User Documents and Examples

Geant4 School at IFIN-HH, Bucharest

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SLAC

NATIONAL
ACCELERATOR
LABORATORY

Outline

- 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

Geant 4

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.
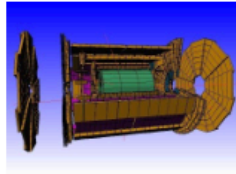
Applications

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

User Support
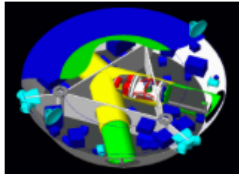
Getting started, *guides* and information for users and developers

Publications

Validation of Geant4, results from experiments and publications

Collaboration

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

News

- *9 March 2016* - 2016 planned developments.
- *2 March 2016* - **Patch-01** to **release 10.2** is available from the Download area.
- *17 February 2016* - **Patch-03** to **release 10.1** is available from the source archive area.
- *6 March 2015* - **Patch-04** to **release 10.0** is available from the source archive area.

Events

- 3rd Geant4 School and Monte Carlo Workshop for Radiotherapy, Imaging & Radiation Protection, University of Wollongong, Wollongong (Australia), **26-30 April 2016**.
- 43rd Geant4 Technical Forum, LAL, Orsay (France), **3 May 2016**.
- Geant4 Tutorial, at the Southern Methodist University, Dallas (Texas, USA), **16-19 May 2016**.
- IN2P3 Geant4 French School, LAL, Orsay (France), **23-27 May 2016**.
- Geant4 Course at the 13th Seminar for Nuclear, Sub-nuclear and Applied Physics, Porto Conte, Alghero (Italy), **5-10 June 2016**.
- Geant4 Tutorial 2016 at the Massachusetts Institute of Technology, Boston (USA), **20-23 June 2016**.
- 21st Geant4 Collaboration Meeting, Ferrara (Italy), **12-16 September 2016**.

- **Past events**

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Installation Guide

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

Application Developers' Guide

- 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

Toolkit Developers Guide

- 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.

Physics Reference Manual

- 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
- 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
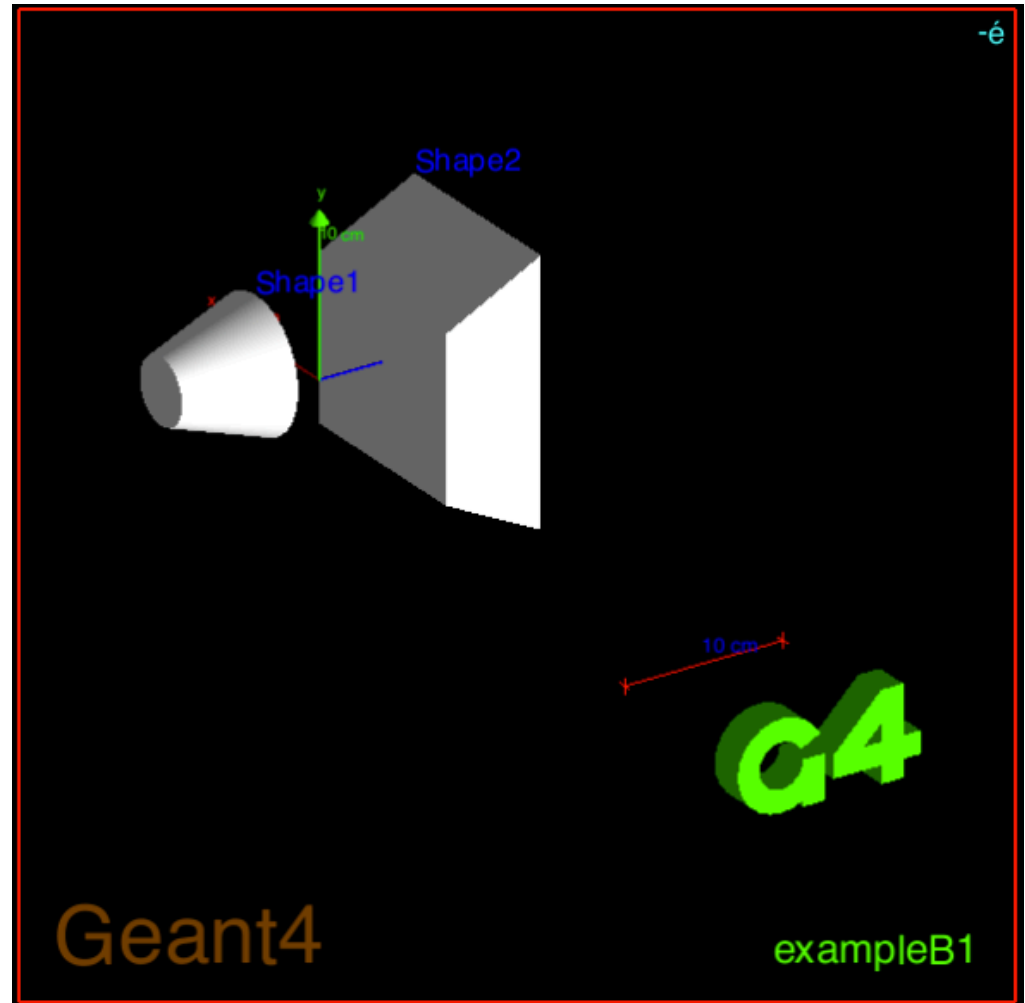
Basic Examples

- 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
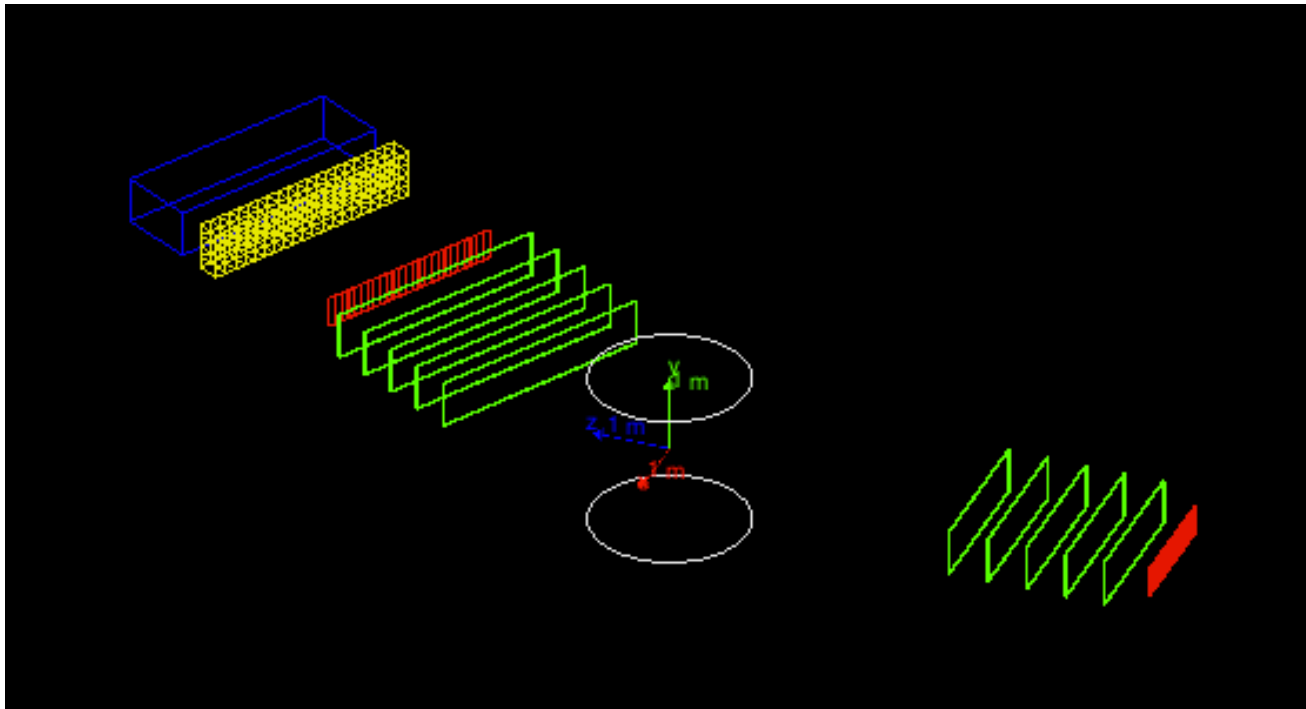
A Sampling of Extended Examples

- 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

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 ~GeV gammas

16 Si foil tracker towers

16 CsI calorimeters

GammaRayTelPhysicsList

customized particle generator

AIDA-based analysis
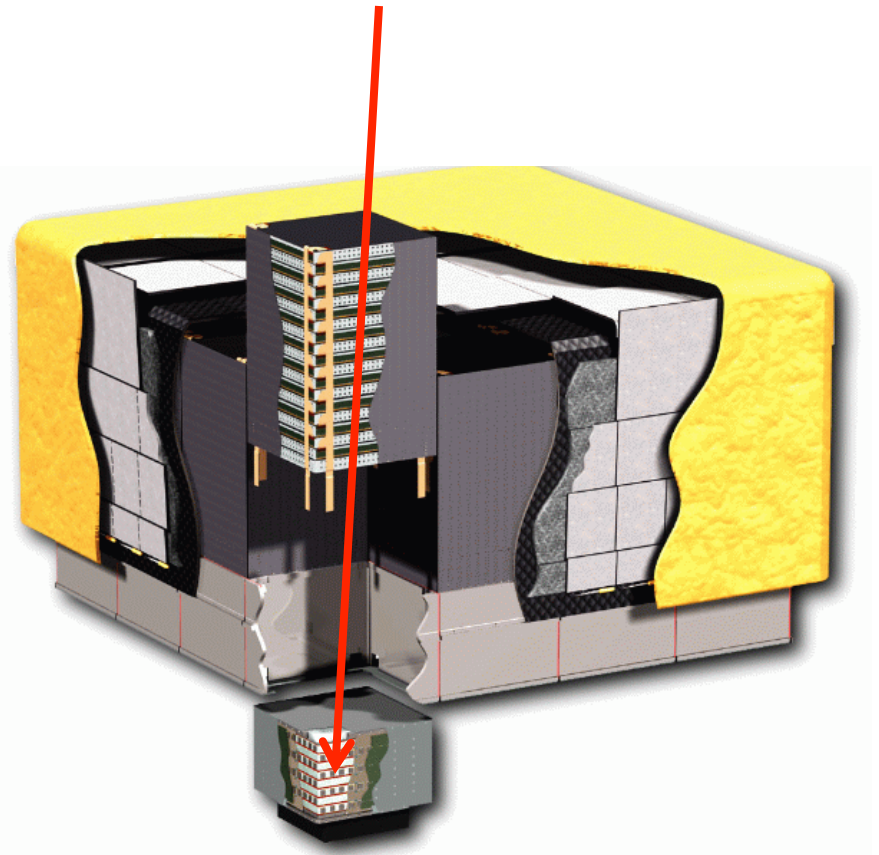
Advanced: X-ray Telescope

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

Laboratory

Concrete Cavern also implemented

PMT

Liquid/Gas Xe Scintillator
including grids + calibrator
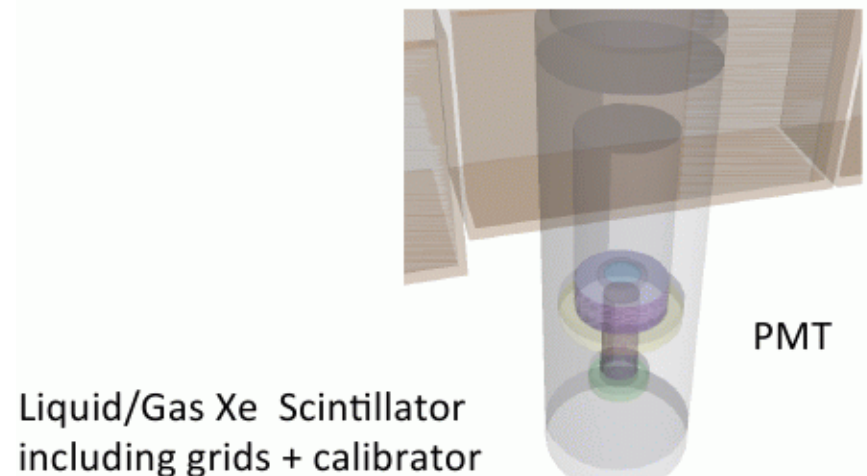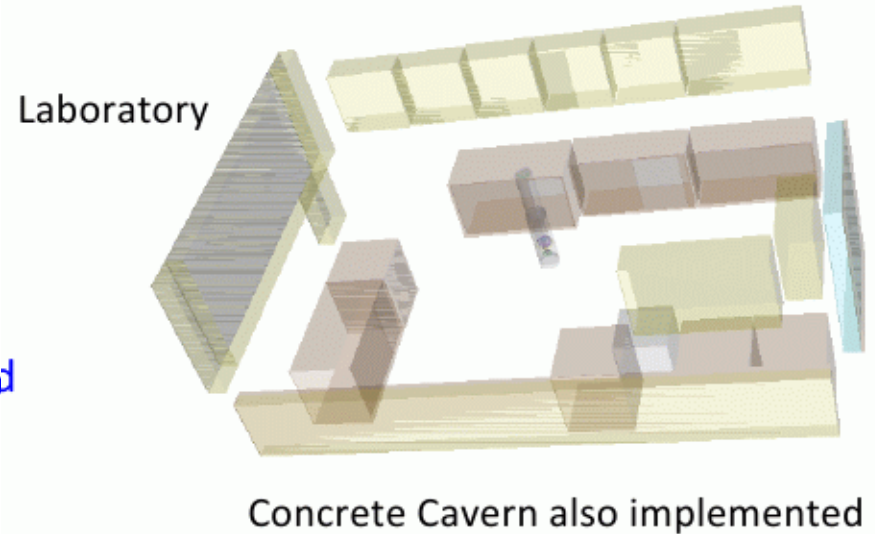
Advanced: Hadron Therapy

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

Water Phantom
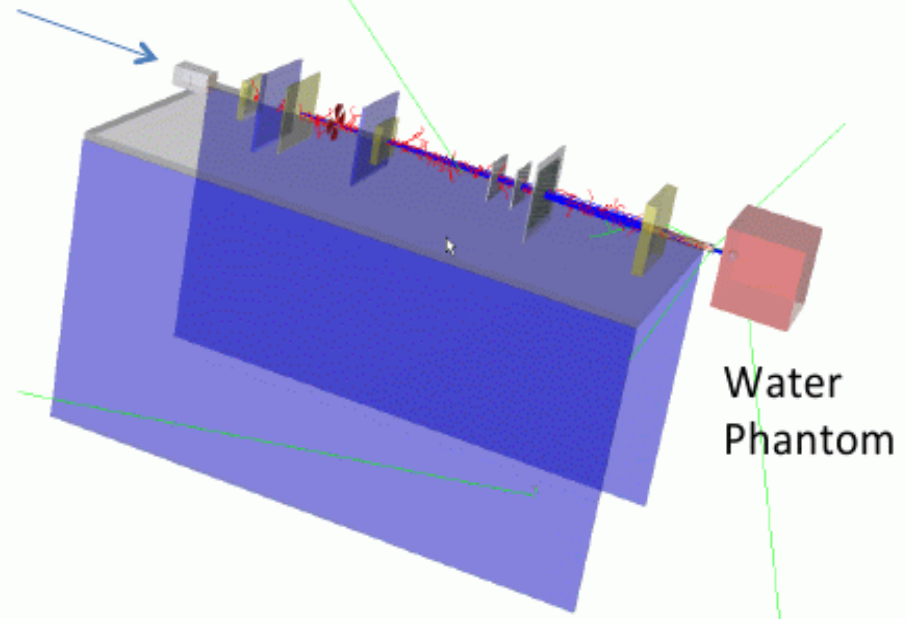
Advanced: Human Phantom

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
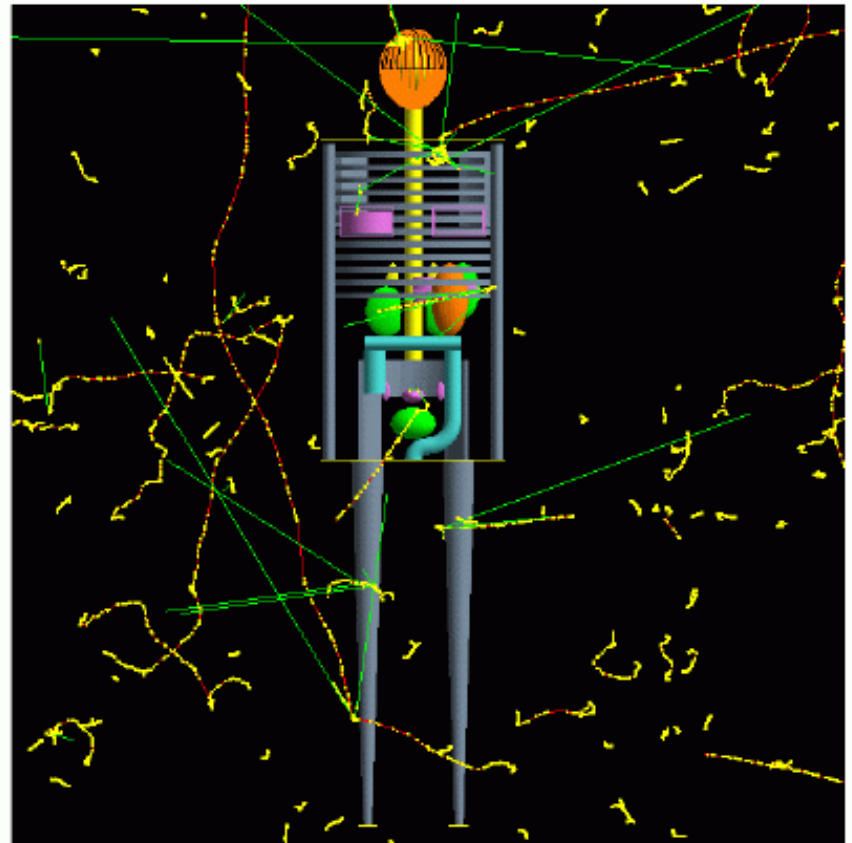
21 Advanced Examples

- 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

G4AllocatorPool
G4AllocStats
▶ **G4Alpha**
G4AlphaCoulombBarrier
G4AlphaDecayChannel
G4AlphaEvaporationChann
G4AlphaEvaporationProba
G4AlphaGEMChannel
G4AlphaGEMCoulombBarr
G4AlphaGEMProbability
G4AlphaInelasticProcess
G4alphaIonisation
G4Analyser
G4AnalysisManagerState
G4AnalysisMessenger
G4AnalysisVerbose
G4AnalyticalPolSolver
G4AngleDirect
G4AngularDistribution
G4AngularDistributionNP
G4AngularDistributionPP
G4AnnihilationCrossSectic
G4AnnihiToMuPair
G4AntiAlpha
G4AntiAlphaInelasticProce
G4AntiBarionBuilder
G4AntiBMesonZero
G4AntiBsMesonZero
G4AntiDeuteron
G4AntiDeuteronInelasticPr
G4AntiDMesonZero
G4AntiHe3
G4AntiHe3InelasticProcess

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

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