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Fine tuning of the collimator calibration parameters for modeling an Elekta Synergy accelerator with an Agility head in RayStation

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INTRODUCTION

Model accuracy is a critical prerequisite of treatment planning system commissioning. RayStation (RaySearch Laboratories, Stockholm, Sweden) provides a series of automated routines which facilitate the modeling process. However, these routines are designed to optimize the parameters directly related to the beam itself (e.g. energy spectrum, off-axis softening or other source properties) using open fields measurements with simple geometries. Several MLC-related parameters (transmission, tongue and groove, leaf tip width, offset and gain calibration) can, and should, also be adjusted in the model. These MLC parameters can have a major dosimetric impact for highly modulated plans[1], but are not part of the optimization routines. Moreover, the dosimetric impact of MLC parameters is difficult to assess inside the Beam commissioning module of RayStation.

AIM

A systematic method to evaluate the MLC parameters in RayStation (version 7) is presented. In this work, the purpose is to determine the MLC transmission, MLC y-position gain, tongue and groove and leaf tip width required to model the photon fluence of an Elekta Agility accelerator. Another related work by the same authors (poster PO-GeP-T-585) addresses the collimator calibration correction. A general methodology for an optimal modelling process has been described but provides no detail of the resulting parameters[2]. Another work have reported some results for a Varian Millennium[3], but to our knowledge no work have reported values specific for an Elekta Agility.

METHOD

Plans with geometries specifically designed to evaluate each MLC parameter have been created in the Beam 3D Modeling module of RayStation. These plans have also been exported to the accelerator for measurements. An initial evaluation of the results was performed with portal imaging to assess variability of measured dose distribution. The measurements were then repeated with radiochromic films inside solid water once for each energy on two matched accelerators for a more representative setup of the patient geometry. All phantom calculations and film measurements are made at SSD 90, 10 cm depth, gantry = collimator = 0°. Each analysis is performed independently for each energy. The calculated dose distributions of these plans were compared to measurements, and the model was modified until a satisfactory match was obtained. A few iterations among all four parameters (MLC transmission, MLC y-position gain, tongue and groove and leaf tip width) were necessary as their dosimetric impact is not completely independent. Dosimetric analysis were performed outside of RayStation with an in-house program.

For clarity, we refer to the “MLC transmission” the actual parameter value in the model. We simply refer to “transmission” the measured or calculated transmission for a given point on the dose distribution. In general, these numerical values are different as the latter varies depending on the measurement geometry. The geometry to evaluate the MLC transmission parameter is a half-blocked field. Both leaf banks (X1 and X2) are used alternatively to define the field, and an average transmission “T” is calculated as T=B/O, where “B” is a point representing the blocked region, and “O” the open region. An example of the field where bank X1 is closed is shown on Figure 1. The other points on the image are used to evaluate and remove background.

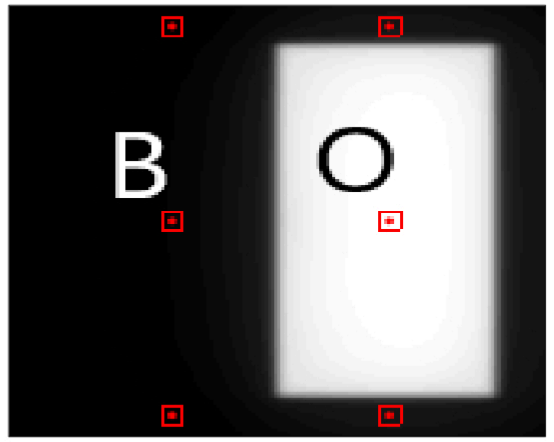

Figure 1
Dose distribution for MLC transmission

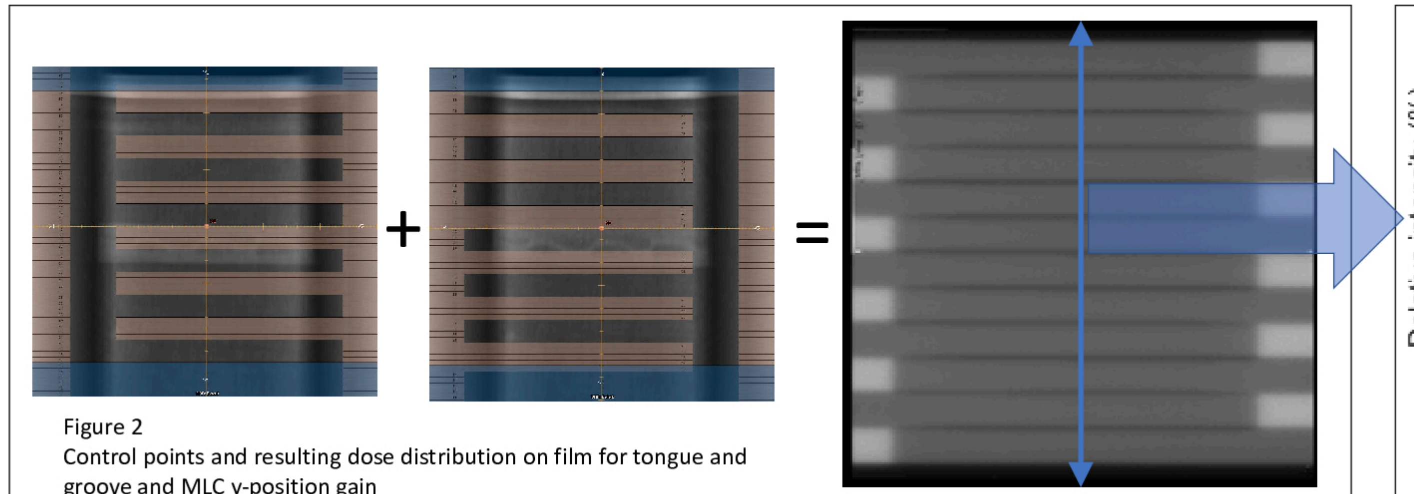

Figure 2
Control points and resulting dose distribution on film for tongue and groove and MLC y-position gain

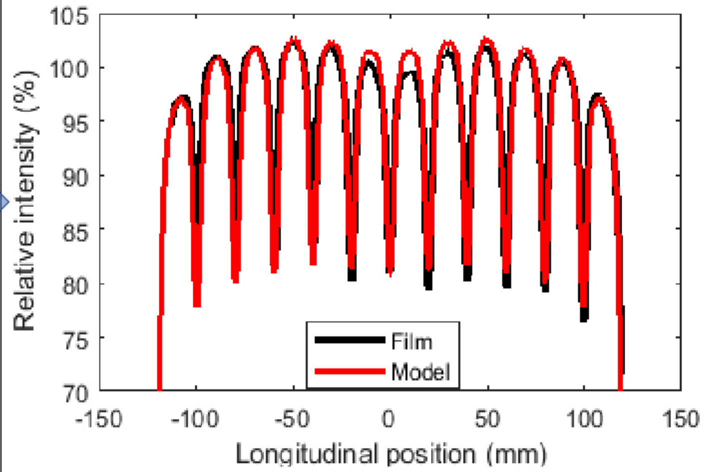

Figure 3
Dose profile for tongue and groove and MLC y-position gain

Tongue and groove and MLC y-position gain were evaluated using a unique, common field geometry (Figure 2). A field with two control points (CP) has been created. The nominal size of the field is 20 cm x 20 cm. On the first CP, 2 cm strips are closed alternately with open strips. On the second CP, the strips of closed and open leaves are interchanged. A longitudinal profile is made (Figure 3). On that profile, the horizontal axis represents the longitudinal positions of the gaps, and the vertical axis represents the relative dose, from which attenuation can be calculated. The tongue and groove parameter has a direct impact on attenuation. The MLC transmission parameter is fixed first (previous paragraph), then tongue and groove is adjusted until the average attenuation for all gaps matches with film. MLC y-position gain has a direct impact on the longitudinal position of gaps. Its value is adjusted until the positions match with film. Finally, the geometry to evaluate leaf tip is a field junction made with two abutting, half-blocked fields defined by MLC (similar to Figure 1). Leaf tip was adjusted until the relative dose at junction on the model matches with film.

RESULTS

The optimal parameters for each energy found using the method described in this work are given in the table below. Although all these are “effective parameters”, i.e. parameters matched empirically to fit a dose distribution, they are found to be physically plausible. The variability analysis using portal imaging is not shown here, but the difference between two metrics measured for a given accelerator and energy was less than the difference between metrics measured for the same energy from two matched accelerators.

	6 MV	10 MV	18 MV
MLC transmission	0.49%	0.47%	0.63%
Tongue and groove	0.089 cm	0.072 cm	0.108 cm
Leaf tip width	0.378 cm	0.400 cm	0.380 cm
MLC y-position gain	-0.0043	-0.0041	-0.0029

CONCLUSIONS

Four MLC model parameters, namely MLC transmission, MLC y-position gain, tongue and groove and leaf tip width, were evaluated using dosimetric measurements. All values obtained are consistent both with the expected ranges from the RayStation documentation and with the physical properties of the accelerators. Because beam modeling can be an underdetermined problem, this method facilitates model optimization as it reduces the number of parameters to estimate.

REFERENCES

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