Reference Photon Dosimetry Data
for the Siemens Primus Linear Accelerator:
Preliminary Results for Depth Dose and Output Factor

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ABSTRACT

Over the years, the Radiological Physics Center (RPC) has acquired the basic dosimetry data for photon and electron beams during its on-site dosimetry review visits. Consequently, the RPC has become a unique place where one can study some standard behavior among institutions' machines of the same model and manufacturer, in terms of their basic dosimetry data (e.g., output factor, depth dose, off-axis profile, etc.). An analysis of the data indicated that photon beams from linear accelerators of the same make, model, and energy could be represented by a single reference data set within ±2%. This observation did not always hold for older machines built before 1990, nor for machines that had been altered from the manufacturer's specifications. More investigation was necessary to demonstrate the validity of this hypothesis for machines that were not included in our initial analysis. As the first step for further investigation, we chose the Siemens Primus, one of the recent model linear accelerators. Our preliminary investigation was conducted for two important dosimetry data sets, output factor and depth dose. Four sets of randomly selected RPC-verified data were analyzed for 6 and 18 MV photon beams. It was found that all the data were within ±2% of the average, which strongly supports our hypothesis.

INTRODUCTION

- **Typical *basic photon dosimetry data* collected and verified by the Radiological Physics Center (RPC) during its on-site dosimetry review include:**

   - Output factor
   - Percentage depth dose (PDD) / Tissue maximum ratio (TMR)
   - Off-axis factors (in air or in water)
   - Wedge factor

INTRODUCTION

- **The RPC has acquired significant amounts of *basic photon dosimetry data* for most common medical linear accelerators.**

- **The RPC's data can be used to investigate the existence of standard behavior (or average nature) in the *basic photon dosimetry data* for the same make, model, and energy.**

- **An analysis of the accumulated data yielded a hypothesis that photon beams from modern linear accelerators[1] of the same make, model, and energy could be represented by a single set of *reference data* within ±2%, in terms of their *basic dosimetry data*.**

1 : Most computer-controlled accelerators built and released after 1990 (e.g., Varian 600C, 2100C, Siemens Primus, etc.)

INTRODUCTION

- **Our observation did not always hold for older machines, nor for machines that had been altered from the manufacturers' specifications.**

- **Our observation, at least for photon beams, seemed to support some manufacturers' claim that they could match the dosimetry data between the machines with the same model and energy.**

- **More investigation was necessary to demonstrate the validity of our hypothesis for machines that were not included in our initial analysis.**

METHODS

- **As the 1st step for further investigation, the Siemens Primus, one of the recent model linear accelerators, was chosen.**

- **There were four sets of Primus data available, all of which were randomly selected and verified by the RPC during its on-site review.**

- **Our preliminary investigation was conducted for two important dosimetry data sets, output factor and percentage depth dose.**

- **Our investigation is still on-going and will include other *basic dosimetry data*.**

RESULTS

• **Siemens Primus 6 MV Output Factor (OF)**

Field Size	Average OF	% SD
6 x 6	0.954	0.31
10 x 10	1.000	0.00
15 x 15	1.034	0.28
20 x 20	1.056	0.32
30 x 30	1.080	0.48

No. of Data Sets = 4

RESULTS

• **Siemens Primus 18 MV Output Factor (OF)**

Field Size	Average OF	% SD
6 x 6	0.952	0.26
10 x 10	1.000	0.00
15 x 15	1.036	0.35
20 x 20	1.056	0.34
30 x 30	1.078	0.36

No. of Data Sets = 4

RESULTS

• Siemens Primus 6 MV Percentage Depth Dose (PDD)

	6 cm x 6 cm		10 cm x 10 cm		20 cm x 20 cm		30 cm x 30 cm	
	PDD	%SD	PDD	%SD	PDD	%SD	PDD	%SD
1	97.0	1.56	97.4	1.04	98.6	0.70	99.0	0.27
1.5	100.0	0.00	100.0	0.00	100.0	0.00	100.0	0.00
2	99.2	0.35	98.9	0.10	99.0	0.12	98.6	0.21
3	94.9	0.32	94.9	0.12	95.3	0.24	95.6	0.34
4	90.2	0.59	90.8	0.29	91.5	0.25	91.8	0.11
5	85.6	0.28	86.8	0.33	88.1	0.44	88.7	0.37
6	81.1	0.14	82.4	0.31	84.1	0.27	85.0	0.53
7	76.7	0.13	78.5	0.19	80.5	0.50	81.7	0.43
8	72.3	0.42	74.5	0.36	76.9	0.53	78.3	0.64
9	68.3	0.67	70.7	0.37	73.4	0.39	75.0	0.80
10	64.8	0.56	67.3	0.65	70.4	0.63	72.0	0.62
15	48.3	0.92	51.3	0.79	55.3	0.94	57.5	0.70
20	36.1	1.10	39.0	1.11	43.2	1.22	45.4	0.82
25	26.9	0.79	29.3	0.48	33.4	0.35	35.5	0.40
30	20.3	1.05	22.5	0.94	25.8	0.89	27.9	0.51

No. of Data Sets = 4

RESULTS

• **Siemens Primus 18 MV Percentage Depth Dose (PDD)**

	6 cm x 6 cm		10 cm x 10 cm		20 cm x 20 cm		30 cm x 30 cm	
	PDD	%SD	PDD	%SD	PDD	%SD	PDD	%SD
2	95.5	0.30	96.4	1.10	99.1	1.36	100.4	1.13
3.5	100.0	0.00	100.0	0.00	100.0	0.00	100.0	0.00
4	98.9	0.07	98.7	0.00	98.3	0.36	98.0	0.72
5	95.7	0.49	95.5	0.23	95.1	0.34	94.8	0.53
6	91.7	0.15	91.9	0.08	91.7	0.39	91.6	0.70
7	87.9	0.32	88.2	0.16	88.4	0.08	88.4	0.72
8	84.3	0.42	84.8	0.08	85.2	0.08	85.3	0.66
9	80.6	0.35	81.4	0.26	82.0	0.26	82.3	0.60
10	77.2	0.41	78.1	0.17	79.0	0.35	79.4	0.25
15	61.9	0.46	63.3	0.15	65.1	0.26	65.8	0.38
20	49.6	0.45	51.2	0.16	53.6	0.38	54.5	0.38
25	39.7	0.18	41.4	0.00	43.8	0.32	45.1	0.47
30	31.9	0.44	33.6	0.21	35.9	0.00	37.1	0.38

No. of Data Sets = 4

Summary

- Our preliminary investigation showed that all the data were within ±2% of the average.

- The results presented here strongly support our hypothesis.

- More investigation is on-going to test the validity of our hypothesis for most modern machines.

- If a series of well-established *reference dosimetry data* becomes available, physicists may perform spot-checking of their dosimetry data using *reference dosimetry data*, instead of performing full commissioning of the beams.