

Validation of a 6FFF Reference Beam Model for SRS on a Varian TrueBeam linac

Johnny Morales | Ashley Cullen

Purpose

Brainlab now provides Reference Beam Models for Pencil Beam and Monte Carlo algorithms for Varian and Elekta linear accelerators. These Reference Beam Models are pre-generated for different photon source sizes. They are available in Physics Administration 6.0 and can be selected by measuring a reduced set of beam data thus helping to potentially speed up the beam data collection process during commissioning. The work presented in this poster presents the process we followed to select and validate a 6 FFF Reference Beam Model for a Varian TrueBeam linac equipped with the Millennium 120 MLC. The focus of the work was on field sizes ranging from 1.0 to 3.0 cm as required for SRS treatments.

Materials and Methods

Reduced Data Set

We measured the required reduced data set which comprised the following:

- PDDs in water at SSD of 90 for MLC field sizes of 5 × 10 mm (Jaws 8 × 12 mm) and 100 × 100 mm (Jaws 100 × 100 mm).
- X and Y profiles in water at SSD of 90 cm and 10 cm depth for MLC field sizes of 5 × 10 mm (Jaws 8 × 12 mm), 10 × 10 mm (12 × 12 mm), 100 × 100 mm (Jaws 100 × 100 mm) and 300 × 300 mm (Jaws 300 × 300 mm).
- Output factors in water at SSD of 90 cm and 10 cm depth for MLC field sizes of 5 × 10 mm (Jaws 8 × 12 mm), 10 × 10 mm (12 × 12 mm), 100 × 100 mm (Jaws 100 × 100 mm) and 300 × 300 mm (Jaws 300 × 300 mm)

The PDDs for the 5 × 10mm and the 100 x 100 mm were measured with a PTW microDiamond 60019 high-resolution detector and a PTW 31010 Semiflex ion chamber respectively. The X and Y profiles were measured with a PTW microDiamond 60019 high-resolution detector. The output factors were measured with the PTW microDiamond 30019 high-resolution detector and a PTW 31010 Semiflex chamber to comply with the TRS-483 Code of Practice for Small Field dosimetry. These results are not presented here due to reduced space. However, the results allowed us to select the Reference Beam model number 9.

Verification Data Set

Output Factors were calculated in a water phantom for a subset of small fields using the Reference Beam Model and compared to measured data using a microDiamond detector. The SSD for this comparison was 95 cm and the depth of measurement was 5cm. PDDs were also compared with measurements.

Independent verification against 3rd party 3D planning system

A plan was created for a Liam anthropomorphic head phantom (SunNuclear, USA) using the Beam Reference Model in Cranial SRS 3.0. The plan consisted of 3 ipsilateral arcs and a prescription of 12.5 Gy to 80% IDL. The target volume was 1.88 cm³ and equivalent diameter of 1.5 cm. The plan was then exported to a 3rd party 3D planning system (Eclipse, Varian, USA) and re-calculated for comparison.

Results

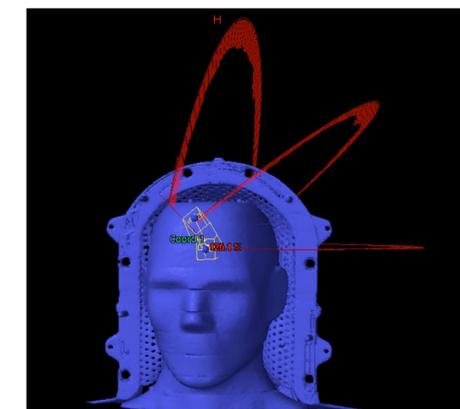
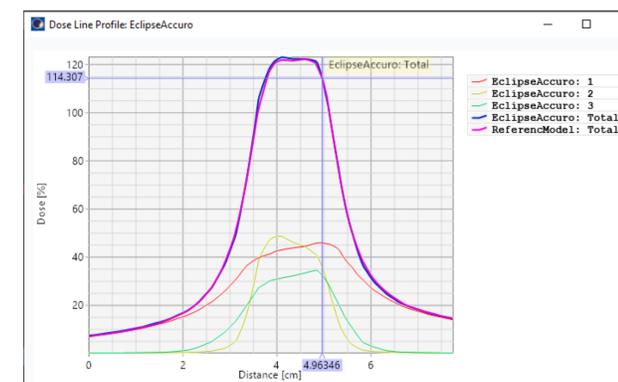
The table below shows the results for the output factor verification measurements. The agreement with measurement was within 1.3%.

Output Factors				
MLC (cm)	Jaw (cm)	Reference Model (MC)	microDiamond	% diff
10x10	10x10	1.000	1.000	0.0
1x1	3x3	0.796	0.787	1.1
1x1	2x2	0.796	0.786	1.3
2x2	3x3	0.871	0.867	0.5
3x3	4x4	0.903	0.901	0.3
4x4	5x5	0.925	0.924	0.1
5x5	6x6	0.946	0.942	0.4

The table below shows the results for the PDD verification measurements. The agreement with measurement was within 1.9%, with the best agreement observed at depth of 10 cm.

PDDs							
Depth	Reference Model (MC)			microDiamond			% diff
	3x3	2x2	1x1	3x3	2x1	1x1	
5.0	79.3	79.03	76.3	80.8	79.3	76.9	-1.9
10.0	56.6	54.86	53.2	57	55.5	53.4	-0.7
20.0	28.6	27.59	26.41	29	28.2	26.9	-1.4

The graph below shows a line plot comparing the Reference Beam model plan with the re-calculation of the same plan with the Varian Accuros XB v17.0 dose algorithm using the same CT data set, Plan and Structure sets with a dose grid resolution of 1 mm. A 3D dose gamma evaluation with a criteria of 2%/1 mm (10% threshold) produced a gamma pass rate of 98.9%. A 3D render of the treatment plan on the Liam phantom is also shown.



Conclusion

Our initial investigation demonstrates that it is possible to use one of the 10 Reference Models provided by Brainlab in Physics Administration 6.0. However, extreme care is required in verifying the Reference Model. Our next step will be to perform end-to-end testing with radiochromic film using a larger set of plans including plans with multiple targets.