MONTE CARLO MODELING OF A 4 MM CONICAL COLLIMATOR FOR A NOVALIS TX LINEAR ACCELERATOR

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Introduction

The work presented in this poster outlines the steps taken to model a 4 mm conical collimator (BrainLab, Germany) on a Novalis Tx linear accelerator (Varian, Palo Alto, USA) capable of producing a 6MV photon beam for treatment of Stereotactic Radiosurgery (SRS) patients. The verification of this model was performed by measurements in liquid water and in virtual water. The measurements involved scanning depth dose and profiles in a water tank plus measurement of output factors in virtual water using Gafchromic® EBT3 film.

Experimental methods

We used the BEAMnrc/DOSXYZnrc (NRC,Canada) package, version V4 2.3.2, to simulate the Novalis Tx linear accelerator for the 6MV SRS flattening filter. We modeled the 4 mm conical collimator (BrainLab, Germany) which is used for the treatment of trigeminal neuralgias. Measurements were performed for percentage depth dose (PDD) and output factor using PTW 60012 Dosimetry Diode (PTW, Germany) at standard conditions of 100 cm SSD and a field size of 10 × 10 cm^2. The output factor was corrected for at an intermediate field size. The diode measurement for the 4 mm conical collimators were "normalised" by the diode measurement for a 30 mm conical collimator at the same depth. The output factor for the 30 mm conical collimator with respect to the standard field of 10 x 10 cm^2, was then obtained with an ion chamber. These two values were then multiplied to obtain the "corrected" output factor for the 4 mm conical collimator by the diode. Comparison between the Monte Carlo output factor and the diode were performed. Output factors were also measured with Gafchromic® EBT3 film and compared to the Monte Carlo values. Measurements for profiles at depth were taken with new Gafchromic® EBT3 film. The film was scanned in an EPSON XL 10000 scanner at a resolution of 75 DPI in transmission mode. The software package used to analyse the film scan was RIT 113 V5 (Colorado, USA). Comparison between the Monte Carlo profiles and the Gafchromic® EBT3 film were then carried out.

Results and Discussion

Figure 1 below is a partial schematic drawing from BEAMnrc showing the lower section of the model used for this system. The lower jaws are shown in purple colour and the conical collimator assembly mount is shown in orange colour. And the conical collimator is shown in pink colour.

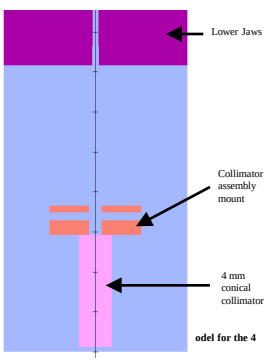
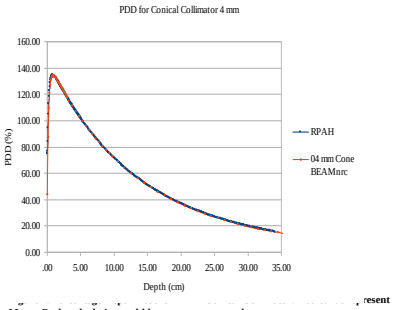


Figure 1. Schematic dr odel for the 4 mm Conical Collimato

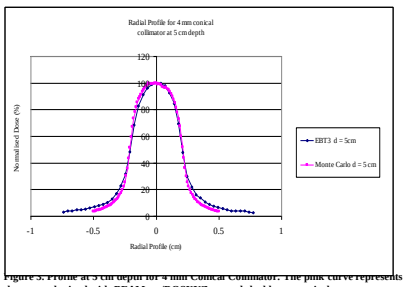
Results and Discussion

Figure 2 below shows the percentage depth dose for the 4 mm conical collimator as measured with a PTW 60012 diode and the percentage depth dose calculated with BEAMnrc/DOSXYZnrc. Both curves were normalized to a depth of 5 cm to avoid noise around the depth of dose maximum.



resent Monte Carlo calculation and blue curve represent the measurement

Figure 3 below shows the radial profile calculated with BEAMnrc/DOSXYZnrc and the profile measured with Gafchromic® EBT3 at a depth of 5 cm. Both curves were normalized to the value at the centre of the field.



the curve obtained with BEAMnrc/DOSXYZnrc and the blue curve is the measurement with Gafchromic® EBT3 film.

Table 1 below shows the output factors obtained by BEAMnrc/DOSXYZnrc, PTW 60012 diode and Gafchromic® EBT3 film. This table shows the BEAMnrc output factors for two different values of full width at half maximum parameter that can be adjusted for the incident electron beam on the target.

Table 1 Measured Output factors versus Monte Carlo calculation

Overall Comparison of Output Factors with PTW 60012 diode, Gafchromic EBT3 film and BEAMnrc/DOSXYZnrc calculation for the 4 mm conical collimator				
Depth (cm)	Gafchromic EBT3	Diode	Monte Carlo (FWHM=4 mm)	Monte Carlo (FWHM = 8mm)
1.5	0.641	0.663	0.655	0.650
5.0	0.594	0.560	0.593	0.587
10.0	0.533	0.552	0.541	0.535
20.0	0.501	0.501	0.490	0.483

Table 2 below presents the percentage difference of the output factors from Table 1 normalised to the output factors measured with the diode

Table 2 Shows the % difference between all results with respect to diode measurements

Depth (cm)	% difference with respect to Diode		
	Gafchromic EBT3	Monte Carlo (FWHM = 4 mm)	Monte Carlo (FWHM = 8 mm)
	% difference	% difference	% difference
1.5	-3.3	-1.2	-2.0
5.0	-0.8	-1.0	-2.0
10.0	-3.4	-2.0	-3.1
20.0	0.0	-2.2	-3.6

Discussion

PDD

The uncertainty for the Monte Carlo simulations was 0.5%. This is in agreement with the measurement uncertainty of 2 % for depths deeper than depth of dose maximum. This close agreement is promising and it provides confidence about the selection of energy for this model.

Profile at depth

The uncertainty for the Monte Carlo simulation was approximately 3.0% at the edges of the profiles, this area corresponds to the transmission of the conical collimator. The uncertainty of the film measurements could be up 4 %, as indicated by the manufacturer. In the region close to the peak the Monte Carlo simulations produced an uncertainty of 0.3%.

Output Factors

For the output factors, the reproducibility in the measurement of diode has been estimated to be around 1.5% (standard uncertainty) as published by Cranmer-Sargison (Cranmer-Sargison, Weston et al. 2011). For Gafchromic EBT3 film the manufacturer quotes a value of 4% uncertainty due to the in homogeneity of the film alone. Therefore the values obtained by the diode have been used for comparing all results in this study including the Monte Carlo calculations as shown in Table 2.

Conclusion

It can be concluded from these results that the Monte Carlo model with a FWHM = 4 mm, for the 4 mm conical collimator, agrees within 2.2% with the results obtained by the diodes for the measurement of the output factor and this is the model that we prefer to use. The Monte Carlo model with a FWHM = 8 mm will not be used for further calculations.

References

G.Cranmer-Sargison, S.Weston, J.A. Evans, N.P. Sidhu, D.I.Thwaites " Implementing a newly proposed Monte Carlo based small field dosimetry formalism for a comprehensive set of diode detectors" Med. Phys. 38, 6592-6602, 2011.