GEANT4 Tutorial Course for Beginners

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Introduction to GEANT4

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What is GEANT4?

GEANT4 is *a toolkit for the simulation of the passage of particles through matter.*

- Often used in physics (nuclear, high-energy, accelerator, and medical) as well as space science
- **Toolkit:** Using GEANT4, users need to build a simulation program.
- Developed from GEANT3 (fortran). GEANT4 is written in C++ (Object-Oriented programming)
- Developed and maintained by **GEANT4 Collaboration** ([http://www.cern.ch/geant4](http://www.cern.ch/geant4))
What does GEANT stand for?

There seem to be two answers:

- GEneration ANd Tracking (End of 1970’s, at the beginning of GEANT1)
- GEometry ANd Tracking (Nowadays)
Why is simulation needed anyway?

In nuclear/high-energy physics, Monte-Carlo simulation is often needed to do the followings:

- To determine the experimental setup
  - optimize the detector/shielding locations to obtain decent results in experiment
  - study the expected background and radiation level
- Compare the simulated results with experiment to make sure there is no error in analysis (or simulation code).
- Correct the experimental results by comparing them with simulated results with inputs from theory
What are needed in simulation?

To simulate a nuclear physics experiment, information on the followings is needed.

- Beam
- Target
- Detectors
- E&M Fields
- Physics interactions (in the target and detector) and cross sections
- and so on...
What are needed in GEANT4?

Below is a minimum list of things users need to do in GEANT4 programming

- Define Materials and Geometries (target, detector...)
  Add E&M fields [optional]
- Define particles and physics interactions
- Decide how a primary event should be generated
- and so on...
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G4VUserDetectorConstruction class

G4VUserPhysicsList class

G4VUserPrimaryGeneratorAction class
Then, what does GEANT4 do for you?

• A particle is transported through matter for every step until the particle
  • goes out of the world volume
  • loses its kinetic energy to zero
  • it disappears by an interaction or decay

• Users can access the transportation process to get the simulated results ==》 USER Action
  • at the beginning and end of transportation
  • at the end of each transportation step
  • when the particle enters the sensitive volume of the detector
GEANT4 related resources

- GEANT4 Home page:  [http://cern.ch/geant4](http://cern.ch/geant4)

- Overview of C++ for GEANT4 users:  

- Software reference manual and GEANT4 cross reference are available to understand Geant4 classes

- GEANT4 Tutorial classes held almost every year by SLAC GEANT4 team [Many lecture slides available online]
GEANT4 credits

- Two main reference papers for Geant4 have been published:
- Geant4 software license is given at http://cern.ch/geant4/license.
- Many course slides for this TUNL geant4 tutorial are courtesy of SLAC GEANT4 team (http://geant4.slac.stanford.edu/)