimuthal angular response for the CAX diode. The response was verified against plastic Scintillator detector. The measurements were performed for the gantry angles irradiating the electronics.



1. C: Angular response of CAX diode at 6MV for various combinations of gantry and couch angles.



1. D: Angular response of diode at CAX and selected off-axis positions at 6MV (upper row) and 6MVFFF (lower row) for various combinations of gantry and couch angles.

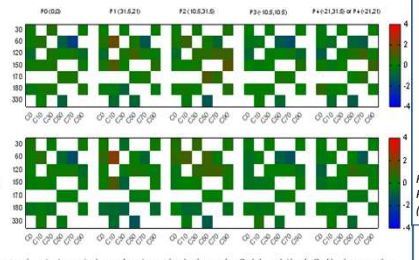
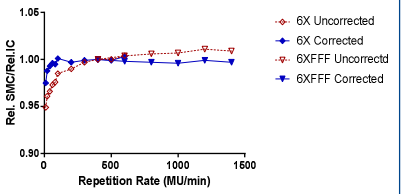


Figure 1: The percent difference of SMC response at central axis in axial and azimuthal plane (a & b), while (c&d) shows the percent differences for diodes against W1 scintillator detector at CAX and off-axis locations in the form of heat map for a range of gantry - couch combinations.

2. Dose rate dependence

Figure 2: SMC response verification against dose rate for both 6 MV and 6 MVFFF. The response was verified against the ion chamber.



3. Field size dependence

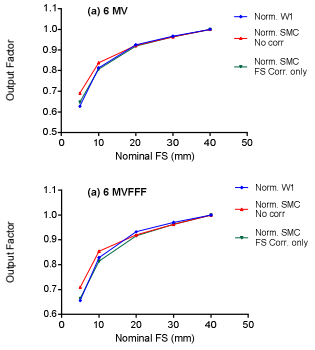


Figure 3: Verifications of field size corrections against scintillator detector; (a) 6MV; (b) 6MVFFF

4. Cross profiles

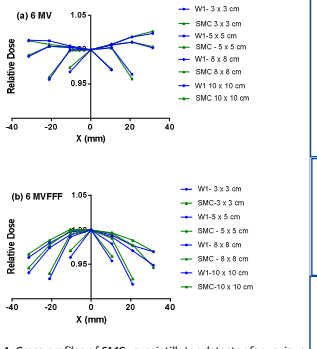
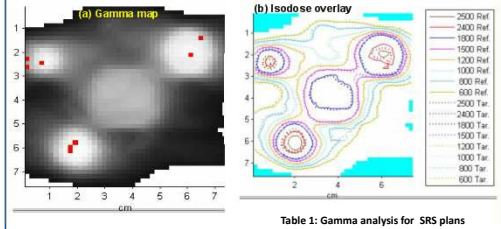


Figure 4: Cross profiles of SMC vs. scintillator detector for various field sizes. (a) 6MV; (b) 6MVFFF

5. SRS plan dosimetry



C: Profile of a 1.1 cm target

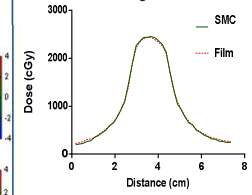


Table 1: Gamma analysis for SRS plans

Plan	SMC vs. Film	
	3%/1mm	2%/2mm
6X-P1	97.57	98.07
6X-P2	97.98	97.98
6XFFF-P1	99.51	99.21
6XFFF-P2	99.12	98.66

Figure 5: SRS dosimetry with SMC. (a) Gamma map of SMC vs. film measurements for 6XFFF-P1 at 3%G/1mm level showing 99.51% passing rate; (b) isodose overlay of the same plan; (c) horizontal profile comparison through the center of a 1.1 cm target for 6X-P1.

CONCLUSIONS

- The response of the calibrated SMC for the dependence on beam incidence angle (axial, azimuthal plane or gantry-couch combinations), dose rate and small field output factors was found in a good agreement <2% with the ion chamber and/or scintillator measurements for both energies.
- SMC exhibits common sensitivity variation when the beam is nearly parallel to the detector plane which does not meaningfully affect the composite dose.
- The average gamma analysis between SMC and film was 98.5% for both 3%/1mm and 2%/2mm gamma criteria with global normalization and 10% low dose threshold.
- Our results show that the calibration is sufficiently accurate and the device is feasible for the true composite SRS measurements.

ACKNOWLEDGEMENTS

- This work was supported in part by Sun Nuclear Corporation.

CONTACT INFORMATION

Saeed Ahmed

Email: saeedahmed@mail.usf.edu