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Dosimetric verification and clinical evaluation of PRIMO as an independent Monte-Carlo-based dose verification tool

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Purpose

For highly conformal dose delivery techniques like VMAT there is a need of an independent dose verification procedure. This can be achieved via calculations or measurements. The purpose of this study is to test the Monte-Carlo dose calculation program PRIMO [1] to verify the dose distributions of 6-MV-FF VMAT plans and compare the results with ionization chamber array measurements (IC array) and portal dosimetry measurements (PDM).

Materials and Methods

A clinical accelerator [I] in 6-MV-FF mode was commissioned in PRIMO (V.0.3.1.1626) using phase space files [2], distributed by the vendor, for the upper linac head simulation. Field sizes from 3 x 3 cm^2 up to 40 x 40 cm^2 were simulated in PRIMO and compared to measured data. Furthermore six VMAT plans (one glioblastoma, two prostate and three head-neck plans) were calculated with the Acuros-XB algorithm [II] (dose to medium) and verified in three independent ways:

TPS

IC array [III] | PRIMO | PDM

Results

For the percent depth dose curves (PDD) and cross profiles (CP) of the different field sizes pass rates greater than 99 % were achieved using a gamma criterion of 2 % and 2 mm. See Fig.1 as an example.

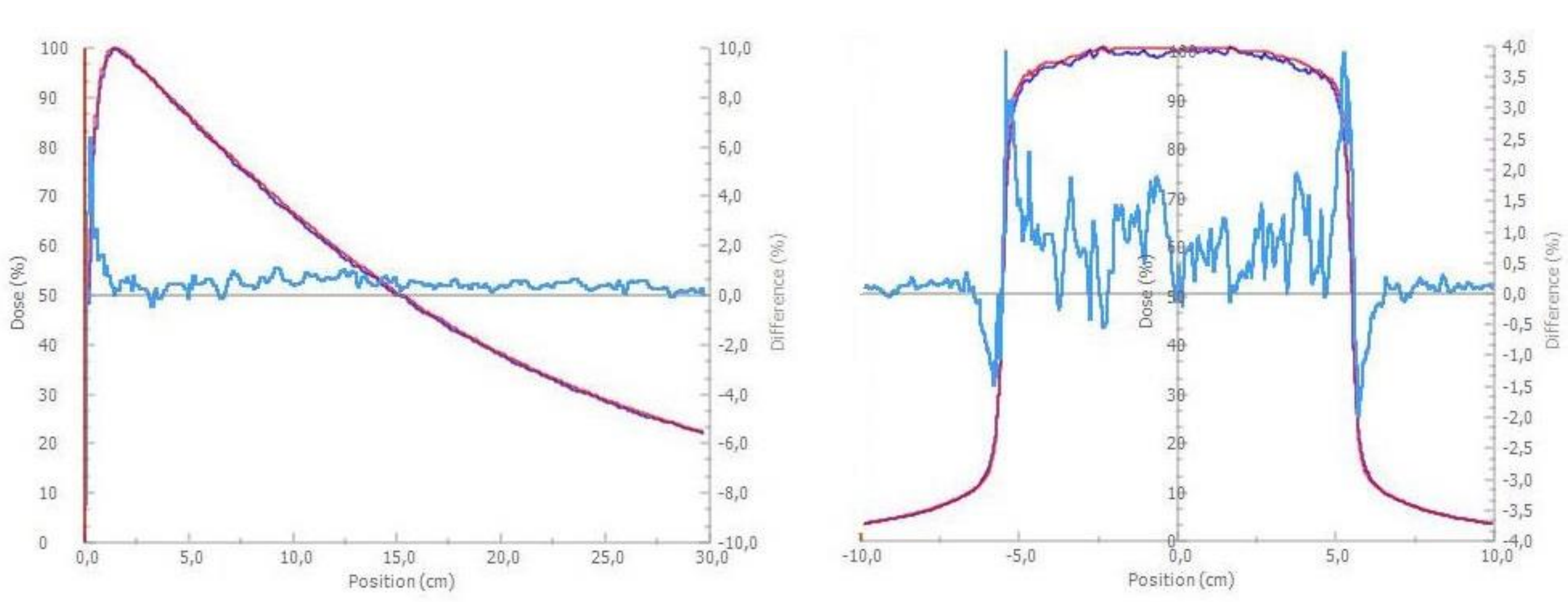

Fig.1: PDD and CP of a 10 x 10 cm^2 field. The red lines show the measured data, the blue lines the result of the Monte-Carlo simulation with PRIMO. The light blue lines give the differences of both curves.

Comparing the average pass rates of the three different dose verification methods for distinct gamma criteria in Tab.1, there is a very good agreement between the PRIMO and Acuros-XB simulations as well as between the Acuros-XB and PDIP simulations and their corresponding measurement method.

	Acuros-XB vs. IC array	Acuros-XB vs. PRIMO	PDIP vs. PDM
$\gamma_{3\%,3mm}$ in %	(98.1 ± 0.6)	(99.9 ± 0.1)	(99.0 ± 1.5)
$\gamma_{2\%,2mm}$ in %	(89.9 ± 2.2)	(98.3 ± 1.9)	(96.4 ± 2.8)
$\gamma_{1\%,1mm}$ in %	(53.7 ± 4.9)	(92.5 ± 7.0)	(67.3 ± 10.0)

Tab.1: Average accordance between Acuros-XB and PRIMO simulations, Acuros-XB simulations and IC array measurements and PDIP simulations and PDM.

Fig. 2 gives an example of a head-neck boost dose distribution simulated in PRIMO and the result of the gamma evaluation ($\gamma_{1\%,1mm}$) comparing the Acuros-XB and PRIMO simulation. The red areas of the gamma distribution are areas were the PRIMO dose distribution fails the gamma criterion related to the Acuros-XB simulation and the blue areas are areas were the PRIMO dose distribution fulfills $\gamma_{1\%,1mm}$. The two algorithms disagree especially in regions of high gradients.

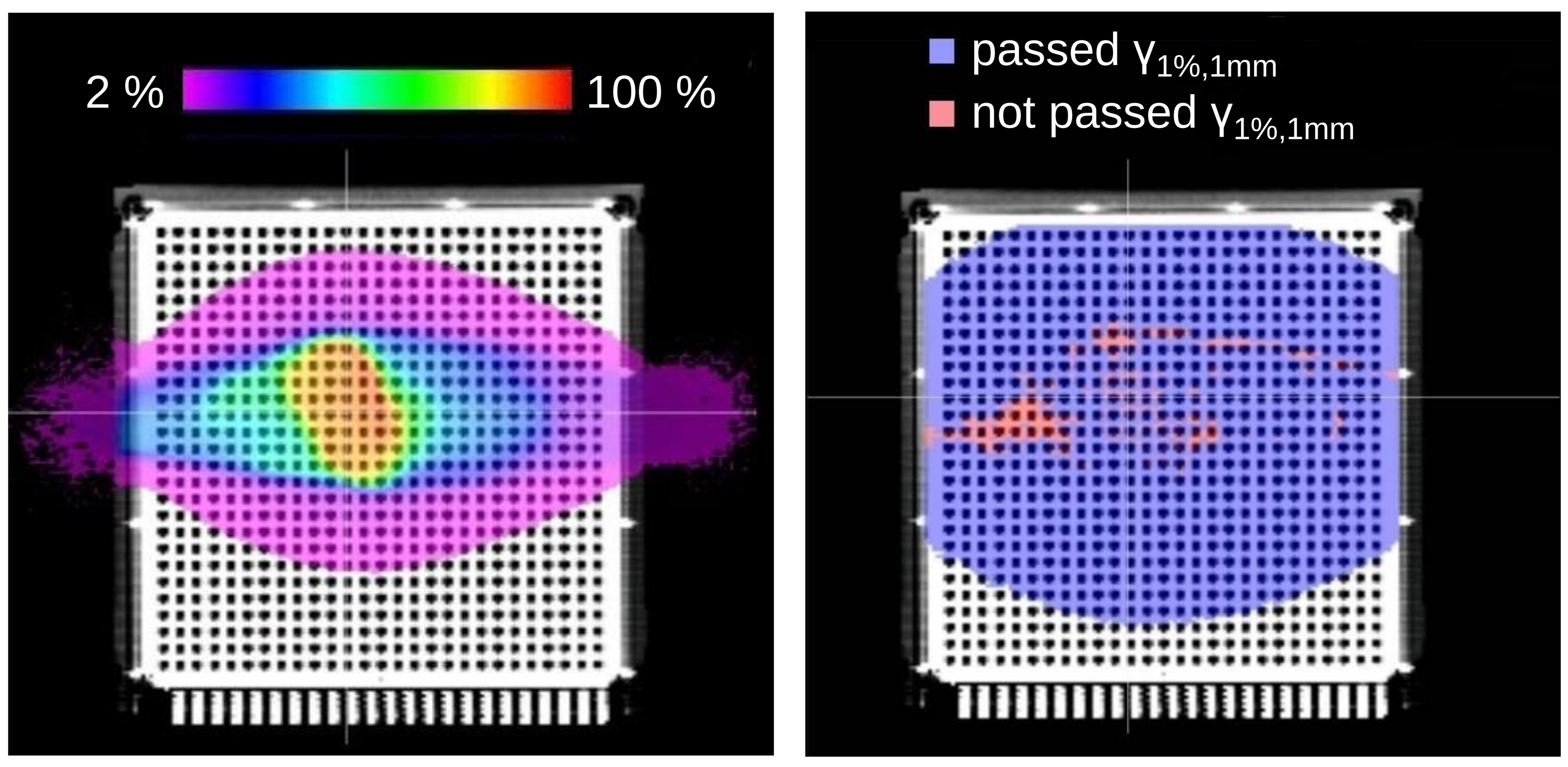

Fig.2: Dose distribution of a head-neck boost plan simulated in PRIMO and the corresponding gamma evaluation ($\gamma_{1\%,1mm}$) between the PRIMO and Acuros-XB calculation.

Conclusion

PRIMO is a Monte-Carlo-based dose simulation program which gives the possibility of independent dose verification of highly conformal and complex treatment plans. In future cumbersome measurements could be replaced by simulations. Further investigations on the sensitivity of PRIMO for MLC misalignment and dose errors have to be done.

Literature

[1] M. Rodriguez, J. Sempau and L. Brualla PRIMO: A graphical environment for the Monte Carlo simulation of Varian and Elekta linacs, Strahlentherapie und Onkologie 189(2013)881-886

[2] M. Constantin, D. Sawkey and M. Svatos SU-E-T-504: Electron Beam tuning Methodology for TrueBeam Phase-Space Library Generation, Medical Physics 40(2013)321-321

[I] Varian TrueBeam
[II] Varian Eclipse (V.13.0.26)
[III] Octavius 729 PTW Freiburg