

User Documents and Examples

Geant4 Tutorial at MIT

26 May 2015

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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>

Geant 4

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Search Geant4

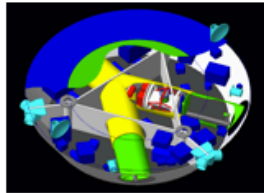
Geant4 is a toolkit for the simulation of the passage of particles through matter. Its areas of application include high energy, nuclear and accelerator physics, as well as studies in medical and space science. The two main reference papers for Geant4 are published in *Nuclear Instruments and Methods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

Applications



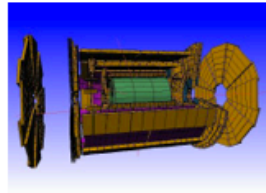
A [sampling of applications](#), technology transfer and other uses of Geant4

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

- [Geant4 Workshop at the M&C+SNA+MC 2015 Conference](#), Nashville, Tennessee (USA), **19 April 2015**.
- [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**.
- [Geant4 Tutorial 2015 at the Massachusetts Institute of Technology](#), Boston (USA), **26-30 May 2015**.
- 11th Space Users Workshop, Hiroshima (Japan), **26-28 August 2015**.
- 20th Geant4 Collaboration Meeting, at Fermilab, Batavia (Illinois, USA), **28 September - 2 October 2015**.
- [Past events](#)

Installation Guide

- URL: geant4.web.cern.ch/geant4/UserDocumentation/UsersGuides/InstallationGuide/html/
- 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
 - geant4.web.cern.ch/geant4/UserDocumentation/UsersGuides/ForApplicationDeveloper/html/ch02s08.html

Application Developers' Guide

- URL: geant4.web.cern.ch/geant4/UserDocumentation/UsersGuides/ForApplicationDeveloper/html/
- 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

- geant4.web.cern.ch/geant4/UserDocumentation/UsersGuides/ForToolkitDeveloper/html/
- 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

- geant4.web.cern.ch/geant4/UserDocumentation/UsersGuides/PhysicsReferenceManual/fo/PhysicsReferenceManual.pdf
- 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/
- radioactivedecay/
- 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 \sim GeV gammas

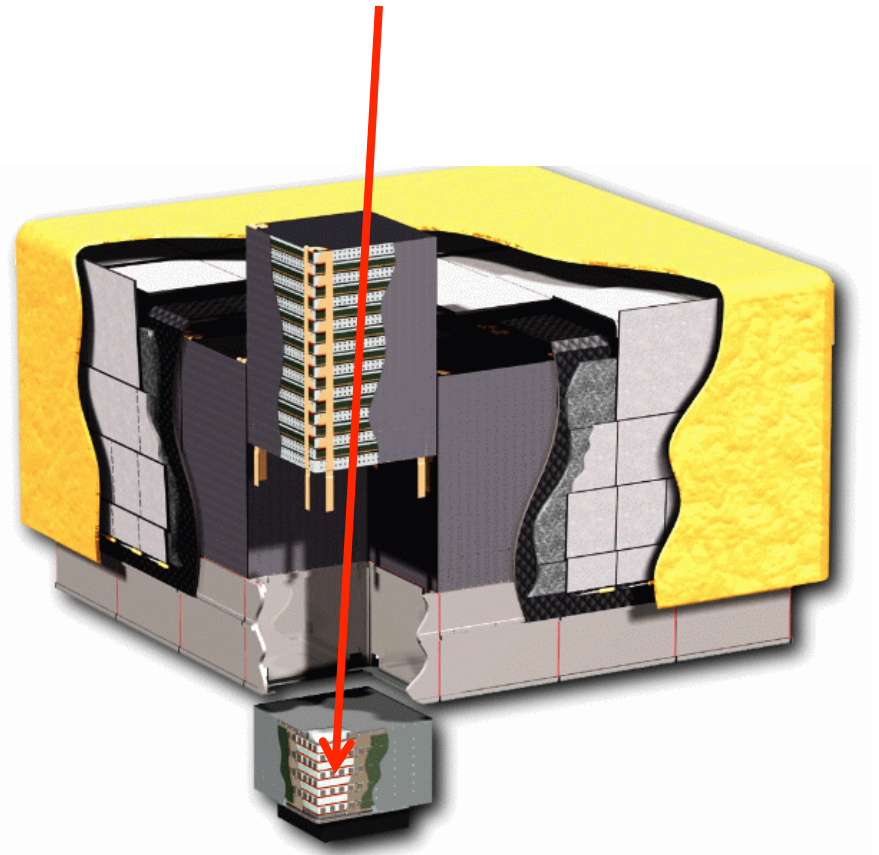
16 Si foil tracker towers

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 window

important for neutron scattering

Physics

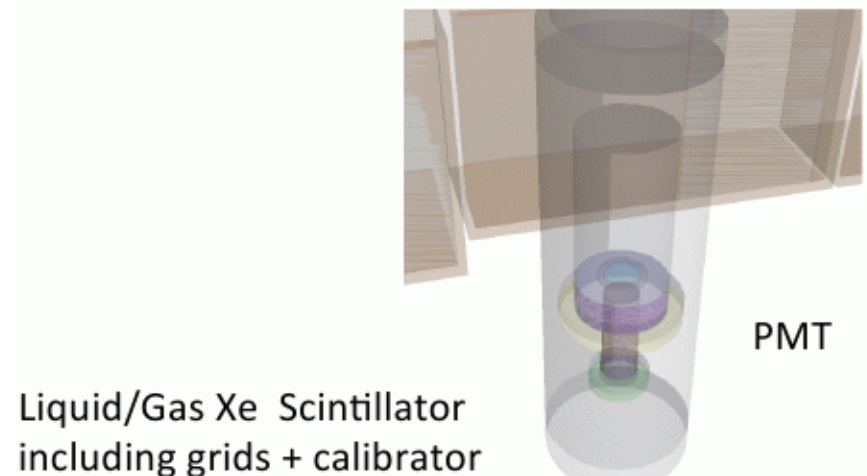
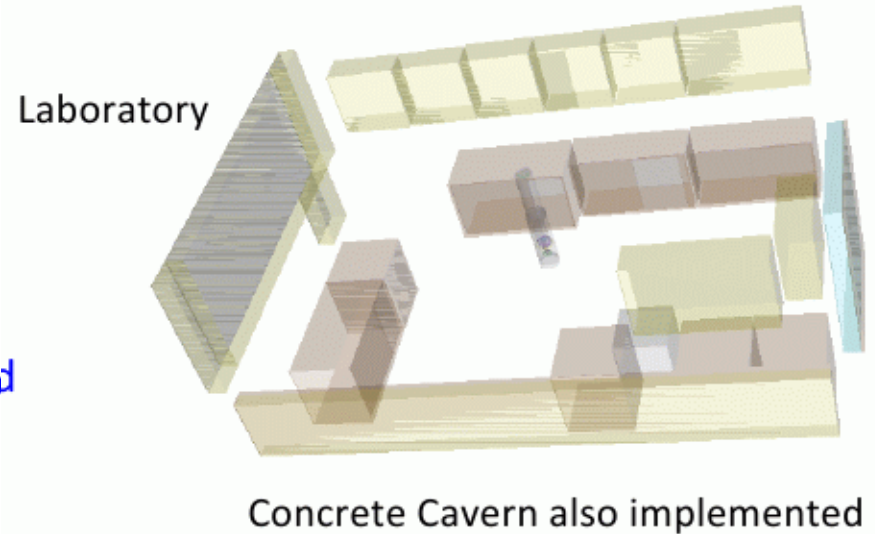
low energy, standard EM

neutron HP

optical processes

radioactive decay

General Particle Source



Advanced: Hadron Therapy

Specifically developed to address needs of proton and ion therapy

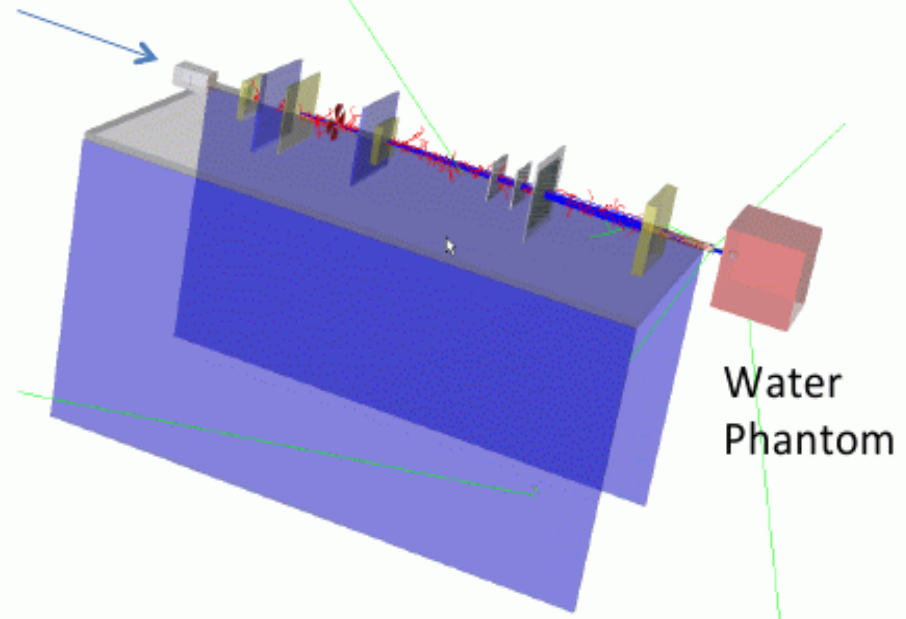
Proton beam line

Standard geometry for IAEA benchmark

Physics

uses Reference Physics Lists
specific “local” physics list for ion-ion interactions

Proton beam line for eye-treatments installed at the INFN-LNS facility in Catania



Advanced: Human Phantom

Anthropomorphic phantoms for
Geant4 simulations

Two models are available:

MIRD and ORNL

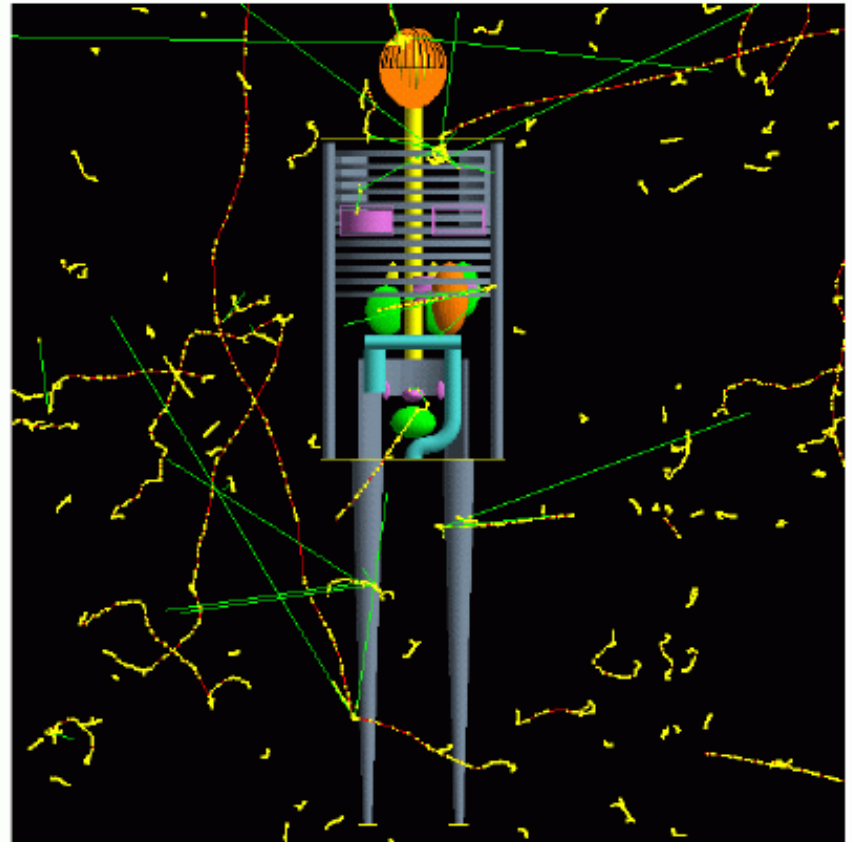
male and female for each
model

Some geometries are
implemented through GDML

Physics processes

standard EM processes

MIRD Female Phantom with particle tracks



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

Main Page	Namespaces	Classes	Files	Search	
Class List	Class Index	Class Hierarchy	Class Members		
<div><div>▶ G4AllocatorPool</div><div>▶ G4AllocStats</div><div>▶ G4Alpha</div><div>▶ G4AlphaCoulombBarrier</div><div>▶ G4AlphaDecayChannel</div><div>▶ G4AlphaEvaporationChan</div><div>▶ G4AlphaEvaporationProba</div><div>▶ G4AlphaGEMChannel</div><div>▶ G4AlphaGEMCoulombBarr</div><div>▶ G4AlphaGEMProbability</div><div>▶ G4AlphaInelasticProcess</div><div>▶ G4alphalonisation</div><div>▶ G4Analyser</div><div>▶ G4AnalysisManagerState</div><div>▶ G4AnalysisMessenger</div><div>▶ G4AnalysisVerbose</div><div>▶ G4AnalyticalPolSolver</div><div>▶ G4AngleDirect</div><div>▶ G4AngularDistribution</div><div>▶ G4AngularDistributionNP</div><div>▶ G4AngularDistributionPP</div><div>▶ G4AnnihilationCrossSectic</div><div>▶ G4AnnihiToMuPair</div><div>▶ G4AntiAlpha</div><div>▶ G4AntiAlphaInelasticProce</div><div>▶ G4AntiBarionBuilder</div><div>▶ G4AntiBMesonZero</div><div>▶ G4AntiBsMesonZero</div><div>▶ G4AntiDeuteron</div><div>▶ G4AntiDeuteronInelasticP</div><div>▶ G4AntiDMesonZero</div><div>▶ 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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