Verification of the radiotherapy treatment planning system based on the PENFAST Monte Carlo code for dose calculations in photon and electron beams

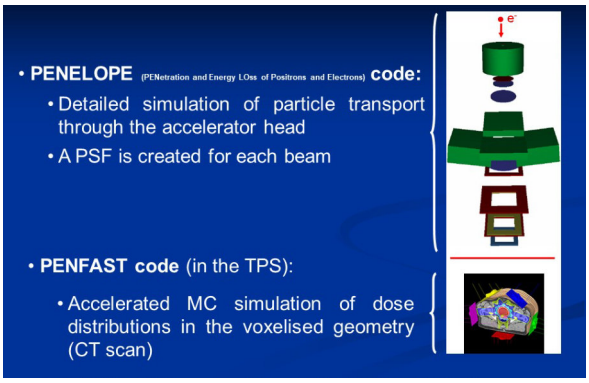
Bouchra Habib, Serge Marcié, Bénédicte Poumarède, Jean Barthe

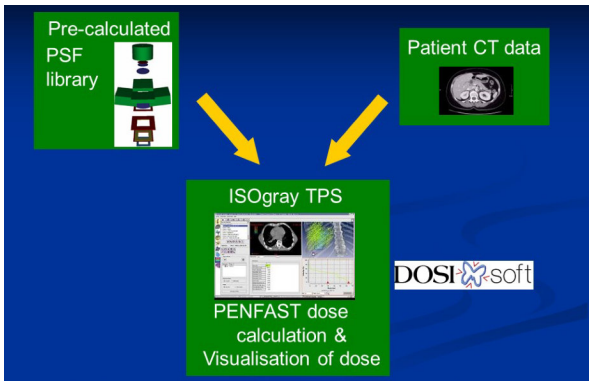
Title: Dosimetric verification of the radiotherapy treatment planning system based on the PENFAST Monte Carlo code for dose calculations in photon and electron beams

Authors:
Bouchra HABIB bouchra.habib@cea.fr
Serge MARCIÉ serge.marcie@cal.nice.fnclcc.fr
Bénédicte POUMARÈDE benedicte.poumarede@cea.fr
Jean BARTHE jean.barthe@cea.fr

Address:
CEA, LIST, 91191 Gif-sur-Yvette Cedex, France.
Centre Antoine Lacassagne – 33, avenue Valombrose – 06189 Nice Cedex 2, France.

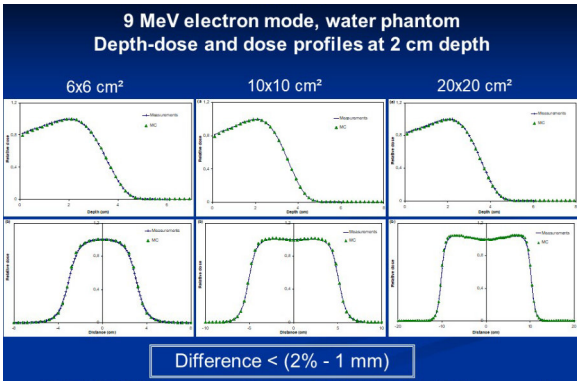
Purpose: Developments in radiation therapy require a higher precision in dose delivery. Monte Carlo (MC) methods yield better accuracy than analytical ones but with longer computing times. Based on the conventional MC code PENELOPE physics, a fast MC code named PENFAST was recently developed and included in the treatment planning system ISOgray™ (DOSIsoft). PENFAST performs photon and electron dose calculations in computerized tomography (CT) structures. It is necessary to assess the accuracy of the dose estimation before any clinical use of PENFAST.

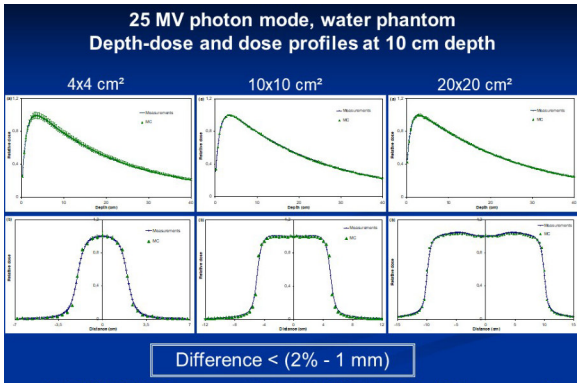




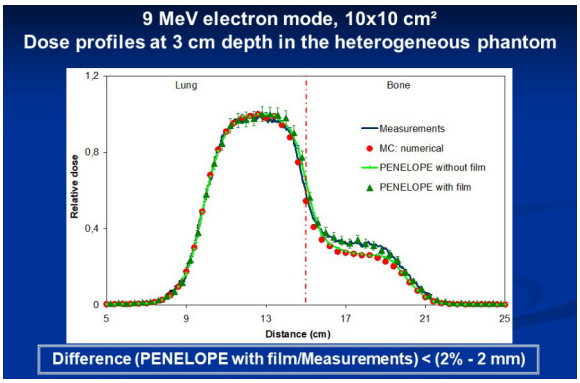
Method and Materials: The MC simulation is split into 2 parts:
(1) the simulation of particle transport through the accelerator head, using PENELOPE. A phase space file (PSF) is created.
(2) The simulation of dose distributions in the phantom starting from the PSF, using PENELOPE or PENFAST.

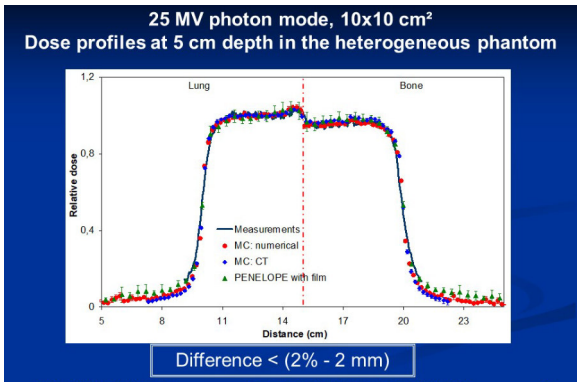
Depth-dose and dose profiles calculated with PENELOPE in water are compared to experimental measurements in order to validate the PSF calculation. Measured doses with radiographic films are compared with simulated results (PENELOPE and PENFAST) in inhomogeneous phantoms (lung and bone). An 9 MeV electron beam and a 25 MV photon beam (with different field sizes) of the Siemens Primus accelerator are studied.





Results: Since comparisons among simulations and measurements in water are in good agreement (within ± 1%-1mm), the PSF calculation is validated. In inhomogeneous phantoms, the PENFAST results agree to within a 1%-1mm difference with the PENELOPE ones, and to within a 2%-2mm difference with measurements. Largest discrepancies (> 5%) between PENFAST and measurements are observed on dose profiles behind the cortical bone for the electron beam. These differences are due to the film sensibility on low energy radiation backscattered from the high density material and to the presence of artefacts in the CT image.





Conclusions: This work shows the ability of PENFAST to calculate accurate dose distributions for photon and electron beams.