User Documents and Examples

Geant4 Tutorial at MIT
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Outline

• User Documents

• Examples
  – basic
  – extended
  – advanced

• User Support
  – LXR and Doxygen source code browsers
  – HyperNews User Forum
Your First Stop: Geant4 Web Pages
http://geant4.cern.ch

Geant4 is a toolkit for the simulation of the passage of particles through matter. Its areas of application include high energy, nuclear and accelerator physics, as well as studies in medical and space science. The two main reference papers for Geant4 are published in *Nuclear Instruments and Methods in Physics Research A* 506 (2003) 250-303, and *IEEE Transactions on Nuclear Science* 53 No. 1 (2006) 270-278.

Applications

- **Sampling of applications**, technology transfer and other uses of Geant4

User Support

- **Getting started**, guides and information for users and developers

Publications

- **Validation of Geant4**, results from experiments and publications

Collaboration

- **Who we are**, collaborating institutions, members, organization and legal information

News

- **1 April 2015** - Patch-01 to release 10.1 is available from the [Download](#) area.
- **16 March 2015** - 2015 planned developments.
- **6 March 2015** - Patch-04 to release 10.0 is available from the [source archive](#) area.
- **4 February 2015** - Patch-04 to release 9.6 is available from the [source archive](#) area.

Events

- **IN2P3 Geant4 Tutorial**, LAL, Orsay (France), 18-22 May 2015.
- **Geant4 Course at the 12th Seminar for Nuclear, Sub-nuclear and Applied Physics**, Porto Conte, Alghero (Italy), 24-29 May 2015.
- **14th Space Users Workshop**, Hiroshima (Japan), 20-28 August 2015.
- **20th Geant4 Collaboration Meeting**, at Fermilab, Batavia (Illinois, USA), 28 September - 2 October 2015.

Past events
Installation Guide


• List of supported platforms
  – currently Linux, Mac OSX, Windows

• List of required software
  – C++ compiler, CMake, Make (Linux/MAC only), Geant4 toolkit
  – choices for visualization software

• How to install using CMake

• How to make an executable program
Application Developers’ Guide


• Introduces new users to Geant4 toolkit

• Describes the most useful tools

• Describes how to set up and run a simulation application

• Intended as an overview of the toolkit, not an exhaustive treatment. For more details:
  • Physics Reference Manual
  • Toolkit Developers’ Guide
Toolkit Developers Guide


• For developers and experienced users of Geant4
  – already familiar with functionality of Geant4 toolkit as explained in the “User’s Guide For Application Developers”
  – a working knowledge of programming using C++ is assumed

• Includes
  – a description of the object oriented design of the Geant4 toolkit
  – philosophy behind design choices
  – a guide for users who want to extend the functionality of Geant4: adding new solids, modifying the navigator, creating new fields, etc.
Physics Reference Manual


• Presents the theoretical formulation, model or parameterization of the physics interactions included in Geant4
• Describes the probability of occurrence of an interaction and the sampling mechanisms required to simulate it

• Serves as a reference for toolkit users and developers who wish to consult the underlying physics of an interaction
• The manual contains some gaps in documentation – we’re working on it
• Now distributed only in pdf
Examples

• Extensive set of examples distributed with the toolkit

• Varying complexity:
  • Basic: complete applications demonstrating simple features of toolkit – good for tutorials
  • Extended: demonstrating specific features of Geant4 and more complex use cases – some require external (non-Geant4 libraries)
  • Advanced: complex, “real life” applications with complex geometries and physics focused on specific user communities

• Documentation provided in README files in each example, and web pages
Basic Examples

• B1
  • A few simple solids and simple placements
  • Total dose scoring in user-selected volume
  • User action classes

• B2
  • Magnetic field, parameterized placements
  • Scoring in tracker using sensitive detector and hits
  • Geant4 physics list (FTFP_BERT) with step limiter

• B3 (schematic PET system)
  • Simple placements with rotations
  • Scoring within crystals using Geant4 scorers
  • radioactive source, modular physics list using builders
Basic Examples

• B4 (layered calorimeter)
  • Geometry with replicas (G4PVReplica)
  • Multiple scoring methods
  • Histograms (1D) and ntuples saved in output file

• B5 (double-arm spectrometer)
  • Complex geometry with rotation, replicas, parameterization
  • Scoring in multiple volumes with sensitive detector and hits
  • Defining local UI commands
  • Histograms (1D, 2D) and ntuples saved in output file
A Sampling of Extended Examples

• Analysis – histogramming using G4tools

• Biasing – event biasing, scoring and reverse Monte Carlo

• Electromagnetic – many EM physics simulations with histogramming (some also used as part of Geant4 testing)

• Hadronic – same as EM but with hadronic models

• Parallel – examples of parallel computing

• Visualization – specific visualization features and graphics customizations
20 Extended Examples

- analysis/
- biasing/
- common/
- electromagnetic/
- errorpropagation/
- eventgenerator/
- exoticphysics/
- field/
- g3tog4/
- geometry/
- hadronic/
- medical/
- optical/
- parallel/
- parameterisations/
- persisitency/
- polarisation/
- radioactive
decay/
- runAndEvent/
- visualization/
Advanced: Gamma Ray Telescope

Simulation of a gamma ray space telescope
  very similar to Fermi Gamma Space Telescope

Studies the tracking and calorimetry of ~GeV gammas
  16 Si foil tracker towers
  16 CsI calorimeters
  GammaRayTelPhysicsList
  customized particle generator
  AIDA-based analysis
Advanced: X-ray Telescope

Simulation of XMM Newton telescope
  
  first application of Geant4

Studies the focusing of background protons onto focal plane arrays
  
  carbon fiber tube, x-ray mirrors

XrayTelPhysicsList

G4hMultipleScattering is main process

General Particle Source

AIDA-based analysis
Advanced: Underground Physics

Realistic example of underground dark matter search experiment

Full lab geometry
- desks, cupboards, door and windows
- important for neutron scattering

Physics
- low energy, standard EM
- neutron HP
- optical processes
- radioactive decay
- General Particle Source
Advanced: Hadron Therapy

Specifically developed to address needs of proton and ion therapy

Proton beam line
Standard geometry for IAEA benchmark

Physics
uses Reference Physics Lists
specific “local” physics list for ion-ion interactions
Advanced: Human Phantom

Anthropomorphic phantoms for Geant4 simulations

Two models are available:
  - MIRD and ORNL
  - male and female for each model

Some geometries are implemented through GDML

Physics processes
  - standard EM processes
21 Advanced Examples

- amsEcal/
- Brachytherapy/
- ChargeExchangeMC/
- Composite calorimeter/
- Dnaphysics/
- Dnageometry/
- eRosita/
- Gamma-knife/
- Hadrontherapy/
- iort_therapy/
- Medical linac/
- Microbeam/
- Microdosimetry/
- Microelectronics/
- Nanobeam/
- Purging magnet/
- Radioprotection/
- RICH/
- Underground physics/
- X-ray fluorescence/
- X-ray telescope/
User Support: LXR Code Browser

• URL: www-geant4.kek.jp/LXR/

• Search entire Geant4 source tree by
  – filename (e.g. G4Track.hh)
  – identifier
  – text

• Result: a source file fully hyper-linked to classes and methods
  – tells where classes and methods are defined
  – also where they are referenced

• Also have a doxygen version:
  – www-geant4.kek.jp/Reference
G4Alpha Class Reference

Inheritance diagram for G4Alpha:

Static Public Member Functions

- static G4Alpha * Definition()
- static G4Alpha * AlphaDefinition()
- static G4Alpha * Alpha()

Static Public Member Functions inherited from G4ParticleDefinition

Private Member Functions

- G4Alpha()
- ~G4Alpha()

Static Private Attributes

- static G4Alpha * theInstance

Additional Inherited Members

- Public Member Functions inherited from G4Ions
- Public Member Functions inherited from G4ParticleDefinition
- Protected Types inherited from G4ParticleDefinition
- Protected Member Functions inherited from G4Ions
HyperNews User Forum

- URL: hypernews.slac.stanford.edu/HyperNews/geant4/cindex

- See also top of Geant4 home page
- Discuss problems with other users, post questions for experts, etc.
- 23 forums roughly based on Geant4 categories

- 4 forums for specific application areas
- New forums may be requested by users

- To join: click on “New Member” at top of page and fill out form
Summary

• **Installation, Application, Toolkit and Physics Guides** take you from making your first Geant4 installation to developing your own application to developing advanced Geant4 features

• **Three levels of examples: ranging from very easy to complex**
  - basic – getting started
  - extended – exploring specific features of Geant4
  - advanced - real world applications

• **User support includes:**
  - cross reference code browser (LXR, Doxygen)
  - user forum is available for sharing ideas, asking questions
  - periodic tutorials