



HAL
open science

Incorporating dynamic motion in PENELOPE

Cindy Le Loirec, Bénédicte Poumarède, Eric Barat, Thomas Dautremer,
Thierry Montagu, L. Guérin, A. Batalla, Delphine Lazaro

► **To cite this version:**

Cindy Le Loirec, Bénédicte Poumarède, Eric Barat, Thomas Dautremer, Thierry Montagu, et al.. Incorporating dynamic motion in PENELOPE. 2nd ESTRO Forum, Apr 2013, Geneve, Switzerland. Radiotherapy and Oncology, 106 (Supplement 2), pp.S218, 2013, 2nd ESTRO Forum 19-23 April 2013, Geneva, Switzerland. 10.1016/S0167-8140(15)32875-9 . hal-02268273

HAL Id: hal-02268273

<https://hal.science/hal-02268273>

Submitted on 21 Aug 2019

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

¹Ludwig-Maximilians-University Munich Klinikum Grosshadern, Radiation Oncology, Munich, Germany

²Ludwig-Maximilians-University Munich, Physics Department Medical Physics, Munich, Germany

Purpose/Objective: The sensitivity of QA protocols is tested for the novel Elekta Agility™ MLC (5 mm leaf width) and the widely used Elekta MLCi2 (10 mm leaf width) using both a 2D ionization chamber array (MatriXXevolution, IBA dosimetry) and a 2D diode array (MapCHECK 2, Sun Nuclear).

Materials and Methods: Geometric characterisation includes detection of leaf and jaw penumbra as well as detection of leaf misalignments using a 'comb field' with shifts of adjacent leaves ranging from 1 to 5 mm. Further accuracy checks are done evaluating tongue-and-groove, stair pattern and picket fence test. These fields are measured in original setup position and with the devices shifted half a leaf towards the gantry. Results are compared against EBT3 film and Monte Carlo dose calculations. Dosimetric accuracy is checked against a Farmer-type ionisation chamber (FC) with respect to dose linearity and dose summation.

Results: Dose linearity and dose summation for MatriXX is always consistent (<0.5 %) with the FC. MapCHECK shows consistency (<0.5 %) for doses higher than 15 cGy. Smaller doses (2 cGy) are measured with up to -3 % deviation. Penumbrae measured with MapCHECK are consistent with film measurements. Depending on the steepness of the penumbra, MatriXX shows up to 2.8 mm wider penumbrae. Measurements of the comb field show that both devices detect leaf misalignments down to 1mm. However, the amount of the dose perturbation is highly dependent on the geometry of the misaligned leaf relative to the detector geometry, especially for the smaller leaf widths of the Agility MLC (5 mm). Accuracy checks show higher sensitivity of leaf misalignments for MapCHECK. Combining original and shifted measurements, MatriXX provides the same information.

Conclusions: Both arrays are suitable for 2D dose measurements, even though every device has specific strengths. MatriXX performs better for dose linearity and dose summation due to the use of ionization chambers. MapCHECK is advantageous in MLC accuracy measurements due to the detector geometry setup and the point-like detection characteristics of diode detectors. Using either array with MLCi2 (10 mm), each device will provide sufficient measurements for patient specific QA using a Gamma Index 3% / 3mm. However, the smaller the leaves the better MapCHECK will detect leaf misalignments. MatriXX performs better if many subfields have small MU. Using the devices for machine QA, it is highly important to design tests in accordance to the measurement geometry. Especially for MatriXX measurements with small MLCs (e.g. Agility) measurements of original and shifted setups need to be combined for sufficient MLC QA.

PD-0569

Incorporating dynamic motion in PENELOPE

C. Le Loirec¹, B. Poumarede¹, E. Barat¹, T. Dautremer¹, T. Montagu¹, L. Guerin², A. Batalla², D. Lazaro¹

¹CEA Saclay, DRT/LIST, Gif sur Yvette, France

²Centre F. Baclesse, Physics, Caen, France

Purpose/Objective: The traditional way to take time into account in Monte Carlo (MC) simulations is to simulate individual static component fields separately and integrate the results. This method can be very efficient but leads to a high demand of phase space file storage. To avoid this, the position probability sampling (PPS) method, in which the position of a geometrical object is treated as a random variable during the simulation, has been developed. We aim here to incorporate this method in Penelope in the case of a virtual wedge.

Materials and Methods

1.1 Monte Carlo simulation: We have used the 2006 release of the Penelope code with a new version of the main program Penmain, in which several conventional variance reduction techniques were implemented in order to increase the efficiency of the linac treatment head simulations. The MC code was used to model both the Siemens Artiste linac with a full description of the Siemens 160 MLC and the OptiVue™ 1000 EPID (Siemens Medical Solutions).

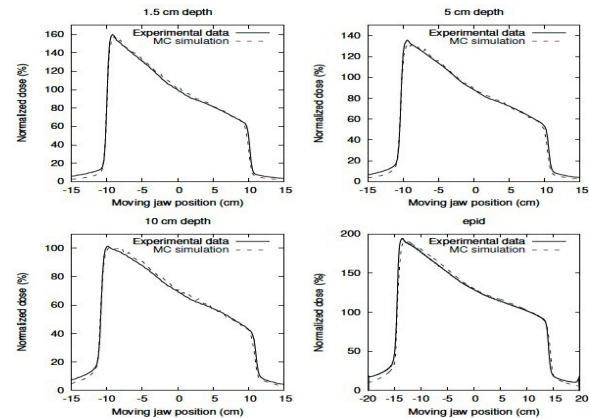
To model the dynamic jaw motion of the virtual wedge, the PPS method has been implemented in Penmain. This implementation required an adequate modelling of the jaws to allow their motion without a complete re-initialization of the geometry for each particle. We have thus written a new subroutine which needs as inputs: the index of the moving jaw surface, the first and last positions of the moving jaw, the wedge angle α , and the value of $(C \times \mu)$ with μ the effective linear attenuation coefficient in water for the particular photon spectrum, and C a tuning coefficient for μ .

1.2 Measurements

All the measurements have been performed on a Siemens Artiste linac with a 20 cm x 20 cm field size and for a 6 MV photon beam. A first

set of measurements has been performed in a water tank positioned at 100 cm skin source distance. Wedged beam profiles have been measured with a linear detector array at three different depths: 1.5 cm, 5 cm, and 10 cm. Then a portal image of a 40° wedged beam has been acquired at 145 cm detector source distance without any phantom in the beam.

Results: We have first performed MC simulations for the 45° wedged beam in a water tank and we have reported the dose distribution in a 4 x 3 x 2.5 mm³ scoring grid. The profiles have been extracted and compared with the experimental ones. We have then simulated the acquisition of the portal image of a 45° wedged beam with the EPID's physical resolution (0.39 mm). The results are reported in figure 1.



Conclusions: In this work the PPS method was used to incorporate the collimator motion into Penelope. A 6 MV photon beam of a Siemens Artiste linac equipped with a 160 MLC and an OptiVue™ 1000 EPID (Siemens Medical Solutions) was simulated with a virtual wedge. Measurements and simulations have been performed in a water tank and in the portal device. The simulated dose profiles reproduce the experimental data with a fairly good accuracy.

PD-0570

A comparison of the beam configuration modules of two proton treatment planning systems.

P. Doolan¹, I. Rosenberg², C. Ainsley³, A. Gibson¹, G. Royle¹

¹University College London, Department of Medical Physics and Bioengineering, London, United Kingdom

²University College London Hospital, Department of Radiotherapy, London, United Kingdom

³University of Pennsylvania, Department of Radiation Oncology, Philadelphia, USA

Purpose/Objective: With the potential improvement of dose conformality of protons over photons, the number of new proton treatment centres is increasing rapidly. One of the key physics decisions for a new centre is the choice of treatment planning system and one of the first important tasks facing the physics team is beam commissioning. Proton beam commissioning consists of modelling pristine Bragg peaks and lateral profiles for the range of energies to be used clinically. Both are equally important as they effectively define the proximal/distal and lateral beam penumbrae respectively. This study analyses the performance of beam configuration modules of two treatment planning systems: commercially-available Eclipse (v10.0.39) and research-only Pinnacle (v9.1, Feb 2012).

Materials and Methods: Pristine Bragg peaks (for 27 energies between 100-226.7MeV) from the University of Pennsylvania horizontal fixed beam line were acquired in a water tank with a 42mm measurement offset (water tank wall, surface offset and chamber offset). Lateral profiles were acquired at 8 positions in air, for each energy, using IBA's Lynx scintillator/CCD camera system. The depth dose curves and profiles were modelled by both systems using their respective automated fitting tools. After resampling the measured and fitted datasets to a consistent high resolution, the fitting quality was assessed using gamma analysis with a 2%/2mm criteria for depth dose curves and a 2%/0.1mm criteria for lateral profiles. The tighter distance-to-agreement criterion was required for profiles to ensure the analysis did not reach a false local minimum.

Results: Both models were within clinical tolerances, however their algorithms differ and so there were slight differences in the fitting. For energies >180MeV in Eclipse the entrance dose in the depth dose curves was underestimated (by up to 2.5%), while Pinnacle consistently overestimates the distal Bragg peak depth with a mean distal R50 error of 0.3mm. The mean gamma index for the profiles,