



HAL
open science

Commissioning of PENELOPE and GATE Monte Carlo models for 6 and 18 MV photon beams from the Siemens Artiste linac

Delphine Lazaro, L. Guérin, A. Batalla, Thibault Frisson, David Sarrut

► **To cite this version:**

Delphine Lazaro, L. Guérin, A. Batalla, Thibault Frisson, David Sarrut. Commissioning of PENELOPE and GATE Monte Carlo models for 6 and 18 MV photon beams from the Siemens Artiste linac. 11th Biennial on Physics & Radiation Technology, May 2011, London, United Kingdom. Radiotherapy and Oncology, 99 (Supplement 1), pp.S515, 2011, 10.1016/S0167-8140(11)71507-9 . hal-02268801

HAL Id: hal-02268801

<https://hal.science/hal-02268801>

Submitted on 30 Sep 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.

Commissioning of PENELOPE and GATE Monte Carlo models for 6 and 18 MV photon beams from the Siemens ARTISTE Linac

D. Lazaro-Ponthus¹, L. Guérin², A. Batalla², T. Frisson³, D. Sarrut³

¹CEA, LIST-DOSEO, F-91191 Gif-sur-Yvette, France; ²Centre F. Baclesse, F-14076 Caen Cedex, France;

³Centre L. Bérard / CREATIS CNRS UMR 5220, F-69622 Lyon, France;

Contact : delphine.lazaro@cea.fr

Context and objectives

- Importance of the linac model commissioning to ensure dose computation accuracy using Monte Carlo (MC)-based algorithms.
- Objectives of this work:
 - ✓ development of MC models for the 6 and 18 MV photon beams of the Siemens Artiste linac using PENELOPE and GATE codes,
 - ✓ validation of these models against experimental data,
 - ✓ comparison of the performances of both codes in terms of dosimetry and efficiency.

Materials and methods

EXPERIMENTAL DATA

- Siemens ARTISTE Linac (cf Figure 1).
- 6MV and 18 MV photon modes.
- Field sizes: 5x5, 10x10, 20x20, 30x30 cm².
- Percentage depth doses (PDD) and lateral beam profiles at d_{max} (6 MV: 1.5 cm; 18 MV: 3 cm), 5 cm and 10 cm measured at 100 SSD using a PTW large MP3 water tank with a PTW Semiflex 0.125 cm³ ionization chamber.



Figure 1. The Siemens ARTISTE Linac.

MC SIMULATIONS WITH PENELOPE AND GATE

Determination of the incident electron beam parameters

- Incident electron beam modelled by a monoenergetic beam (mean energy E_0) in both codes. The spatial distribution of the spot was considered as circular (radius R) in PENELOPE and as Gaussian (FWHM) in GATE.
- These parameters were determined following the methodology proposed by Pena et al. [1] using PDDs and dose profiles of the 5x5, 10x10 and 30x30 cm² fields.

Comparison between GATE [2] and PENELOPE [3, 4]

- Computation in two steps:

- ✓ **step 1:** PSF file stored above the secondary collimator (GATE) and below (PENELOPE),
- ✓ **step 2:** dose computation within a 40x40x40 cm³ water phantom using the PSF file as input data, with GATE and PENFAST (voxel size: 4 mm).

	GATE	PENELOPE
CODE VERSION	v6.0 (GEANT4 9.3 p02) (steps 1 and 2)	PENELOPE 2006 parallelized (step 1) PENFAST (step 2)
PHYSICS SETTINGS	Standard ELM package Cuts for e-, e+, γ = 1 mm	$W_{cc} = W_{cr} = 10$ keV E_{abs} : e-, e+ = 500 keV, γ = 10 keV, $C_1 = C_2 = 0.05$
VARIANCE REDUCTION METHODS	Selective Bremsstrahlung Splitting (splitting factor = 100, emission cone angle = 20°), Splitting of the particles stored in the PSF file (splitting factor = 50)	

Table 1. List of parameters used in the physics settings and the variance reduction methods for GATE and PENELOPE/PENFAST codes.

- Once the MC model determined for each photon energy and each code, the dosimetric performances and the efficiencies of both codes were assessed by comparing simulated PDDs and lateral dose profiles and the photon output rate (number of photons reaching the PSF file for a fixed number of primary electrons), respectively.

Results

DETERMINATION OF THE ELECTRON BEAM PARAMETERS

- The parameters determined using the methodology of Pena et al. are summarized in Table 2.

	GATE	PENELOPE
6 MV	$E_0 = 6$ MV spot FWHM = 0.6 mm	$E_0 = 6.25$ MV spot radius R = 1.0 mm
18 MV	$E_0 = 14.2$ MV spot FWHM = 0.5 mm	$E_0 = 14.2$ MV spot radius R = 1.0 mm

Table 2. Parameters of the MC models.

COMPARISON BETWEEN GATE AND PENELOPE

Efficiency comparison

- Photon output rates obtained with PENELOPE and GATE are presented in Table 3: PENELOPE is about 2 times faster than GATE.

		Primary electrons	Time (s)	Collected photons	Output rate (s ⁻¹)
PENELOPE	6 MV	2×10^6	8076	17 470 047	2173
	18 MV	1.5×10^6	28092	60 425 092	2151
GATE	6 MV	2×10^6	10 200	9 994 565	979
	18 MV	1.5×10^6	16 200	1.606333×10^7	991

Table 3. Photon output rates obtained with PENELOPE and GATE, at 6 and 18 MV.

Dosimetric validation

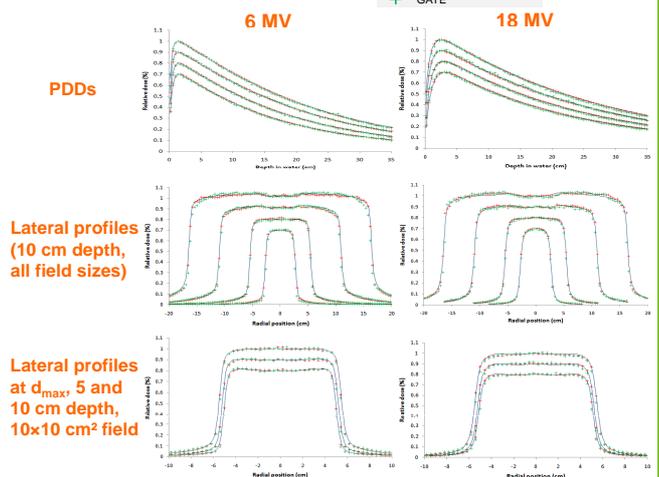


Figure 2. Comparison of simulated and measured PDDs and lateral dose profiles.

- Simulated and experimental PDDs agreed within 1%, at both energies.
- Lateral profiles matched measured ones within 1%/1 mm at 6 MV and within 2%/2 mm at 18 MV, for both codes. For field sizes > 25x25 cm², larger discrepancies are observed: the influence of the electron energy distribution is currently investigated.

Conclusions and perspectives

- 6 and 18 MV photon beam models of the Siemens Artiste linac were developed using PENELOPE and GATE MC codes and were validated against experimental data.
- This study demonstrates the ability of the new GATE v6.0 release to accurately model radiotherapy photon beams at different energies, with an efficiency compatible to that of well-established codes in RT as PENELOPE.

References

- [1] Pena et al. 2007 Med. Phys. 34 1076-84.
- [2] Jan et al. 2011 Phys. Med. Biol. 56 881-901
- [3] J. Baro et al., 1995 Nucl. Instr. and Meth. B 100 31-46.
- [4] B. Habib et al., 2010 Phys. Med. 26 17-25.

