

# Geant 4

*IEEE Nuclear Science Symposium and Medical Imaging Conference  
Short Course*

## **Simulation Techniques Using Geant4**

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<http://www.ge.infn.it/geant4/events/nss2008/geant4course.html>

This course exploits training material developed by several Geant4  
Collaboration members: thanks to all of them!

# Introduction

Basic concepts of simulation with Geant4 a s  
a general purpose Monte Carlo toolkit

# The role of simulation

- Simulation plays a fundamental role in various domains and phases of an experimental physics project
  - design of the experimental set-up
  - evaluation and definition of the potential physics output of the project
  - evaluation of potential risks to the project
  - assessment of the performance of the experiment
  - development, test and optimisation of reconstruction and physics analysis software
  - contribution to the calculation and validation of physics results
- The scope of these lectures (and of Geant4) encompasses the **simulation of the passage of particles through matter**
  - there are other kinds of simulation components, such as *physics event generators*, *electronics response* generation, etc.
  - often the simulation of a complex experiment consists of several of these components interfaced to one another

# Detector Simulation - General

- General characteristics of a detector simulation system
  - You specify the set-up of an experimental system
  - Then the software system automatically transports the particle you shoot into the defined system by simulating their interactions in matter based on the Monte Carlo method
- The heart of the simulation: the Monte Carlo method
  - A method to search for solutions to a mathematical problem using statistical sampling with random numbers

# Basic requirements for a simulation system

- Modeling the experimental set-up
- Tracking particles through matter
- Interaction of particles with matter
- Modeling the detector response
- Run and event control
- Accessory utilities (*random number generators, PDG particle information etc.*)
- Interface to event generators
- Visualisation of the set-up, tracks and hits
- User interface
- Persistency

# The zoo

EGS4, EGS5, EGSnrc

Geant3, Geant4

MARS

MCNP, MCNPX, A3MCNP, MCNP-DSP, MCNP4B

MVP, MVP-BURN

Penelope

Peregrine

Tripoli-3, Tripoli-3 A, Tripoli-4

...and I probably forgot some more

DPM

EA-MC

FLUKA

GEM

HERMES

LAHET

MCBEND

MCU

MF3D

NMTC

MONK

MORSE

RTS&T-2000

SCALE

TRAX

VMC++

# What can Geant4 do for you?

- Transports a particle step-by-step by taking into account the interactions with materials and external electromagnetic fields, until the particle
  - loses its kinetic energy to zero,
  - disappears by an interaction,
  - comes to the end of the simulation volume
- Provides a way for the user to interact with the transportation process and access the simulation results
  - at the beginning and end of transportation
  - at the end of each step in transportation
  - at the time when the particle is in the sensitive volume of the apparatus
  - etc.

# What should you do for Geant4?

- Three essential pieces information you must provide:
  - Geometrical and material description of the detector
  - Choice of physics processes
  - Kinematical information of the primary particles to be tracked
- Auxiliary matter you could provide, if you wish:
  - Magnetic and electric field
  - Actions you want to take when you access particle transportation
  - Actions you want to take when a particle goes into a sensitive volume of the detector
  - etc.



# Minimum computing background knowledge to use Geant4

- **C++**

- Geant4 is implemented in C++, therefore a basic knowledge of C++ is required
- C++ is a complex language, but you are not required to be a C++ expert to use Geant4

- **Object Oriented Technology**

- basic concepts
- in-depth knowledge needed only for the development of complex applications

- **Unix/Linux**

- it is a standard working environment for Geant4, therefore a minimum knowledge/experience is required
  - How to use basic Unix command
  - How to compile a C++ code

- **Windows**

- You can use Visual C++
- Though still you need some knowledge of Unix (cygwin) for installation
- *Beware: like most Geant4 developers, I never used Geant4 on Windows!*