



GEANT4
A SIMULATION TOOLKIT

Version 10.5

User Documents and Examples

Gunter Folger (CERN)
Geant4 Beginners Course

Acknowledgement

- This lecture is by large taken from a lecture of a previous tutorial in Lund prepared by Dennis Wright (SLAC)
- The original lectures of the Lund tutorial are available at <http://geant4.slac.stanford.edu/LUND2018/>

- User Documents
- Examples
 - basic
 - extended
 - advanced
- User Support
 - LXR and Doxygen source code browsers
 - HyperNews User Forum

Your First Stop: Geant4 Web Pages

www.geant4.org



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Overview

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 three main reference papers for Geant4 are published in Nuclear Instruments and Methods in Physics Research A 506 (2003) 250-303, IEEE Transactions on Nuclear Science 53 No. 1 (2006) 270-278, and Nuclear Instruments and Methods in Physics Research A 835 (2016) 186-225.

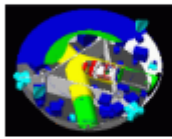
Applications



A sampling of applications, technology transfer and other uses of Geant4

[printer-friendly version](#)

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

- 12 Mar 2018
[2018 planned developments](#)
- 6 Mar 2018
Patch-01 to release 10.4 is available from the [Download area](#).
- 20 Oct 2017
Patch-03 to release 10.3 is available from the [source archive area](#).

Events

- Geant4 Course at the 15th Seminar on Software for Nuclear, Sub-nuclear and Applied Physics, Porto Conte, Alghero (Italy), 27 May - 1 June, 2018.
- Geant4 Tutorial, at the University of Texas MD Anderson Cancer Center, Houston (USA), 25-27 June, 2018.
- Geant4 Short Course at the African School of Physics 2018, University of Namibia, Windhoek (Namibia), 3 July, 2018.
- 7th International Geant4 Tutorial, at KIRAMS, Seoul (Korea), 9-13 July, 2018.
- 23rd Geant4 Collaboration Meeting, Lund University, Lund (Sweden), 27-31 August 2018.

1 2 next last >

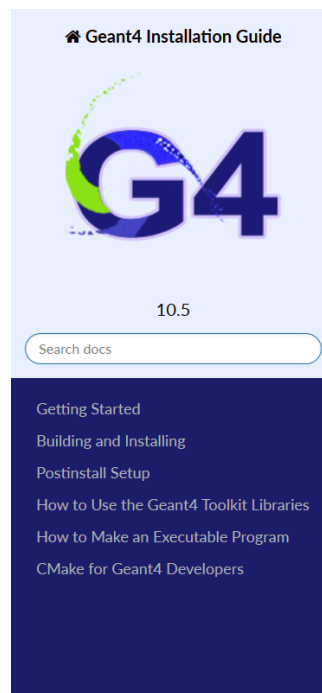
Past Events

DOCUMENTATION

Installation guide

<http://cern.ch/geant4-userdoc/UsersGuides/InstallationGuide/html/gettingstarted.html>

- Geant4 main page → User Support → Item 8b
- 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



Docs » Geant4 Installation Guide

Geant4 Installation Guide

Scope of this Manual

Geant4 uses CMake to configure a build system for compiling and installing the toolkit headers, libraries and support tools. This document covers the basics of using CMake to build and install Geant4 together with an overview of the most commonly used advanced features. We also provide a basic overview of how to build an application that uses Geant4.

Whilst every effort has been made to make the build of Geant4 robust and reliable, the multitude of platforms and system configurations mean we cannot guarantee that problems will not be encountered on platforms other than those listed in [Supported and Tested Platforms](#).

In case of issues with building and installing Geant4, we welcome questions as well as feedback via our [HvnerNews Forum](#) To help us deal with your problem

Application Developers' Guide

<http://cern.ch/geant4-userdoc/UsersGuides/ForApplicationDeveloper/html/index.html>

- Geant4 main page → User Support → Item 8c
- 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

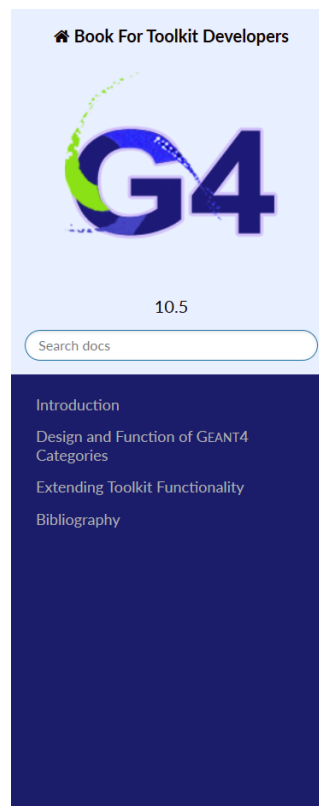


The screenshot shows the 'Book For Application Developers' page for Geant4. The page features a large 'G4' logo with a green and blue trail. Below the logo is a search bar and a version number '10.5'. A dark blue sidebar on the left contains a table of contents with the following items: Introduction, Getting Started with Geant4 - Running a Simple Example, Toolkit Fundamentals, Detector Definition and Response, Tracking and Physics, User Actions, Control, Visualization, Analysis, Examples, Appendix, and Bibliography. The main content area on the right has a breadcrumb trail 'Docs » Geant4 Book For Application Developers', a title 'Geant4 Book For Application Developers', and a section 'Scope of this manual'. The text explains that this manual is the first one to consult for learning about GEANT4 or developing a detector simulation program. It lists three bullet points: introducing the first-time user to the GEANT4 toolkit, providing a description of available tools, and supplying practical information for developing and running simulation applications. At the bottom, it states the manual is an overview rather than an exhaustive treatment, and provides references to the Physics Reference Manual and the User's Guide for Toolkit Developers.

Toolkit developers guide

<http://web.cern.ch/geant4-userdoc/UsersGuides/ForToolkitDeveloper/html/index.html>

- Geant4 main page →
User Support → Item 8d
- 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.



[Docs](#) » [Geant4 User's Guide for Toolkit Developers](#)

Geant4 User's Guide for Toolkit Developers

Scope of this Manual

The User's Guide for Toolkit Developers provides detailed information about the design of GEANT4 classes as well as the information required to extend the current functionality of the GEANT4 toolkit. This manual is designed to:

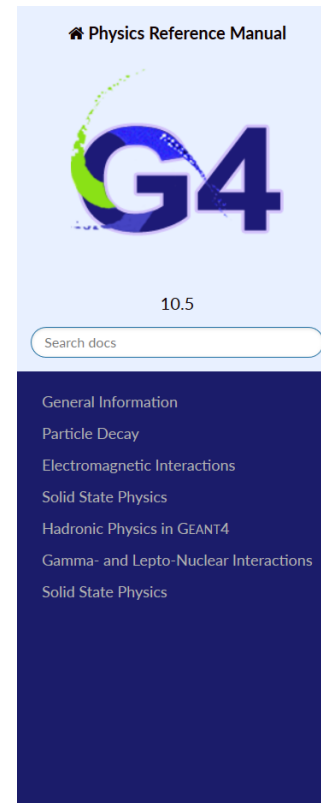
- provide a repository of information for those who want to understand or refer to the detailed design of the toolkit, and
- provide details and procedures for extending the functionality of the toolkit so that experienced users may contribute code which is consistent with the overall design of GEANT4.

This manual is intended for developers and experienced users of GEANT4. It is assumed that the reader is already familiar with functionality of the GEANT4 toolkit as explained in the “User's Guide For Application Developers”, and also has a working knowledge of programming using C++. A knowledge of object-oriented analysis and design will also be useful in

Physics Reference Manual

<http://web.cern.ch/geant4-userdoc/UsersGuides/ForToolkitDeveloper/html/index.html>

- Geant4 main page → User Support → Item 8e
- 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



[Docs](#) » [Physics Reference Manual](#)

Physics Reference Manual

Scope of this Manual

The Physics Reference Manual provides detailed explanations of the physics implemented in the GEANT4 toolkit.

The manual's purpose is threefold:

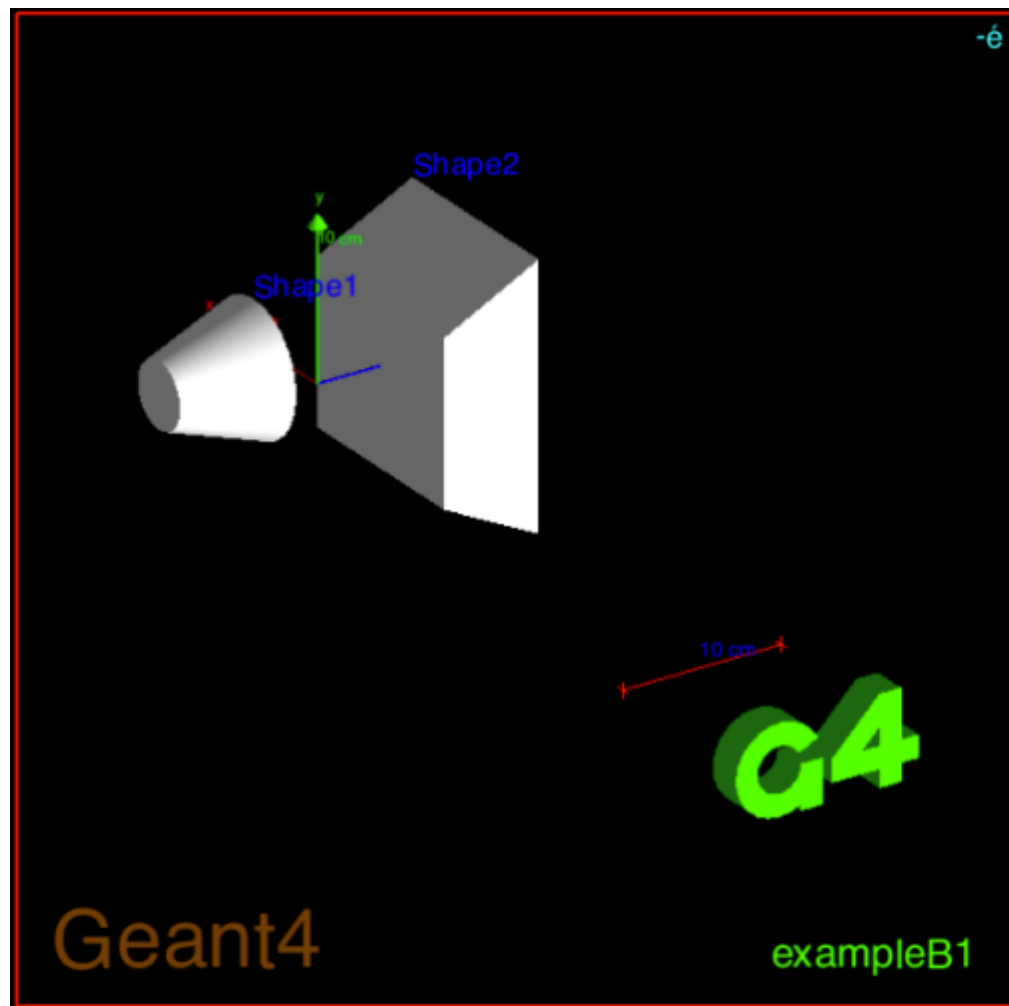
- to present the theoretical formulation, model, or parameterization of the physics interactions included in GEANT4,
- to describe the probability of the occurrence of an interaction and the sampling mechanisms required to simulate it, and
- to serve as a reference for toolkit users and developers who wish to consult the underlying physics of an interaction.

This manual does not discuss code implementation or how to use the implemented physics interactions in a simulation. These topics are discussed in the *User's Guide for Application Developers*. Details of the object-oriented design and functionality of the GEANT4 toolkit are given in the *User's Guide for Toolkit Developers*.

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

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

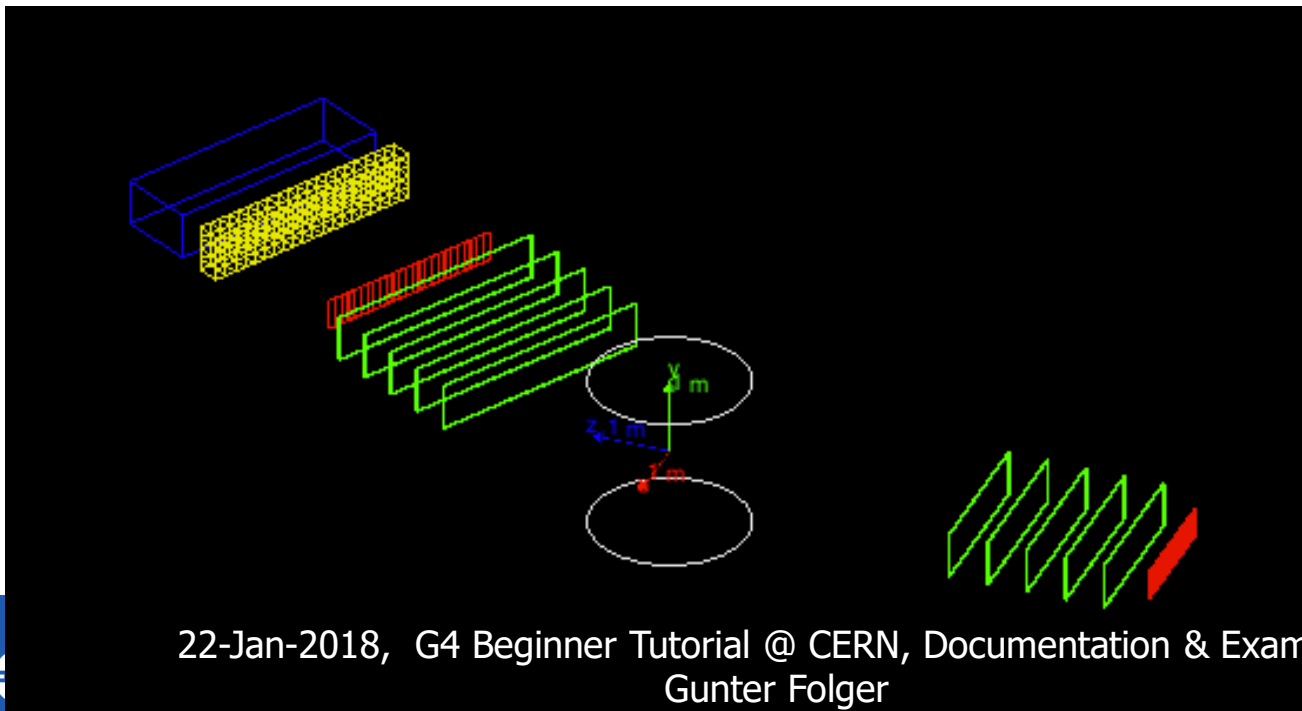


Basic Examples

- 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
- B4
 - geometry with replicas
 - multiple scoring methods
 - histograms (1D) and ntuples saved in output file

Basic Examples

- 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

Extended Examples (10.5)

- analysis/
- biasing/
- common/
- electromagnetic/
- errorpropagation/
- eventgenerator/
- exoticphysics/
- field/
- g3tog4/
- geometry/
- hadronic/
- medical/
- optical/
- parallel/
- parameterisations/
- persisitency/
- physicslists/
- polarisation/
- radioactivedecay/
- runAndEvent/
- visualization/

Advanced Example: Gamma Ray Telescope

Simulation of a gamma ray
space telescope

very similar to Fermi Gamma
Space Telescope

Studies the tracking and
calorimetry of \sim GeV gammas

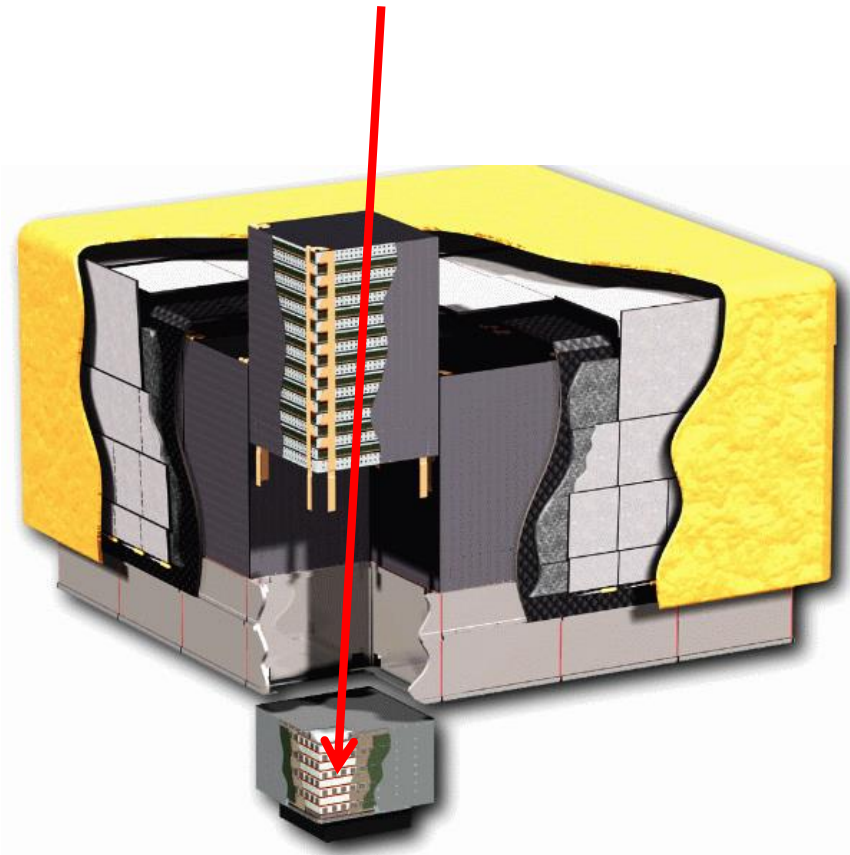
16 Si foil tracker towers

16 CsI calorimeters

GammaRayTelPhysicsList

customized particle generator

AIDA-based analysis



Advanced Example: 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 Example: Underground Physics

Realistic example of underground dark matter search experiment

Full lab geometry

desks, cupboards, door and windows
important for neutron scattering

Physics

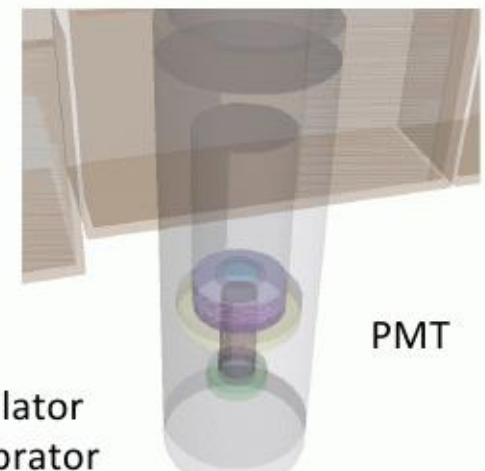
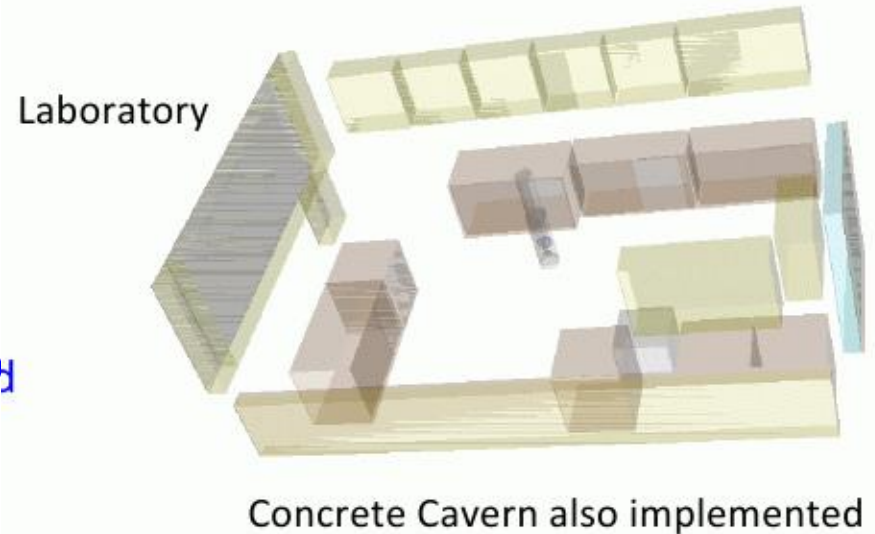
low energy, standard EM

neutron HP

optical processes

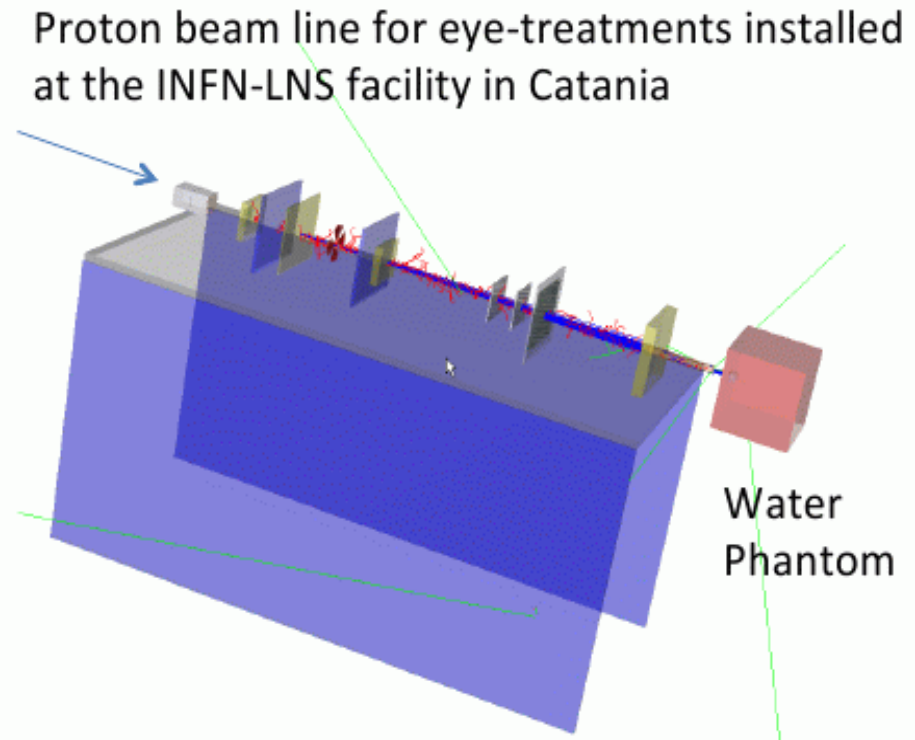
radioactive decay

General Particle Source



Advanced Example: 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 Example: Human Phantom

Anthropomorphic phantoms for Geant4 simulations

Two models are available:

MIRD and ORNL

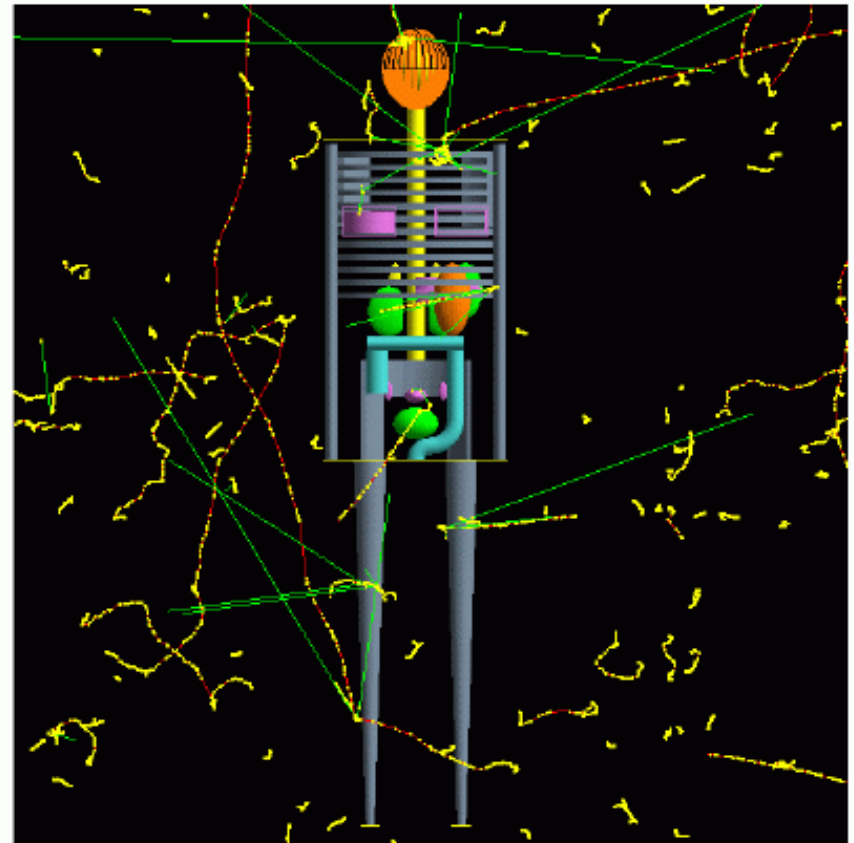
male and female for each model

Some geometries are implemented through GDML

Physics processes

standard EM processes

MIRD Female Phantom with particle tracks



22 Advanced Examples (10.5)

- air_shower
- amsEcal/
- brachytherapy/
- ChargeExchangeMC/
- composite calorimeter/
- doiPET/
- eRosita/
- gammaknife/
- gammaray_telescope
- hadrontherapy/
- human_phantom
- iort_therapy/
- lAr_calorimeter/
- medical linac/
- microbeam/
- microelectronics/
- nanobeam/
- purging_magnet/
- radioprotection/
- underground_physics/
- xray_fluorescence/
- xray_telescope/

USER SUPPORT

User support web page



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User Support

Submitted by Anonymous (not verified) on Wed, 06/28/2017 - 11:23

Related Links

- [Object Oriented Analysis & Design](#)
- [Archive of previous releases](#)
- [Mailing list subscription](#)
- [User requirements document \(pdf\)](#)
- [Technical Forum](#)

1. [Getting started](#)
2. [Training courses and materials](#)
3. [Source code](#)
 - a. [Download page](#)
 - b. [LXR code browser](#)
 - c. [doxygen documentation](#)
 - d. [GitHub](#)
 - e. [GitLab @ CERN](#)
4. [Frequently Asked Questions \(FAQ\)](#)
5. [Bug reports and fixes](#)
6. [User requirements tracker](#)
7. [User Forum](#)
8. [Documentation](#)
 - a. [Introduction to Geant4 \[pdf \]](#)
 - b. [Installation Guide: \[pdf \]](#)
 - c. [Application Developers \[pdf \]](#)
 - d. [Toolkit Developers Guide \[pdf \]](#)
 - e. [Physics Reference Manual \[pdf \]](#)
 - f. [Physics List Guide \[pdf \]](#)
9. [Examples](#)
10. [User Aids](#)
 - a. [Tips for improving CPU performance](#)
11. [Contact Coordinators & Contact Persons](#)

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

Main Page | Namespaces | **Classes** | Files

Class List | Class Index | Class Hierarchy | Class Members

Search

Static Public Member Functions | Private Member Functions | Static Private Attributes | List of all members

G4Alpha Class Reference

Inheritance diagram for G4Alpha:

```
graph BT; G4Alpha --> G4Ions; G4Ions --> G4ParticleDefinition;
```

Static Public Member Functions

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

- ▶ **Static Public Member Functions inherited from G4Ions**
- ▶ **Static Public Member Functions inherited from G4ParticleDefinition**

Private Member Functions

- G4Alpha** ()
- ~G4Alpha** ()

Static Private Attributes

- static **G4Alpha** * **theInstance**

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

Mailing List for Geant4 Announcements



- We offer a mailing list to announce releases, patches, and important events.
 - Low traffic mailing list
- To Subscribe: Geant4 web page -> User Support -> Related links (on right) -> Mailing list subscription

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