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INTRODUCTION

Monitoring the beam energy of a photon beam is part of a routine QA program¹. In order to establish meaningful tolerances for a given method it is important to know how sensitive it is to actual energy changes.

AIM

To evaluate the sensitivity of different methods of measuring photon beam energy.

METHOD

- Baseline scans for beam energy of a 6MV beam on an Elekta Versa HD accelerator were obtained using five methods.
 - PTW Beamscan 3D scanner with PTW Semiflex 3D ionization chamber
 - Daily QA3 (SunNuclear)
 - IC Profiler (SunNuclear)
 - PTW Farmer Chamber in plastic water
 - IQM transmission detector (IRT Systems)
- Depth dose and profile scans at 90cm SSD were measured using a PTW Beamscan 3D scanner with a PTW Semiflex 3D ionization chamber.
- Measurements were then made using the Daily QA3, IC Profiler, a PTW Farmer chamber in plastic water, and the IQM transmission detector.
- The beam energy was then adjusted by approximately 0.5% and 1.0% and then back to the baseline energy making a total of 4 sets of measurements.
- Percent Depth Dose (PDD) at 10cm and 20cm depth was measured with 10x10cm²
- Off-Axis Ratio (OAR) was measured with 30x30cm² field size
- For the Daily QA3 only energy was evaluated
- For the IC Profiler, energy wedge was used to evaluate the energy. The OAR was evaluated as well.
- For the IQM, 30x30cm² and 2x2cm² were measured to get the ratio.
- For the farmer chamber in plastic water, the energy was evaluated using the ratio of measurement in depth of 5cm to 10cm and 15cm.

RESULTS

- PDD₁₀ was 66.17, 66.64, 67.05, and 65.96 after return to baseline.
 - This shows that setting the same values on the linac did not return the energy exactly to baseline. This was confirmed by all of the methods.
- PDD₂₀ was 37.85, 38.48, 39.02, and 37.9.
- The maximum Off-Axis-Ratio in the water tank was 1.040, 1.018, 1.005, and 1.039.
- The energy percentage from the Daily QA3 device was 2.52, 8.99, 15.77, and 2.23. These are percent difference from the baseline.
- The maximum OAR from the IC Profiler was 1.036, 1.022, 1.009, and 1.035.
- The energy from the IC Profiler using the energy wedge was 69.74, 70.01, 70.62, and 70.02.
- The ratio of ionization chamber readings in the plastic water at 10cm and 5cm depth was 0.848, 0.85, 0.852, and 0.847.
- For 15cm and 5cm depth, it was 0.705, 0.709, 0.714, and 0.703.
- Using the ratio of the 30x30cm² and 2x2cm² field readings for the IQM device, the values were 154.0, 150.4, 146.7, and 154.7. The ratio to 5x5cm field was also measured.

CONCLUSIONS

- The sensitivity of the 5 methods in detecting the energy change of a 6MV beam was evaluated.
- There was a wide variation among them and the appropriate tolerances for each method should be set based on these findings.
- The Daily QA3 device was very sensitive to energy change and tolerances should be set appropriately.
- The IQM device was approximately twice as sensitive as the other chamber methods.

Measurement Results	Water scans				DailyQA3	IC Profiler		Solid water		IQM	
	D10cm	D20cm	D20/D10	OAR	Energy	Energy	OAR	Ratio 10/5	Ratio 15/5	Ratio 30/2	Ratio 30/5
Baseline	66.17	37.85	0.572	104	0.0252	69.74	103.6	0.848	0.705	154	32.53
~0.5%	66.64	38.48	0.577	101.8	0.0899	70.01	102.2	0.85	0.709	150.4	31.84
~1%	67.05	39.02	0.582	100.5	0.1577	70.62	100.9	0.852	0.714	146.7	31.2
Return to baseline	65.96	37.9	0.575	103.9	0.0223	70.02	103.5	0.847	0.703	154.7	32.67

Sensitivity	Water scans				DailyQA3	IC Profiler		Solid water		IQM	
	D10cm	D20cm	D20/D10	OAR	Energy	Energy	OAR	Ratio 10/5	Ratio 15/5	Ratio 30/2	Ratio 30/5
~0.5%	0.71%	1.66%	0.95%	-2.12%	256.75%	0.39%	-1.35%	0.25%	0.66%	-2.30%	-2.10%
~1%	1.33%	3.09%	1.74%	-3.37%	525.79%	1.26%	-2.61%	0.51%	1.28%	-4.70%	-4.10%
Return to baseline	-0.32%	0.13%	0.45%	-0.10%	-11.51%	0.40%	-0.10%	-0.11%	-0.23%	0.50%	0.40%

Table 1. Each measurement results including the baseline difference (top) and the sensitivity (bottom).

	Bending Coarse	Bending Fine	Gun Current	Hump Gain
Baseline	40	1.87	7.54	23.9
1st Correction (~ 0.5%)	42	1.96	7.46	23.6
2nd Correction (~ 1%)	44	2.06	7.45	23.3
Return to baseline	40	1.87	7.54	23.9

Table 2. Adjusted bending parameters

REFERENCES

- Gao S, Balter PA, Rose M, Simon WE. A comparison of methods for monitoring photon beam energy constancy. Journal of applied clinical medical physics. 2016 Nov;17(6):242-53.

CONTACT INFORMATION

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