Impact of sampling time on the performance of the Exradin W2 scintillation detector in beam profile scans

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Introduction & Background

- Plastic scintillation detectors (PSDs) are particularly advantageous for *in vivo* radiation dosimetry due to favorable characteristics such as their water-equivalence, high sensitivity, fast response time, small size, and flat energy and dose rate response.
- The Exradin W2® combined with MAX SD electrometer from Standard Imaging Inc. (Middleton, WI) is a commercial PSD system capable of use in a scanning water tank to take profile and PDD measurements as well as other scans. This is unique to this system and is the only known PSD system with this capability on the market.
- One limiting factor of the Exradin W2® is the minimum recommended sampling time required for scanning measurements. This system recommends a 1000 ms minimum sampling for all scanning measurements. In contrast, a typical scanning-type ion chamber only requires ~300 ms sampling time.
- Due to the recent commercial release of the Exradin W2® and MAX SD® electrometer system, only a small number of published articles exist. This study provides additional data to support the use of the W2® in a clinical setting as a physics tool. This study demonstrates the flexibility of the system outside the recommended parameters, allowing for increased use.

Figure 1: Exradin W2 and MAX SD electrometer system. The plastic scintillator comes in two sizes: both with 1.0 mm diameter, one 1.0 mm in length and another 3.0 mm in length.

Methods

- Measurements were performed using the Exradin W2® and MAX SD® electrometer system, the DoseView 3D water tank and corresponding software.
- **Irradiation Conditions:** 6 MV, 600 MU/min, 0.5x0.5 cm^2 and 1.0x1.0 cm^2 fields, depths of 1 cm, 5 cm, 10 cm, and 20 cm, and an SSD of 100 cm
- **Scanning Conditions:** 1 mm scan resolution, for each combination of field size and depth, scans were repeated for sampling times from 100 ms to 2000 ms
- Profiles were compared using 1-D gamma analysis to averaged reference profiles measured with the recommended 1000 ms sampling time at each corresponding field size and depth. The minimum percent dose difference (DD) and distance to agreement (DTA) criteria were determined to achieve gamma pass rates of 95% and 99% relative to the reference 1000 ms scan.

Results

- Figure 2 shows an example of the comparison plots the 1-D gamma analyses was performed on
- Figures 3 and 5 show gamma pass rates to achieve 95% and 99% reproducibilty respectively, as a function of sampling time and depth for a 0.5x0.5 cm^2 field
- Figures 4 and 6 show gamma pass rates to achieve 95% and 99% reproducibilty respectively, as a function of sampling time and depth for a 0.5x0.5 cm^2 field

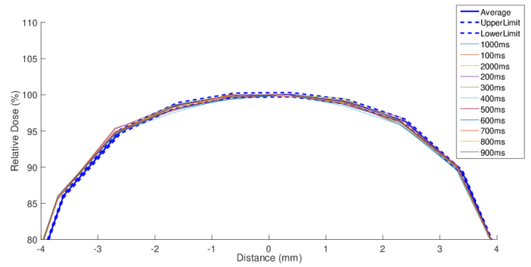

Figure 2: Reference profile vs sampling times. 1x1 cm^2 profile at 1.5 cm depth. The upper and lower limit bands are 0.3% (k=2) from the reference profile.

Sampling Time (ms)	FS: 0.5x0.5 cm^2			
	1.5cm	5cm	10cm	20cm
100	88.9	95.6	84.4	72.3
200	100.0	100.0	95.6	91.5
300	100.0	93.3	97.8	97.9
400	97.8	100.0	95.6	97.9
500	97.8	97.8	100.0	93.6
600	100.0	97.8	100.0	100.0
700	100.0	97.8	97.8	95.7
800	100.0	100.0	100.0	97.9
900	100.0	100.0	100.0	100.0
1000	100.0	100.0	100.0	100.0
2000	97.8	100.0	97.8	100.0

Figure 3: Gamma pass rate table for 0.5x0.5 cm^2 field with criteria of 0.75 mm/0.25% to reach 95% reproducibility of the 1000 ms scan.

Sampling Time (ms)	FS: 1x1 cm^2			
	1.5cm	5cm	10cm	20cm
100	91.5	93.0	78.9	96.2
200	94.4	95.8	95.8	98.1
300	100.0	98.6	97.2	100.0
400	94.4	100.0	98.6	100.0
500	100.0	100.0	100.0	100.0
600	94.4	94.4	94.4	100.0
700	100.0	100.0	100.0	100.0
800	100.0	100.0	97.2	100.0
900	97.2	97.2	97.2	100.0
1000	98.6	97.2	97.2	100.0
2000	100.0	100.0	100.0	100.0

Figure 4: Gamma pass rate table for 1.0x1.0 cm^2 field with criteria of 0.75 mm/0.25% to reach 95% reproducibility of the 1000 ms scan.

Sampling Time (ms)	FS: 0.5x0.5 cm^2			
	1.5cm	5cm	10cm	20cm
100	95.6	100.0	93.3	85.1
200	100.0	100.0	97.8	93.6
300	100.0	100.0	97.8	100.0
400	100.0	100.0	97.8	97.9
500	100.0	100.0	100.0	100.0
600	100.0	100.0	100.0	100.0
700	100.0	100.0	100.0	100.0
800	100.0	100.0	100.0	100.0
900	100.0	100.0	100.0	100.0
1000	100.0	100.0	100.0	100.0
2000	100.0	100.0	100.0	100.0

Figure 5: Gamma pass rate table for 0.5x0.5 cm^2 field with criteria of 1.0 mm/0.50% to reach 99% reproducibility of the 1000 ms scan.

Sampling Time (ms)	FS: 1x1 cm^2			
	1.5cm	5cm	10cm	20cm
100	94.4	95.8	94.4	100.0
200	98.6	98.6	98.6	100.0
300	100.0	100.0	100.0	100.0
400	98.6	100.0	100.0	100.0
500	100.0	100.0	100.0	100.0
600	100.0	98.6	100.0	100.0
700	100.0	100.0	100.0	100.0
800	100.0	100.0	100.0	100.0
900	100.0	100.0	100.0	100.0
1000	100.0	100.0	100.0	100.0
2000	100.0	100.0	100.0	100.0

Figure 6: Gamma pass rate table for 1.0x1.0 cm^2 field with criteria of 1.0 mm/0.50% to reach 99% reproducibility of the 1000 ms scan.

Conclusion & discussion

When taking small field beam profile measurements with the Exradin W2®, the sampling time can be smaller than the recommended sampling time of 1000 ms while retaining the necessary accuracy of the measurements. This is especially important when taking multiple scans to reduce overall measurement time.

- Global 1-D gamma analyses were performed to analyze the impact of sampling times on scanning beam profiles
- The depths and field sizes chosen for this study were designed to reflect the clinical usage of this detector, for applications in small field dosimetry and commissioning
- Future work can be done to enhance the robustness of this study, altering DD/DTA criteria, and acquiring more data at additional depths and field sizes
- Further development of this product to match the current standards of sampling time could result in increased clinical usage of this product

References

1. Standard Imaging Inc., "Exradin W2 Scintillator," 1418-02 datasheet, May 2019
2. Standard Imaging Technical Staff, *MAX SD Electrometer User Manual*, Standard Imaging Inc., 2019

Acknowledgements

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