

Small-field Beam Modeling In Halcyon: Findings on Output Factors and Beam Scanning Profiles

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INTRODUCTION

Small field dosimetry plays a crucial role in ensuring accurate dose delivery in modern radiotherapy, particularly for advanced treatment systems like the Halcyon™ (Varian Medical Systems, Inc., Palo Alto, CA). While Halcyon is designed for streamlined, high-efficiency treatments with a jawless, dual-layer multileaf collimator (MLC) system, its small field dosimetry characteristics remain an area requiring further investigation.

AIM

To investigate the accuracy of small field dosimetry compared to treatment planning system (TPS) beam modeling on a Halcyon.

METHOD

Output factors (OF) and beam scanning profiles are acquired on a Halcyon with PTW 60019 microDiamond (active volume 0.004cc) and PTW 31010 Semiflex (active volume 0.125cc) in a PTWBEAMSCAN water phantom (PTW Dosimetry, Germany).

OF is measured at 95cm Source-to-surface distance (SSD) and 5cm depth and 90cm SSD and 10 cm depth. OF is daisy chained at 4cm x 4cm field size.

The profiles are measured at 90cm SSD and multiple depths (1.3, 5, 10, 20, 30cm). Dose calculation algorithms used are Eclipse v 15.6 with Acuros XB (AXB) algorithm v 15.6.06 and anisotropic analytical algorithm (AAA) v 15.6.06.

RESULTS

The measured OF agreed well with Varian's published measurement data, which is in the TPS beam configuration, with a maximum deviation of 1.24% for 1cm(Y) x 2cm(X) for SSD 90cm, 1.18% for 2cm(Y) x 2cm(X) for SSD 95cm. The TPS calculated OF showed a larger difference for small fields of Y < 2cm. At 95cm SSD, measured OF to AAA agreement for Y=1cm is between 1.92% (1cm (Y) x 1cm (X)) to 2.89% (1cm(Y) x 6cm (X)); measured OF to AXB agreement for Y=1cm is between 1.43% (1cm (Y) x 1cm (X)) to 3.86% (1cm (Y) x 2cm (X)). At 90cm SSD, measured OF to AAA agreement for Y=1cm is between 2.55% (1cm (Y) x 1cm (X)) to 3.46% (1cm (Y) x 4cm (X)); measured OF to AXB agreement for Y=1cm is between 2.23% (1cm (Y) x 1cm (X)) to 3.13% (1cm (Y) x 2cm (X)).

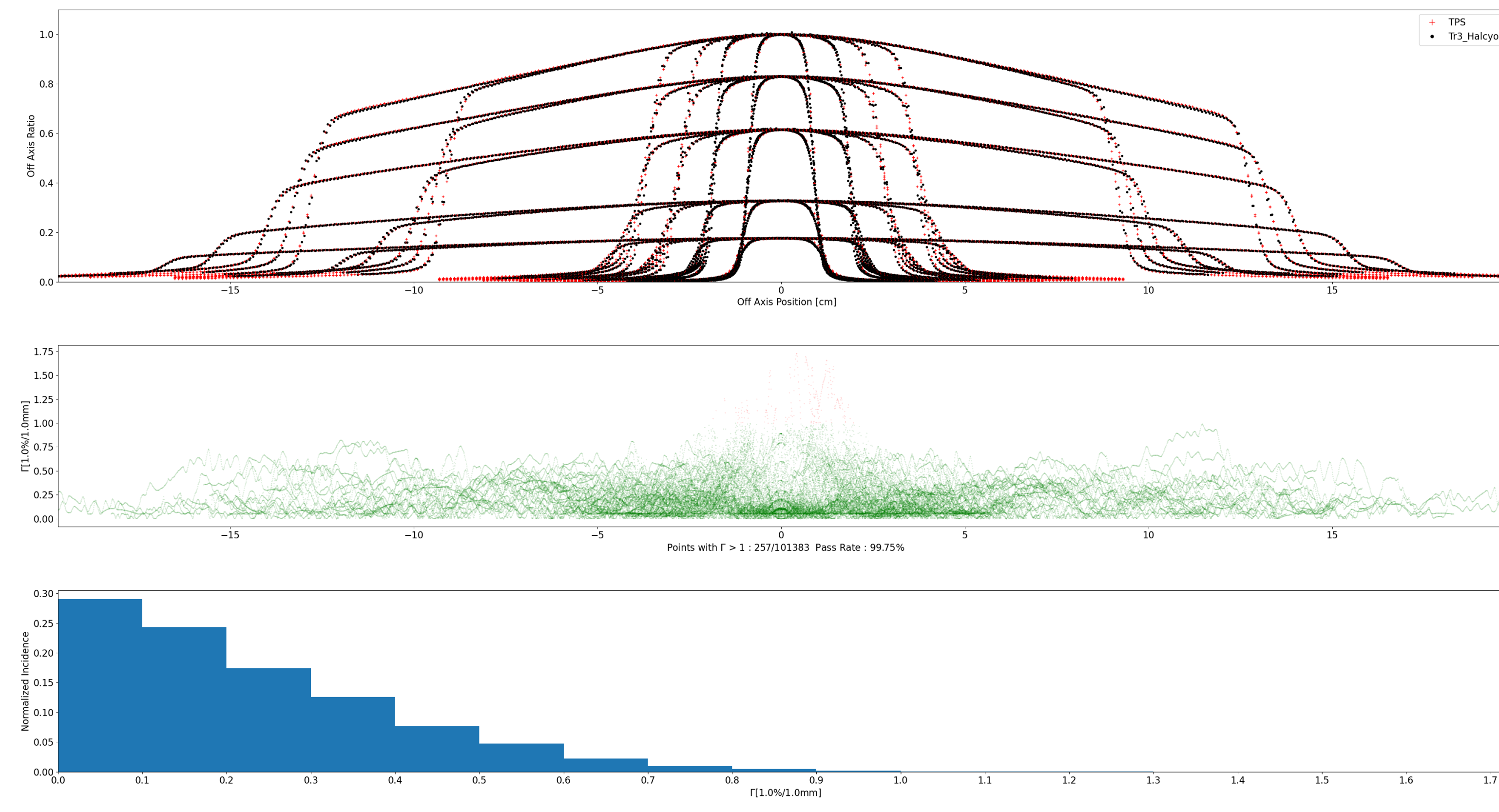


Figure 1. Inline and cross-line scanned profile compared to TPS calculated data. The profiles' overall gamma passing rate for 1% and 1mm criteria is 99.75% where inline penumbra showed the largest difference compared to TPS.

		% diff Daisy Chained Measurement vs Varian Gold Data											
		Field size X(cm)											
		1	2	4	6	8	10	14	20	24	28		
Field size Y(cm)	1	0.86	1.24	1.08	0.94	0.80	0.93	0.79	0.66	0.66	0.66		
	2	0.66	0.62	0.60	0.59	0.71	0.70	0.70	0.70	0.69	0.69		
	4	0.78	0.60	0.23	0.33	0.33	0.22	0.32	0.21	0.11	0.21		
	6	0.78	0.47	0.33	0.11	0.11	0.10	0.00	0.10	0.00	0.10		
	8	0.77	0.35	0.44	0.32	0.10	0.00	0.00	0.00	0.00	-0.10		
	10	0.51	0.35	0.43	0.31	0.10	0.00	0.00	0.00	0.00	0.00		
	14	0.38	0.35	0.43	0.31	0.10	0.10	0.10	0.00	0.09	0.00		
	20	0.51	0.23	0.53	0.41	0.10	0.10	0.09	0.09	0.00	0.09		
	24	0.25	0.35	0.43	0.41	0.10	0.19	0.09	0.09	0.09	0.27		
	28	0.25	0.46	0.53	0.41	0.39	0.19	0.19	0.09	0.09	0.18		

		% diff Daisy Chained Measurement vs TPS-AAA											
		Field size X(cm)											
		1	2	4	6	8	10	14	20	24	28		
Field size Y(cm)	1	2.55	3.42	3.46	3.39	3.34	3.40	3.33	3.24	3.19	3.19		
	2	1.14	1.35	1.41	1.48	1.54	1.52	1.55	1.54	1.66	1.58		
	4	0.74	0.79	0.24	0.40	0.47	0.38	0.44	0.38	0.39	0.38		
	6	0.72	0.67	0.33	0.10	0.12	0.20	0.11	0.20	0.20	0.23		
	8	0.75	0.58	0.33	0.32	0.16	0.02	0.02	0.11	0.09	0.02		
	10	0.51	0.48	0.39	0.27	0.14	0.00	0.05	0.01	0.05	0.08		
	14	0.38	0.51	0.35	0.29	0.11	0.05	0.04	0.04	0.10	0.03		
	20	0.43	0.40	0.40	0.30	0.07	0.10	0.05	0.07	0.08	0.09		
	24	0.33	0.46	0.29	0.33	0.11	0.15	0.07	0.13	0.27	0.33		
	28	0.25	0.57	0.37	0.38	0.30	0.10	0.13	0.09	0.19	0.21		

		% diff Daisy Chained Measurement vs TPS-AXB (%)											
		Field size X(cm)											
		1	2	4	6	8	10	14	20	24	28		
Field size Y(cm)	1	2.23	3.13	3.05	2.99	2.93	3.03	2.97	2.87	2.85	2.84		
	2	1.28	1.51	1.57	1.55	1.59	1.53	1.52	1.47	1.57	1.48		
	4	0.90	0.90	0.56	0.70	0.74	0.64	0.66	0.48	0.47	0.43		
	6	0.84	0.78	0.63	0.26	0.31	0.35	0.26	0.26	0.24	0.23		
	8	0.87	0.64	0.59	0.48	0.21	0.10	0.06	0.06	0.01	-0.08		
	10	0.65	0.49	0.65	0.38	0.21	0.00	0.08	-0.02	0.00	0.01		
	14	0.62	0.48	0.56	0.39	0.13	0.08	0.02	0.02	0.07	-0.03		
	20	0.70	0.36	0.54	0.40	0.03	0.06	0.03	-0.01	0.06	0.07		
	24	0.59	0.41	0.37	0.41	0.04	0.09	0.05	0.12	0.22	0.34		
	28	0.50	0.52	0.39	0.42	0.22	0.02	0.09	0.07	0.21	0.18		

Table1. Output factors for SSD 90 cm. The measured output factor is compared with Varian golden data and TPS calculated data.

		% diff Daisy Chained Measurement vs Varian Gold Data											
		Field size X(cm)											
		1	2	4	6	8	10	14	20	24	28		
Field size Y(cm)	1	-0.74	0.04	0.03	0.03	-0.09	-0.09	-0.09	-0.22	-0.09	-0.09		
	2	-0.09	1.18	0.69	0.68	0.56	0.56	0.67	0.56	0.56	0.67		
	4	0.02	0.35	0.33	0.10	0.10	-0.11	-0.01	-0.11	-0.11	-0.11		
	6	0.02	0.45	0.10	0.10	-0.21	-0.10	-0.10	-0.20	-0.30	-0.20		
	8	0.02	0.34	-0.11	-0.21	0.00	-0.20	-0.20	-0.30	-0.30	-0.20		
	10	0.02	0.56	0.10	0.00	0.00	0.00	-0.10	-0.10	0.00	0.10		
	14	-0.10	0.45	0.10	0.10	-0.10	-0.10	-0.10	-0.10	-0.19	0.00		
	20	-0.10	0.45	0.10	0.10	0.00	0.00	-0.10	-0.10	-0.09	0.09		
	24	0.02	0.45	0.10	0.00	-0.10	-0.10	-0.10	-0.09	-0.09	0.00		
	28	-0.10	0.45	-0.01	0.10	0.00	0.00	0.10	0.00	0.00	-0.09		

		% diff Daisy Chained Measurement vs TPS-AAA											
		Field size X(cm)											
		1	2	4	6	8	10	14	20	24	28		
Field size Y(cm)	1	1.92	2.83	2.86	2.89	2.73	2.77	2.81	2.54	2.65	2.67		
	2	0.70	1.12	1.21	1.23	1.23	1.18	1.31	1.23	1.27	1.34		
	4	0.32	0.50	0.05	0.22	0.26	0.22	0.26	0.17	0.26	0.21		
	6	0.41	0.47	0.15	0.11	0.12	0.17	0.15	0.12	0.15	0.16		
	8	0.36	0.44	0.25	0.22	0.09	0.05	0.06	0.05	0.10	0.04		
	10	0.24	0.43	0.25	0.25	0.16	0.00	-0.02	-0.04	0.10	0.06		
	14	-0.01	0.35	0.20	0.24	0.06	0.00	-1.07	-0.02	0.01	-0.01		
	20	0.00	0.29	0.22	0.25	0.13	0.06	-0.01	-0.06	0.08	0.09		
	24	0.05	0.39	0.21	0.21	0.14	0.12	0.08	0.14	0.15	0.14		
	28	-0.01	0.42	0.13	0.23	0.14	0.09	0.10	0.10	0.19	0.07		

		% diff Daisy Chained Measurement vs TPS-AXB (%)											
		Field size X(cm)											
		1	2	4	6	8	10	14	20	24	28		
Field size Y(cm)	1	1.43	3.86	3.44	3.25	2.96	2.95	2.91	2.58	2.71	2.72		
	2	2.06	0.71	2.27	2.06	2.00	1.88	1.97	1.84	1.87	1.93		
	4	1.36	1.55	-0.36	0.62	0.58	0.46	0.46	0.26	0.32	0.24		
	6	1.19	1.42	0.53	0.26	0.24	0.20	0.15	0.04	0.06	0.04		
	8	1.00	1.33	0.54	0.37	0.19	0.10	0.09	-0.01	0.03	-0.04		
	10	0.80	1.24	0.47	0.32	0.25	0.00	-0.02	-0.13	0.01	-0.03		
	14	0.56	1.11	0.41	0.26	0.13	0.00	0.00	-0.08	-0.05	-0.06		
	20	0.54	0.98	0.38	0.23	0.10	-0.01	-0.07	-0.18	-0.01	0.02		
	24	0.57	1.06	0.31	0.16	0.08	0.01	0.01	0.03	0.07	0.09		
	28	0.49	1.07	0.18	0.16	0.06	-0.03	0.04	0.02	0.14	0.06		

Table2. Output factors for SSD 95cm. The measured output factor is compared with Varian golden data and TPS calculated data.

CONCLUSIONS

TPS beam modeling for the MLC needs further improvement, particularly for the tongue and groove, to achieve closer agreement with measurement data.

CONTACT INFORMATION

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