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Red Temática de Investigación en Física Médica (CONACyT)

Programa

Monte Carlo simulations in radiation therapy: Geant4

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Outline

1 Overview (15 min)

2 Introduction to radiation therapy: x-ray and electrons (1.5 hours)

- Interaction properties of electrons and x-rays
- Physical quantities in radiation physics
- Dose from therapeutic electrons and x-rays

3 Basics of Monte Carlo simulation (1.5 h)

- A brief history of Monte Carlo
- Random number generation
- Sampling techniques
- Statistical error estimation

4 G4-Lab-1: Setup of software and simple simulations (4.0 h)

- Software requirements
- Building setup

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1 Introduction to radiation therapy: protons and carbon ions (1.5 h)

- Introduction
- Stopping power of charged particles: the Bragg curve
- Multiple scattering of charged particles
- Nuclear interactions: elastic and inelastic interactions
- Dose from therapeutic protons and carbon ion beams

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2 Introduction to Geant4 (2 sessions of 1.5 h)

- Introduction to Geant4: architecture and argot
- Definition of materials
- Geometry
- Modular physics list
- Primary generation
- Scoring methods

3 G4-Lab-2: The command line and parallelism (4.0 h)

- Building simple applications
- The command line parameters
- Splitting jobs: random seeds
- Multithreading overview

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1 G4-Lab-3: Patient dose calculation (2.0 h)

- Parameterized and replicated volumes
- Advanced scoring techniques

2 G4-Lab-4: Generic LINAC setup (2.0 h)

- X-Ray from lead target
- Electron scattering from thin foils
- Generic geometry devices
- Phase space scoring

3 G4-Lab-5: Variance reduction (1.0 h)

- Uniform bremsstrahlung splitting
- Russian roulette

4 G4-Lab-6: Scintillator detectors (2.0 h)

- Optical materials
- Optical physics parameters
- Optical surfaces as sensitive detector

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1 Monte Carlo simulations for proton and ion beams (1.5 h)

- Clinical use of proton beams
- Clinical use of carbon beams

2 G4-Lab-7: Beam modeling (1.5 h)

- Pencil beam setup
- Phase space setup

3 Biological modeling in particle therapy (0.5 h)

- About the biological implications of heavy charged particles

4 Monte Carlo track structure simulations with Geant4-DNA (0.5 h)

- A nanodosimetric view point of radiation damage

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1 Individual consulting (On demand)

- 30-60 minute slots available to be booked by individual attendees (faculty with students and post-docs) to help with their particular projects or for individual discussion

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References

1. P.N. McDermott and C.G. Orton, "The Physics and Technology of Radiation Therapy," 2010, Medical Physics Publishing, Madison, WI.

2. F.H. Attix, "Introduction to Radiological Physics and Dosimetry," Wiley-VCH

3. Eric J. Hall, Amato J. Giaccia, "Radiobiology for the radiologist," 7th ed, Philadelphia : Wolters Kluwer Health/Lippincott Williams & Wilkins, c2012

4. "Monte Carlo Techniques in Radiation Therapy" edited by Saco and Verhaegen

5. A. Bielajew. "Fundamentals of the Monte Carlo method for neutral and charged particle transport" http://www- personal.umich.edu/~bielajew/MCBook/book.pdf

6. H. P. Langtangen "A primer of scientific programming with Python" http://hplgit.github.io/primer.html/doc/pub/half/book.pdf

7. Geant4 Collaboration. "User's guide: For application developers." https://geant4.web.cern.ch/geant4/support/userdocuments.shtml

Index Termsâ€"Geant4, Radioactive Decay, Monte-Carlo Simu-lation, Validation, ENSDF. I. INTRODUCTION. Radioactive decays and the resulting radiation play an important role for many experiments, either as an observable, as a background source, or even as a potential hazard when they are a source of radiation-induced damage for hardware and human beings.Â If radioactive decay simulation occurs in the context of a more general Monte Carlo simulation system, the software responsible for the radioactive decay process should interact with other components of the system. 3. B. Problem Domain Analysis. 33) Accurate Monte Carlo simulations for nozzle design, commissioning and quality assurance for a proton radiation therapy facility. H. Paganetti, H. Jiang, S.-Y. Lee, and H. M. Kooy, Med. Phys.Â 36) Validation of GEANT4, an object-oriented Monte Carlo toolkit, for simulations in medical physics. J.-F. Carrier, L. Archambault, L. Beaulieu, and R. Roy, Med. Phys. 31, 484 (2004). 37) Dosimetry characterization of 32P intravascular brachytherapy source wires using Monte Carlo codes PENELOPE and GEANT4, Javier Torres, Manuel J. Buades, Julio F. Almansa, Rafael Guerrero, and Antonio M. Lallena, Med. Phys. A Monte Carlo model of the ID17 biomedical beamline at the European Synchrotron Radiation Facility has been developed, including recent modifications, using the Geant4 Monte Carlo toolkit interfaced with the SHADOW X-ray optics and ray-tracing libraries. The code was benchmarked by simulating dose profiles in water-equivalent phantoms subject to irradiation by broad-beam (without spatial fractionation) and microbeam (with spatial fractionation) fields, and comparing against those calculated with a previous model of the beamline developed using the PENELOPE code. Validation against additional e