# Characterization and validation of a commercial plastic scintillation detector prototype: Exradin W1 Scintillator

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## OBJECTIVE

The purpose of this work is to test a commercial plastic scintillation detector (Exradin W1 Scintillator) prototype made by Standard Imaging. The Exradin W1 Scintillator performance is compared with common clinical dosimeters. We verified the overall accuracy, precision and the capacity to resolve the scintillation signal from the contaminating Cerenkov light.

## MATERIALS AND METHODS

The sensitive volume of the Exradin W1 Scintillator is approximately 1 mm diameter by 3 mm long (0.0024 $cm^3$), and the optical output is guided to a photodiode, by a clear optical fiber. The subtraction of the Cerenkov light from the Exradin W1 measurements has been made by using the spectral discrimination method[1]. The detector was first tested by varying the dose in the same experimental conditions. The second test consisted to change the dose rate by changing the distance between the source and the detector. The Exradin W1 measurements have been compared to an Exradin A12 ion chamber. Then, output factors have been measured for photon and electron beams and compared to the ion chamber and a PTW TN 60008 diode. The measurements were made in a liquid water phantom for photon beams and in a solid water phantom for electron beams. Depth dose curves for a 6MV and 23MV photon beams, 10 by 10 $cm^2$, were measured and compared to a CC04 ion chamber. The tissue-maximum ratio (TMR) for a 6 MV photon beam, 10 by10 $cm^2$, was measured and compared to an A12 ion chamber. The last test consisted of measuring a dose profile, 10 cm field size at 10 cm of depth, using two detector orientations. The crossline orientation was tested to evaluate the validity of the spectral discrimination method. The profile was compared to a CC04 ion chamber and a TN 60008 diode.

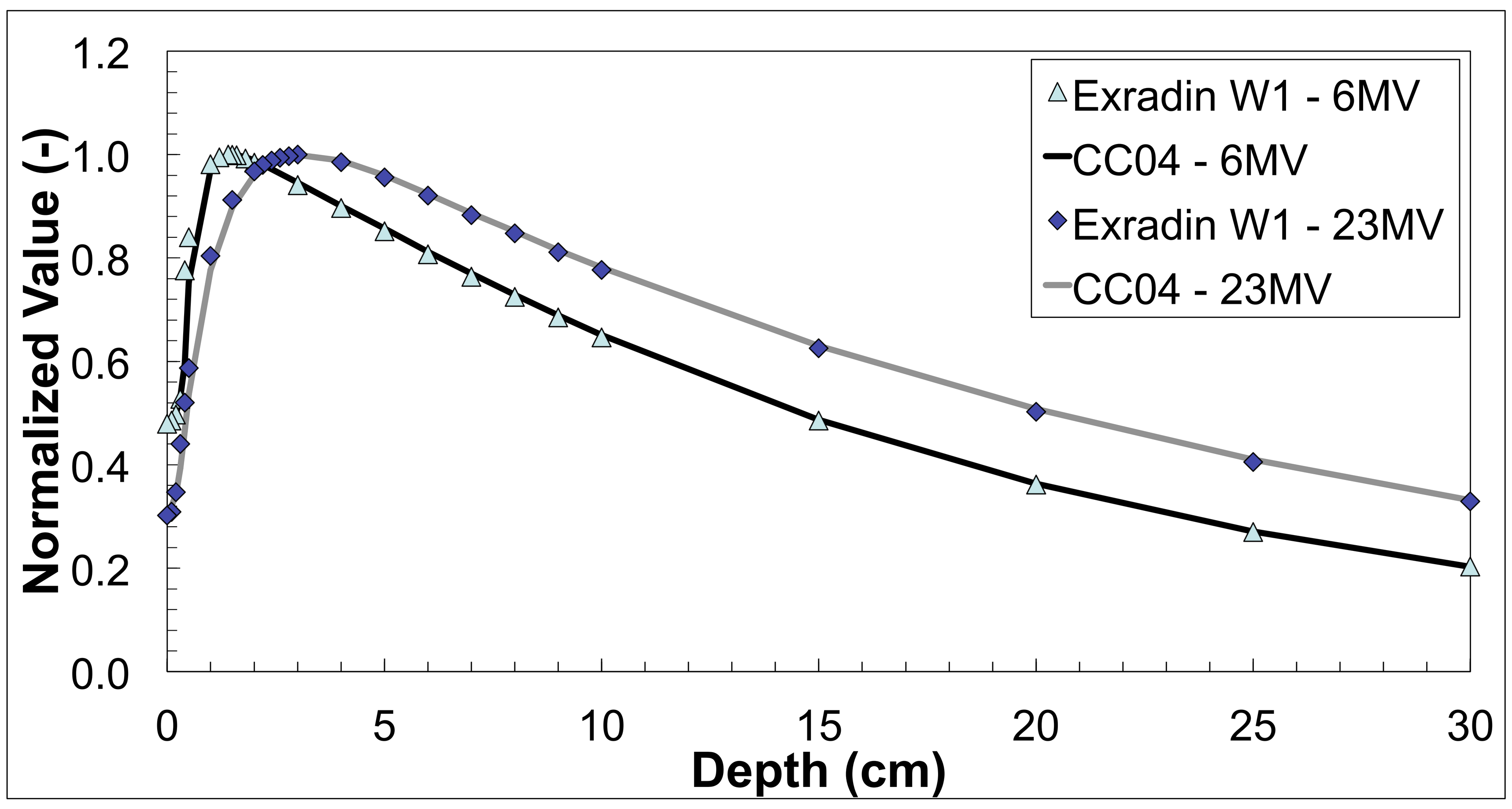


**Fig.1 –** Depth dose of a 10 by 10$cm^2$ field for 6 and 23 MV by a ion chamber CC04 and the Exradin W1 .

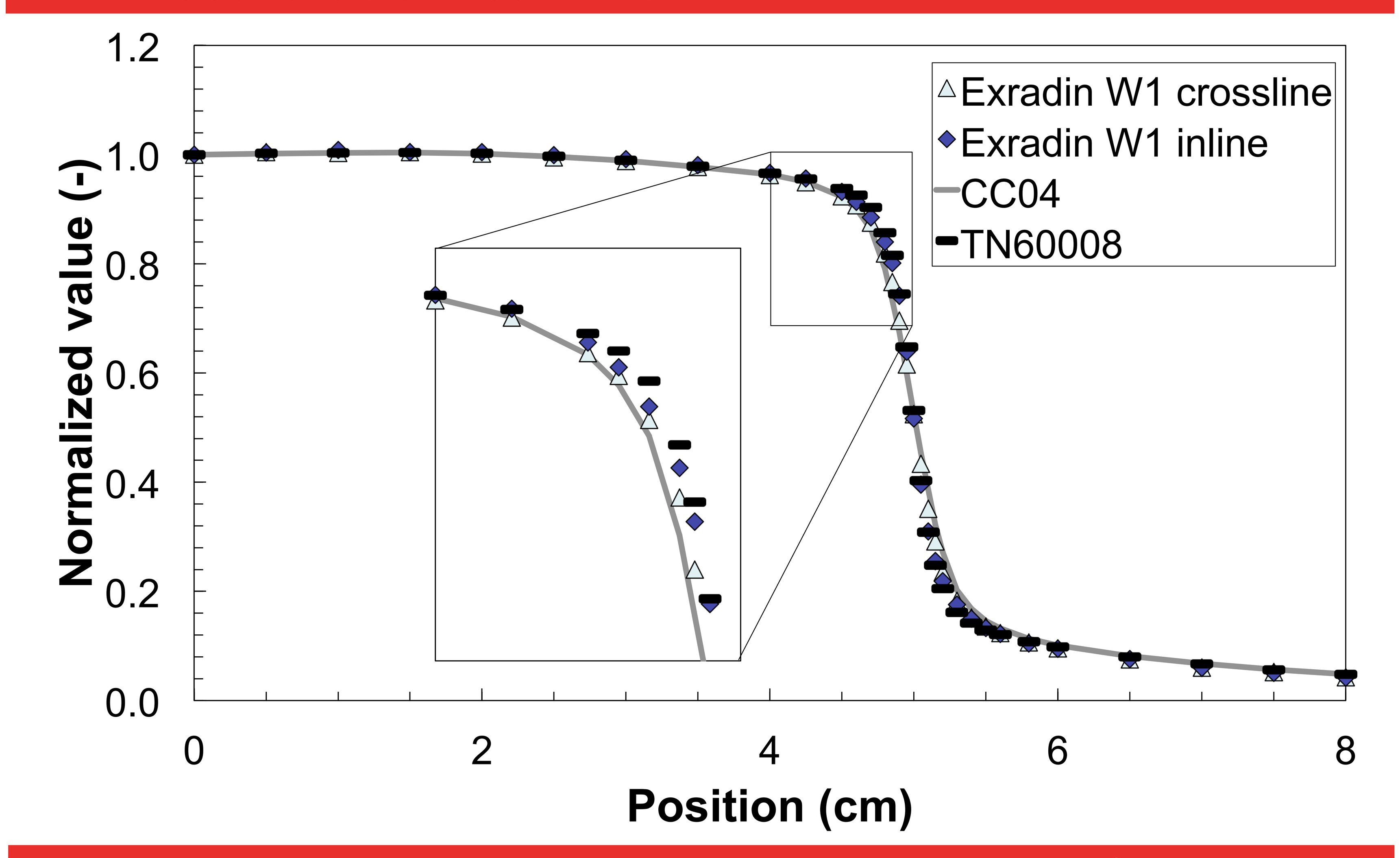


**Fig.2 –** Crossline profile measurements of a 6 MV 10x10 $cm^2$ field by an ion chamber CC04, a diode TN60008 and the Exradin W1 in two different directions: one in the crossline orientation and the other for inline orientation.

| **Field size** (cm) | **Ion chamber CC04** | **Diode TN60008** | **Exradin W1** |
|---|---|---|---|
| *3* | 0.83 | 0.83 | 0.85 |
| *4* | 0.86 | 0.86 | 0.88 |
| *5* | 0.89 | 0.89 | 0.91 |
| *10* | 1.00 | 1.00 | 1.00 |
| *15* | 1.06 | 1.06 | 1.06 |
| *20* | 1.10 | 1.11 | 1.10 |

**Table 1-** Output factors by an ion chamber CC04, a diode TN60008 and the PSD prototype for a **6 MV photon beam**.

| **Field size** (cm) | **Ion chamber A12** | **Exradin W1** |
|---|---|---|
| *5* | 0.99 | 0.99 |
| *10* | 1.00 | 1.00 |
| *15* | 0.98 | 0.98 |
| *20* | 0.96 | 0.96 |
| *25* | 0.93 | 0.93 |

**Table 2-** Output factors by an ion chamber A12, and the PSD prototype for a **18 MeV electron beam**.

## RESULTS

Exradin W1 Scintillator precision was excellent, and the measured standard deviation was typically below 0.4%. The detector response was linear from doses between 0.4 Gy and 10 Gy. Changes in the instantaneous dose rate of up to 100% did not affect the readings. The linearity with dose rate is excellent, the linearity coefficient ($R^2$) is 0.99 for the response of Exradin W1 compared with ion chamber response. Table 1 shows a good agreement between Exradin W1 and other clinical dosimeters. The average difference between Exradin W1 and ion chamber is 0.01%. The same difference is seen between Exradin W1 and diode. Table 2 shows a better agreement between small ion chamber and Exradin W1 for electron beam output factors. There is no significant difference between the output factor measured with the Exradin W1 and A12 ion chamber. TMR and depth dose (Fig. 1) showed differences of less than 0.2 % between Exradin W1 and ionization chamber. Fig. 2 shows a sample profile 10 cm of field size at 10cm of depth (scan in the crossline direction and two Exradin W1 orientations). Excellent agreement is seen between the Exradin W1 and the miniature ionization chamber (CC04). When the detector orientation is crossline, there is a high variation of Cerenkov light. Nevertheless, the symmetry of the measured profiles proves the effectiveness of the spectral discrimination method.

## CONCLUSIONS

Good concordance in different tests listed above between Exradin W1 Scintillator and different dosimeter validated the value acquired by Exradin W1 as part of test QA. Besides, the symmetry of profile in a situation of strong variation of Cerenkov light validates the method of subtraction of Cerenkov light. Also, a linear dependency between the dose rate and the value acquired by the Exradin W1 was shown.

U.S. Patent Serial No. 20090236510

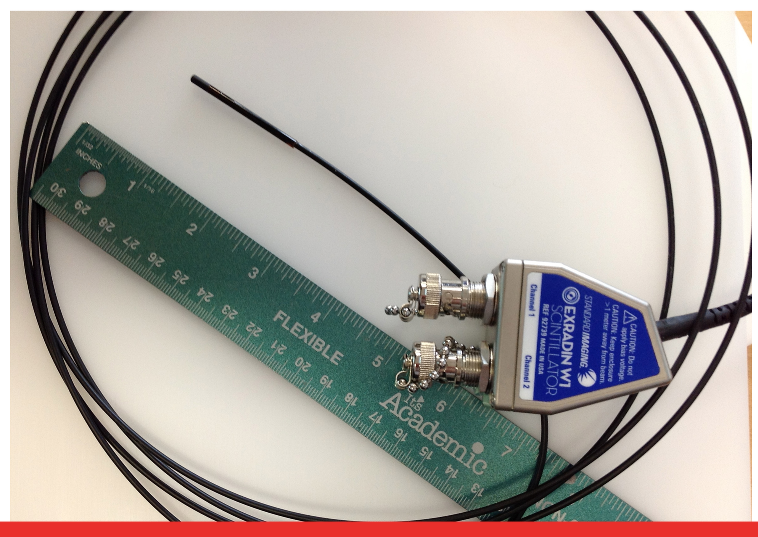

**Fig.3 –** Picture of Exradin W1 Scintillator

## REFERENCES

[1] M.Guillot, L.Gingras, L.Archambault, S.Beddar, L.Beaulieu *"Spectral method for the correction of the Cerenkov light effect in plastic scintillation detectors: A comparison study of calibration procedures and validation in Cerenkov light-dominated situations"* Med. Phys. 38, 2140-2150 (2011)

Thursday, 10 May 2012

Poster number: E31-1099

## ACKNOWLEDGEMENTS

This work has been supported in part by SBIR grant # 1R43 CA153824-01

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