EUTEMPE module 03:
Monte Carlo simulation in Medical Physics with PENELOPE, PRIMO and MANTIS

Aim and learning outcomes

Monte Carlo simulation of radiation transport has numerous applications in medical radiation physics, largely due to its detailed modeling of radiation interactions and to its suitability for dealing with complex geometries. This course aims at providing medical physics experts with the theoretical and, especially, practical abilities required to efficiently use the general-purpose Monte Carlo code PENELOPE/penEasy (see PENELOPE reference manual here and penEasy's here) to simulate a variety of problems related to radiotherapy, imaging and nuclear medicine. Linac simulation and patient dosimetry in external beams will be addressed with PRIMO (see description here), a radiotherapy dose verification system based on PENELOPE/penEasy. The coupling between x-rays and light for digital detectors will be studied with the MANTIS code (see description here).

The main learning outcomes are:

- Understand the principles and physics underlying the Monte Carlo simulation of radiation transport, with emphasis on photons and electrons.
- Devise and prepare models to efficiently simulate medical physics problems with PENELOPE/penEasy, PRIMO and MANTIS.
- Use the PRIMO system to compute accurate dose distributions in external beam radiotherapy patients, including a full simulation of the (Varian) linac.
- Manage a simulation project from beginning (conceptual modeling) to end (analysis of results).

Course structure

Phase 1 (2 weeks–approx 2 h/day):
Online asynchronous, guided self study, based on preparatory reading material (in English) to introduce theorical concepts and guide participants to install and familiarize themselves with some of the software used during phase 2.

Phase 2 (2 weeks–3 h/day):
Online synchronous (over Zoom), based mainly on guided practical exercises and problem-solving scenarios. Sessions will be conducted mainly in English, but simultaneous breakout rooms will be created in Spanish, Portuguese and Italian.

Phase 3 (OPTIONAL, 2 days–6 h/day):
Face-to-face in Barcelona (Spain), based on forums to discuss practical cases brought by participants, advanced topics proposed by the instructors and further issues on the use of the simulation codes introduced in the course.

Contents

- Monte Carlo simulation of radiation transport
  The Monte Carlo method. Radiation transport. Variance-reduction techniques.
- Photon and electron physics
  Interaction models. $e^{\pm}$ condensed simulation. General-purpose codes.
- The PENELOPE/penEasy system
  Structure, installation and operation. Practical aspects.
- Imaging detectors
  Detector models. Imaging metrics. Use of MANTIS & ARTEMIS codes.
- Radiotherapy
  Dosimetry, brachytherapy & teletherapy. The PRIMO system.
- Exercises (throughout the course)
  Absorbed dose distributions. Spectrometry. X-ray tubes & image formation. Point spread functions & pulse-height spectra in indirect detectors. Patient dose distribution in external beam radiotherapy.

Certificate

A Continuing Professional Development (CPD) certificate will be issued for those that pass the phase 2 final exam. An attendance certificate will be issued for those that do not take or pass the examination. To get a certificate you must attend at least 80% of phase 2 sessions.

Lecturers

- José M. Fernández-Varea, University of Barcelona. PENELOPE co-author
- Josep Sempau, Technical University of Catalonia. PENELOPE/penEasy, PRIMO & MANTIS co-author
- Aldo Badano, U.S. Food and Drug Administration. MANTIS co-author
- Lorenzo Brualla, University of Duisburg-Essen. PRIMO co-author
- Hilde Bosmans, Katholieke Universiteit Leuven

Dates 2021

Phase 1 (online, asynchronous): June 20 - July 1 (2 weeks, 2 h/day = 20 h tot)
Phase 2 (online, synchronous via Zoom): July 4-15 (2 weeks, 3 h/day = 30 h tot)
Phase 3 (OPTIONAL, face-to-face in Barcelona): July 21-22 (2 days, 6 h/day)

Registration fee

260 EUR, which includes copies of the simulation software.
The optional phase 3 involves an additional fee of 500 EUR, which includes a social activity and dinner.

For more information

Send an e-mail to EUTEMPE-MC@gmail.com