User Documents and Examples

Geant4 Tutorial 2011 in Seoul
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Slide is modified from original version given by
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Geant4 Collaboration
TRIUMF

Outline

- **User Documents**
  - Web Pages
  - Installation Guides
  - Application Developers' Guide
  - Toolkit Developers' Guide
  - Physics Reference Manual
- **User Aids**
  - LXR source code browser, Doxygen
  - HyperNews User Forum
- **Novice Examples**
  - Simple: trivial detector with non-interacting particles
  - Detailed: complex detector with full physics
- **Extended/Advanced Examples**

User Documents

Geant4 Web Pages

http://geant4.cern.ch/

Forum

Instructions about installation and manuals

News on latest updates

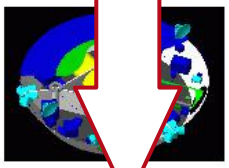
Download | User Forum | Gallery | Contact Us

Search Geant4

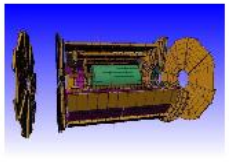
Geant4 is a toolki… areas of application … physics, as well a… papers for Geant4 ar… *in Physics Resear…* 53 No. 1 (2006) 270…

Applications & **Publication**…

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



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



Validation of Geant4, results from experiments and publications

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

News

- *28 August 2009* - **Patch-02** to **release 9.2** is available from the download area.
- *5 June 2009* - **Release 9.3 BETA** is available from the Beta download area.
- *25 February 2009* - 2009 planned developments.
- *18 December 2008* - GDML 3.0.0 released.

Jobs

- *25 June 2009* - Research assistantships for MS and PhD students, at the University of Texas (UTSA), San Antonio, USA.

Events

- 26th Technical Forum, CERN, Geneva (Switzerland), **29 September 2009**.
- Asia Simulation Conference, JSST 2009, Ritsumeikan University, Shiga (Japan), **7-9 Octo… 2009**
- 14th Geant4 Users and Collaboration Workshop, INFN/LNS, Catania (Italy), **15-22 Octobe…**
- SLAC Geant4 Tutorial 2009, SLAC, Stanford (USA), **2-6 November 2009**.
- **Past events**

Announcements for events such as GEANT4 Tutorials, Conferences, Workshops.

Applications | User Support | Results & Publications | Collaboration | Site Map

Contact Webmaster

Last updated: 18 Sep 2009

Official Installation Guides

- Designed for use by software experts

  http://geant4.web.cern.ch/geant4/UserDocumentation/UsersGuides/InstallationGuide/html/index.html

- List of required software
  - C++ compiler, CLHEP, GNU make, Geant4 toolkit
  - choices for visualization software

- How to install on Linux
- Tips for installing on Windows

Other sites

- Twiki CERN GEANT4 Web
  - https://twiki.cern.ch/twiki/bin/view/Geant4/WebHome
- Joseph Perl's Installation Guides
  - Installation
    - http://geant4.slac.stanford.edu/installation
      - Linux, Mac, Windows
  - Tutorials for 3 Most Commonly Used Visualization Systems
    - http://geant4.slac.stanford.edu/Presentations/vis
      - OpenGL, HepRApp, DAWN

Application Developers Guide

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

- Introduces new users to the 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

- URL:
  - http://geant4.web.cern.ch/geant4/UserDocumentation/UsersGuides/ForToolkitDeveloper/html/index.html

- For developers and experienced users of Geant4
  - Already familiar with functionality of the Geant4 toolkit as explained in the "User's Guide For Application Developers".
  - A working knowledge of programming using C++ is assumed

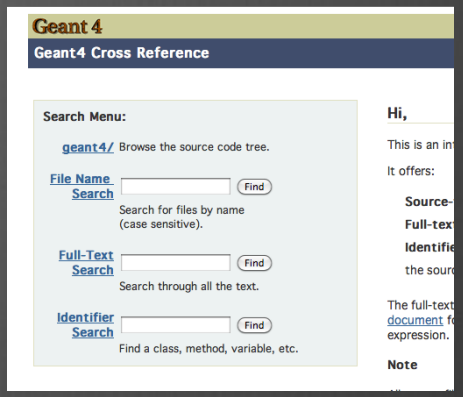
- Describing
  - Object-oriented design of the Geant4 toolkit
  - Philosophy behind design choices
  - A guide for users who want to extend the functionality of Geant4; adding new solids, modifying the navigator, creating new fields, etc.

Physics Reference Manual

- URL:
  - http://geant4.web.cern.ch/geant4/UserDocumentation/UsersGuides/PhysicsReferenceManual/fo/PhysicsReferenceManual.pdf
    - No more html version, only PDF version is available.
- A manual for
  - Presenting the theoretical formulations, models, or parameterisations of the physics interactions included in Geant4
  - Describing the probability of the occurrence of an interaction and the sampling mechanisms required for simulation.
  - Serving references for toolkit users and developers who wish to consult the underlying physics of interactions.
- Physics Reference Manual contains gaps in documentation which corresponding to un-implemented interactions. There are also a few sections in which documentation is slight.

User Aids

LXR Code Browser

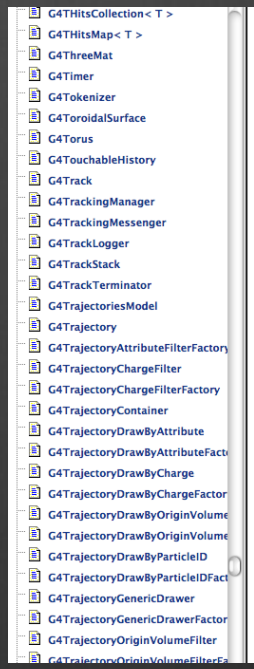


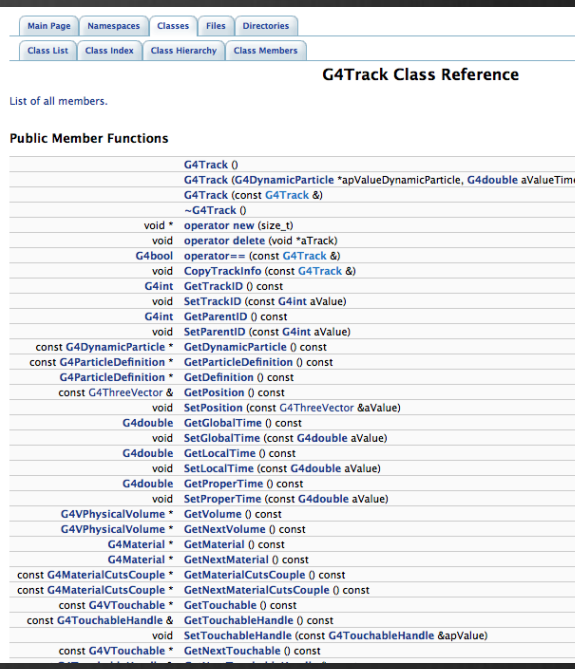
- URL: http://www-geant4.kek.jp/LXR/

(formaly "the Linux Cross Referencer")

is a software toolset for indexing and presenting source code repositories that provides web-based browsing of source code with links to the definition and usage of any identifier.

- Interactive viewing and searching facility for the entire Geant4 source code tree by
  - File name (e.g. G4Track.hh)
  - Text
  - Identifier
- Results are obtained for a source file fully hyper-linked to classes and methods
- Also have a doxygen version in
  - http://www-geant4.kek.jp/Reference





HyperNews User Forum

- URL: hypernews.slac.stanford.edu/HyperNews/geant4/cindex
  - (see also top of Geant4 home page)

HyperNews is a discussion management system providing both the functionality of mailing list systems as well as the web interface of web forums; e.g. it bridges the use of e-mail and forums.

Discussions are organized into forums and threads.

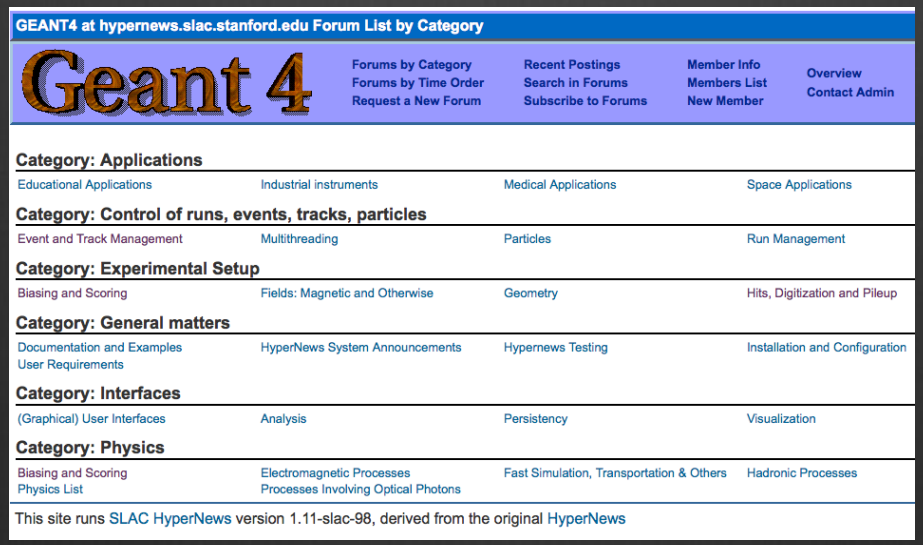
Each forum has an email gateway (if you subscribe).

Access Restrictions:

- Anyone may read messages
- Anyone may add subscriptions for notification
- Anyone may register as new member
- Only members may add messages
  - To join: click on "New Member" at top of page and fill out form

HyperNews User Forum

- Discuss problems with other users, post questions for experts, etc.
- 22 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



GEANT4 at hypernews.slac.stanford.edu Forum List by Category

Geant 4

Forums by Category | Forums by Time Order | Request a New Forum | Recent Postings | Search in Forums | Subscribe to Forums | Member Info | Members List | New Member | Overview | Contact Admin

Category: Applications

Educational Applications	Industrial instruments	Medical Applications	Space Applications

Category: Control of runs, events, tracks, particles

Event and Track Management	Multithreading	Particles	Run Management

Category: Experimental Setup

Biasing and Scoring	Fields: Magnetic and Otherwise	Geometry	Hits, Digitization and Pileup

Category: General matters

Documentation and Examples User Requirements	HyperNews System Announcements	Hypernews Testing	Installation and Configuration

Category: Interfaces

(Graphical) User Interfaces	Analysis	Persistency	Visualization

Category: Physics

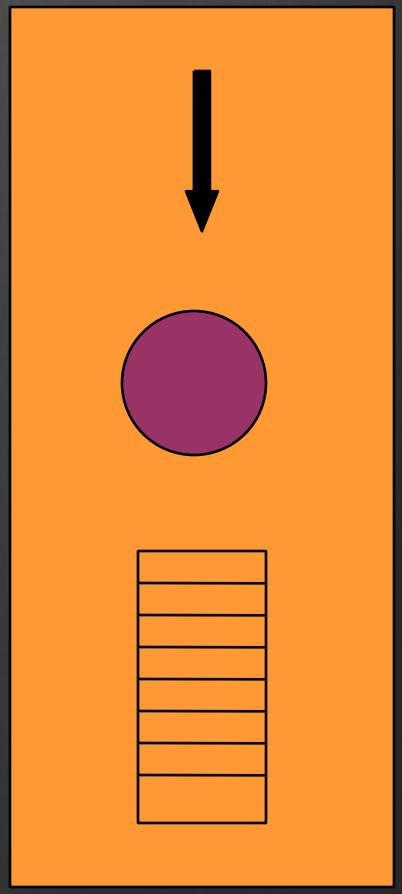
Biasing and Scoring Physics List	Electromagnetic Processes Processes Involving Optical Photons	Fast Simulation, Transportation & Others	Hadronic Processes

This site runs SLAC HyperNews version 1.11-slac-98, derived from the original HyperNews

Geant4 examples

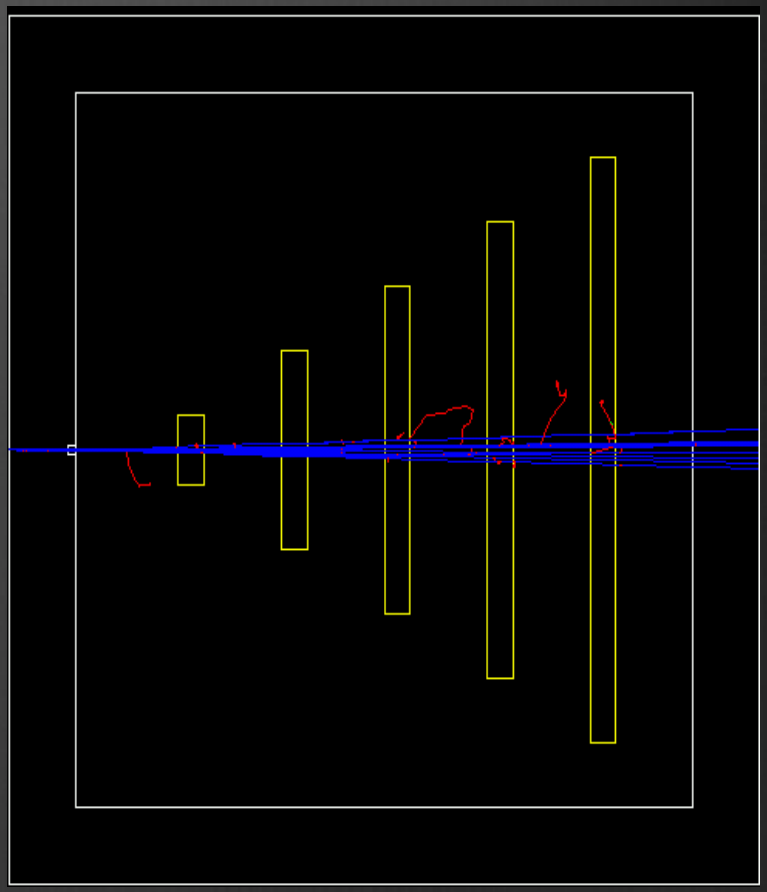
Novice Example N01

- hard coded batch, only mandatory user classes
- single element material, fixed geometry (GSG solids, G4PVPlacement without rotation)
- incident particle is a geantino
- only Transporation and no physics interactions, *G4ParticleGun*
- no magnetic field



Novice Example N02

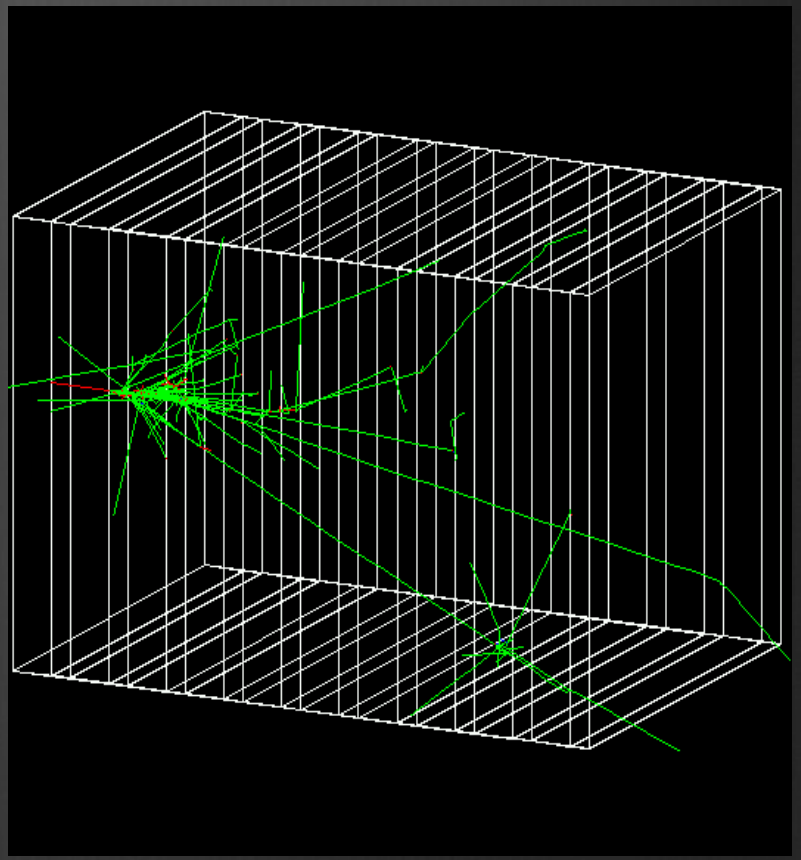
- interactive/batch mode
- simplified tracker geometry (parameterized volumes), mixtures and compound elements
- all EM processes + decay included for γ, charged leptons and charged hadrons
- uniform magn. Field, stack control
- detector response (SD/Hits)
  - trajectories and chamber hit collections may be stored
- Visualization of detector and event
- Command interface introduced



Novice Example N03

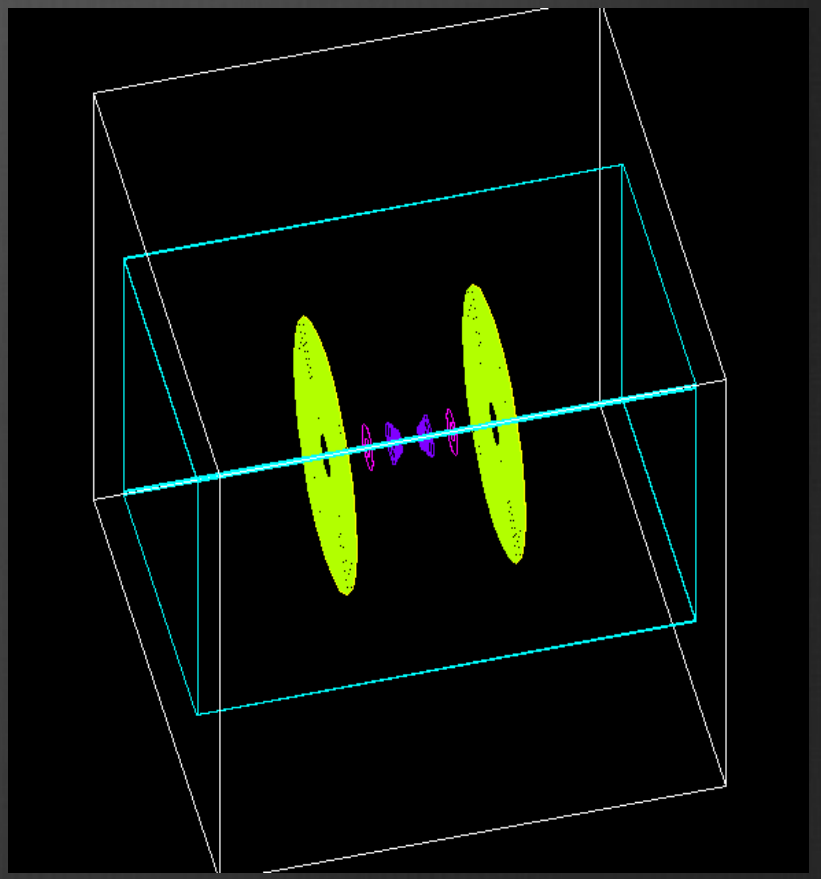
- Sampling calorimeter with layers of Pb absorber and liquid Ar detection gaps (replicas)
- Automatic initialization of geometry via macro file (command interface)
- Exhaustive material definitions
- Randomization of incident beam

- All EM processes + decay, with separate production cuts for γ, e+, e- (use for shower studies)
- Detector response: E deposit, track length in absorber and gap
- **Visualization tutorial**
- **Random number seed handling**



Novice Example N04

- simplified collider detector
  - all kinds of volume definitions
  - Readout geometry
- events from PYTHIA primary generator (HEPEvtInterface)
- full set of EM + hadronic processes
- non-uniform magn. field
- event filtering by using stacking mechanism
- defined user commands

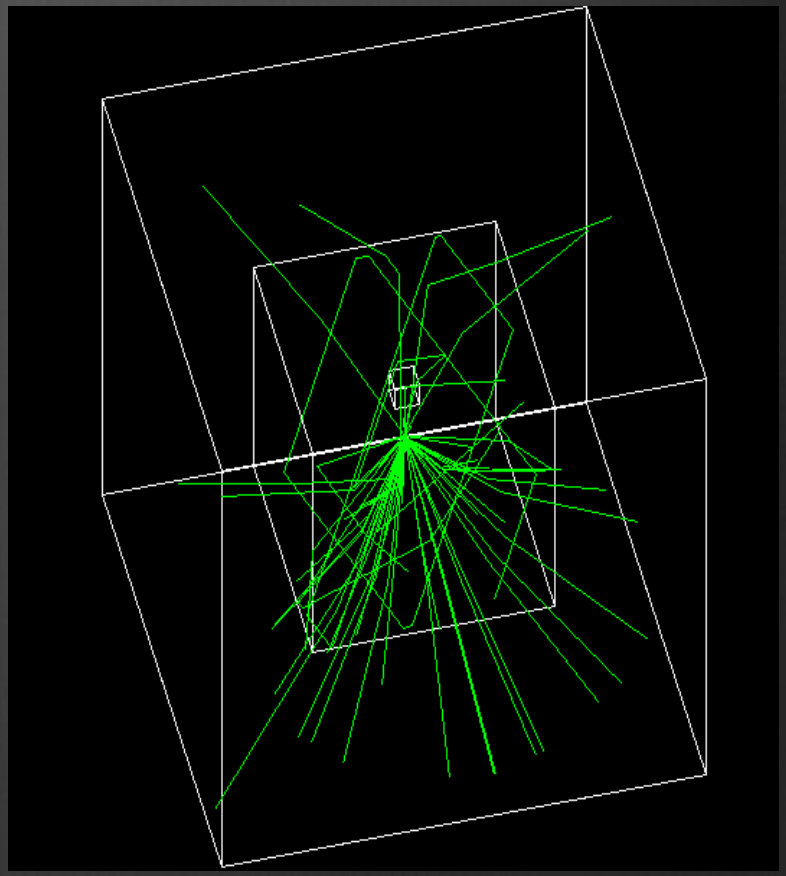


Novice Example N05

- Fast simulation with parameterized showers
  - ghost volume for shower parametrisation
  - EM showers (derived from G4VFastSimulationModel)
- EM physics only
  - Use of G4FastSimulationManagerProcess
- simplified collider detector geometry
  - drift chamber
  - EM, hadronic calorimeter
- sensitive detector

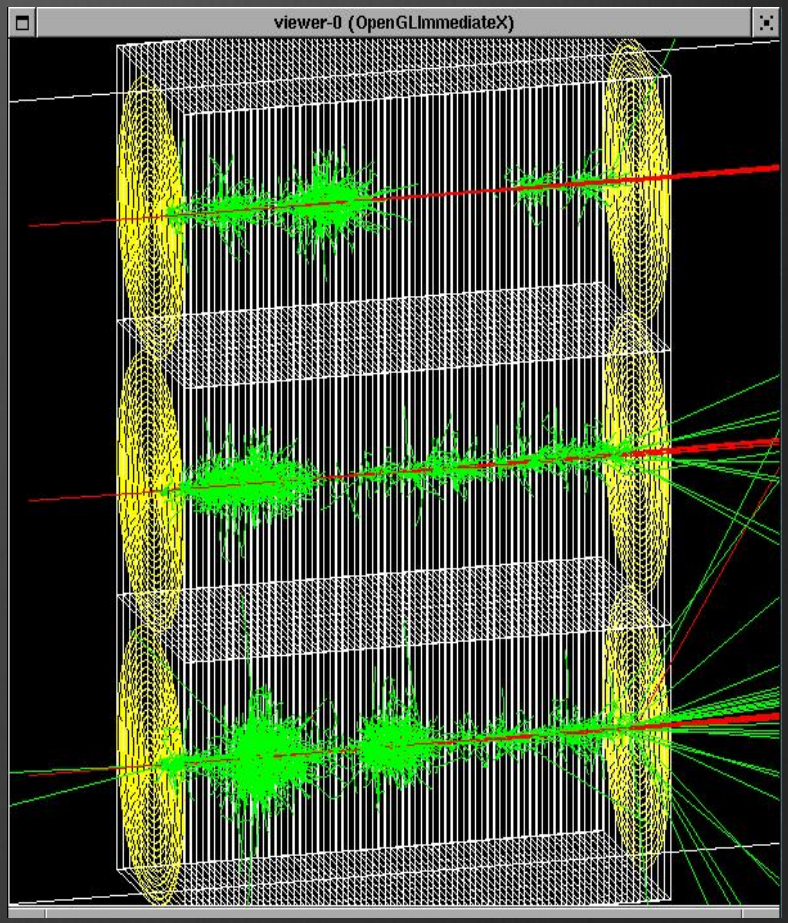
Novice Example N06

- Water Cerenkov detector with air "bubble"
- Materials
  - specification of optical properties
  - specification of scintillation spectra
- Physics
  - Optical processes
  - Generation of Cerenkov radiation, energy loss collected to produce scintillation photons
- Random number engine



Novice Example N07

- 3 simplified sandwich calorimeters
- Derived run class and run action
- cylindrical ghost volume for scoring (primitive scorer and filters)
- Run-based (as opposed to event-based) hit accumulation
- changing geometries without rebuilding world (dynamic geometry setups between runs)
- setting different secondary production cuts for each geometrical region using G4Region



Novice Examples Documentation

WebPages

(UsersGuide Chapter 9.1)

http://geant4.web.cern.ch/geant4/UserDocumentation/UsersGuides/ForApplicationDeveloper/html/ch09.html

Extended Examples

Testing and validation of process and tracking
Demonstration of Geant4 tools, and extending the functionality of Geant4.

- **Analysis:**
  - A01 - hit-scoring and histogramming using the AIDA interface
- **Electromagnetic Physics**
  - TestEm0: how to print cross-section and stopping power used in input by standard EM package
  - TestEm1: how to activate/inactivate processes, survey the range of charged particles, how to define a maximum step size
  - TestEm02: shower development in an homogeneous material, longitudinal and lateral profiles

Extended Examples

- **Electromagnetic Physics**
  - TestEm3: shower development in a sampling calorimeter, collect energy deposited, survey energy flow and print stopping power
  - TestEm4: 9MeV point like photon source, plot spectrum of energy deposited in a single media
  - TestEm5: how to study transmission, absorption and reflection of particles through a single thin or thick layer
  - TestEm6: physics list for rare, high energy EM processes
  - TestEm7: hot to produce a Bragg curve in water phantom, how to computer dose in tallies
  - TestEm8: test of photo-absorption-ionisation (PAI) model in thin absorbers, and transition radiation
  - TestEm9: shower development in a crystal calorimeter, cut per region

Extended Examples

- **Electromagnetic Physics**
  - TestEm10: XTR transition radiation model, investigation of ionisation in thin absorbers
  - TestEm11+12: how to plot a depth dose profile
  - TestEm13: how to compute cross sections of EM processes from rate of transmission coefficient
  - TestEm14: how to compute cross sections of EM processes from direct evaluation of the mean-free path
  - TestEM15: compute and plot final state of Multiple Scattering as an isolated process
  - TestEm16: simulation of synchrotron radiation
  - TestEm17: check the cross sections of high energy muon processes
  - TestEm18: energy lost by a charged particle in a single layer, due to ionization and bremsstrahlung

Extended Examples

- **Error Propagation**
  - Geant4E
- **Event Biasing**
  - Reverse Monte Carlo
- **Event Generator**
  - HepMCEx01: simplified collider detector using HepMC interface and stacking
  - exgps: illustrates the usage of the G4GeneralPartaicleSource utility
  - phythia: illustrates the usage of Pythia as MC event generator, interfaced with Geant4 and shows how to implement external decayer

Extended Examples

- **Fields:**
  - field01: tracking in a magnetic field
  - field02: tracking in an electric field
  - field03: tracking in a magn. field but where the field is associated with a selected logical volume
  - field04: definition of overlapping fields; magnetic, electric or both
  - field05: spin-tracking - demonstration of *'spin-frozen'* condition, how to cancel the muon g-2 precession by applying an electric field
- **Geometry:**
  - OLAP: debugging tool for overlapping geometries
- **Hadronic:**
  - Hadr00: example demonstrating the usage of G4PhysListFactory to build physics list and usage of G4HadronicProcessStore to access the cross sections

Extended Examples

- **Medical Applications:**
  - DICOM: geometry set-up using the G4 interface to DICOM image format
  - fanoCavity: radioactive dose deposition inside cavity from gamma beam (Fano Theorem)
  - fanoCavity2: same as above but for an electron beam
- **Optical Photons:**
  - wls: application simulating the propagation of photons inside a wave length shifting (WLS) fiber
- **Parameterisations:**
  - Gflash: demonstrates the use of the GFLASH parameterisation library to parameterise EM showers in matter
- **Persistency:**
  - GDML: example set illustrating import and export of a detector geometry with GDML
  - P01: storing calorimeter hits using reflection mechanism with ROOT

Extended Examples

- **Polarisation**
  - Pol01: interaction of polarized beam (e.g. circularly polarized photons) with polarized target
- **Radioactive Decay**
  - Exrdm: decays of radioactive isotopes as well as induced radioactivity resulted from nuclear interactions
- **Run & Event**
  - RE01: information between primary particles and hits and usage of user-information classes
  - RE02: demonstration of primitive scorers
  - RE03: use of UI-command based scoring; showing how to create parallel world(s) for defining scoring mesh(es)

Extended Examples Documentation

WebPages

(UsersGuide Chapter 9.2)

http://geant4.web.cern.ch/geant4/UserDocumentation/UsersGuides/ForApplicationDeveloper/html/ch09s02.html

Advanced examples

realistic applications of Geant4 in typical experimental environments.
Most of them also show the usage of analysis tools ,
various visualization features and advanced user interface facilities

Note: Maintenance and updates of the code is under the responsibility of the authors. These applications are therefore not subject to regular system testing and no guarantee can be provided**.**

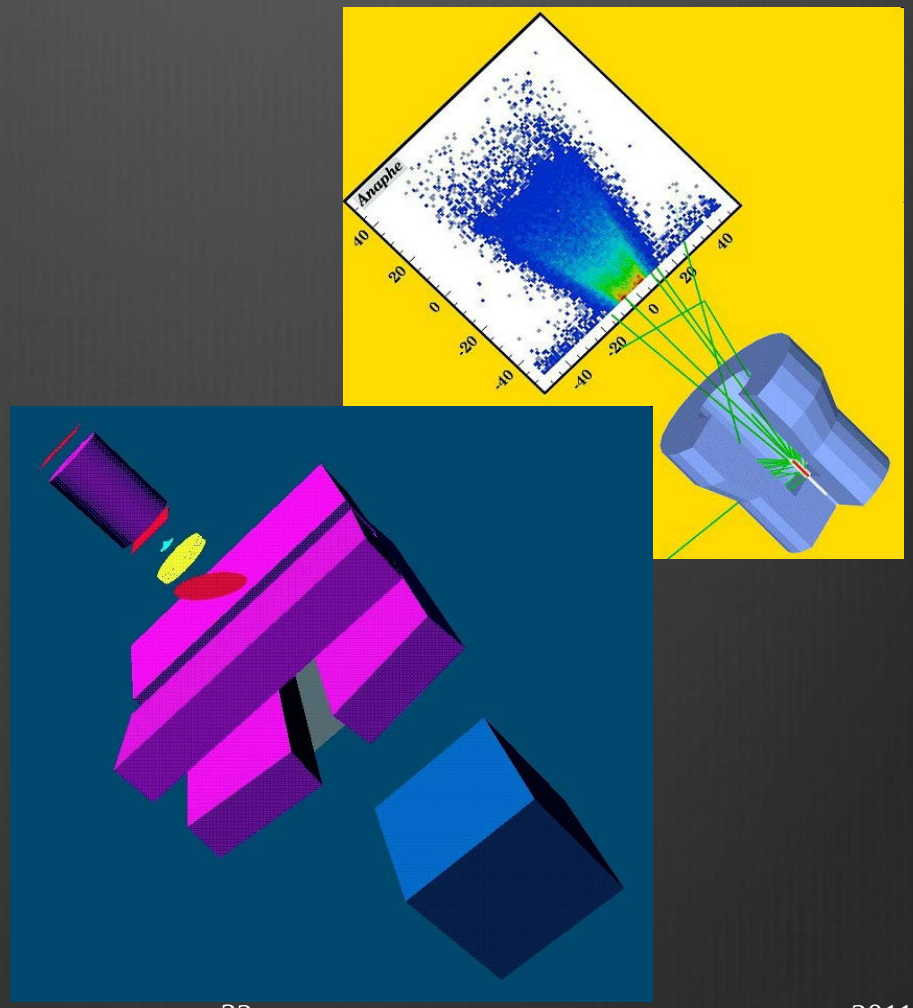
- Located in $G4INSTALL/examples/advanced

- **Medical:** brachytherapy, hadrontherapy, nanobeam, microdosimetry
- **Space/Astrophysics:** xray_telescope
- **High Energy Physics (HEP):** lAr_calormenter (the Forward Liquid Argon Calorimeter - FCAL - of the ATLAS detectgor at the LHC)

- **Physics**
  - **xray_fluorescence:** illustrating the emission of X-ray fluorescence and PIXE
  - **Rich:** simulating the test beam setup of the Rich detectgor at the LHCb experiment, testing the performance of the aerogel radiator (Cerenkov)

Examples in the bio-medical physics field

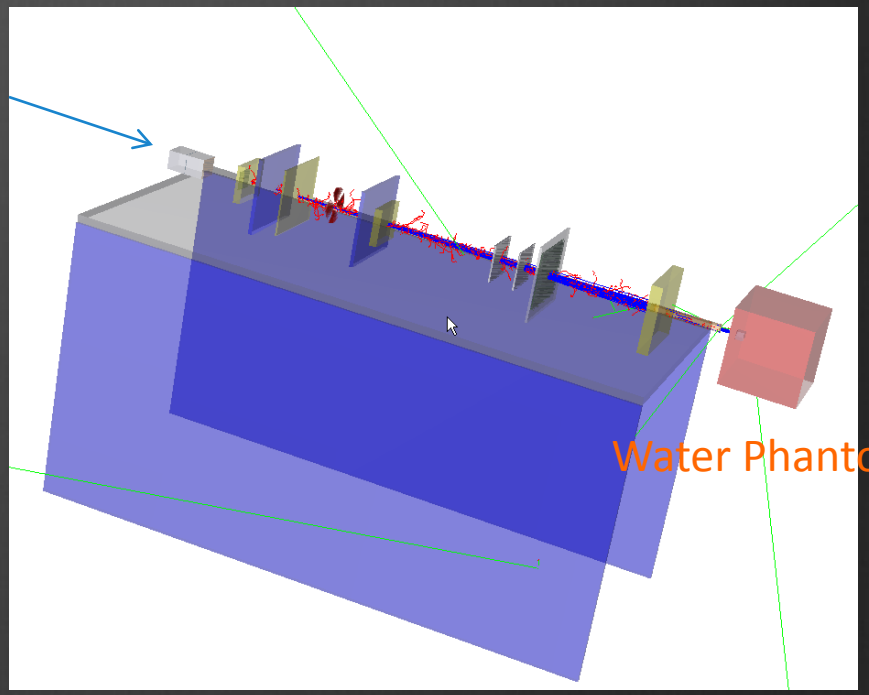
- Brachytherapy
- Hadrontherapy
- Human_phantom
- Medical_linac
- Purging_magnet
- Microbeam
- Microdosimetry
- Nanobeam



Hadron Therapy

- Specifically developed to address typical needs related to the proton and ion therapy
- Proton passive beam line
- Geometry for the IAEA benchmark
- Physics Process
  - Reference Physics Lists
  - Specific 'local' physics list for the ion-ion interactions

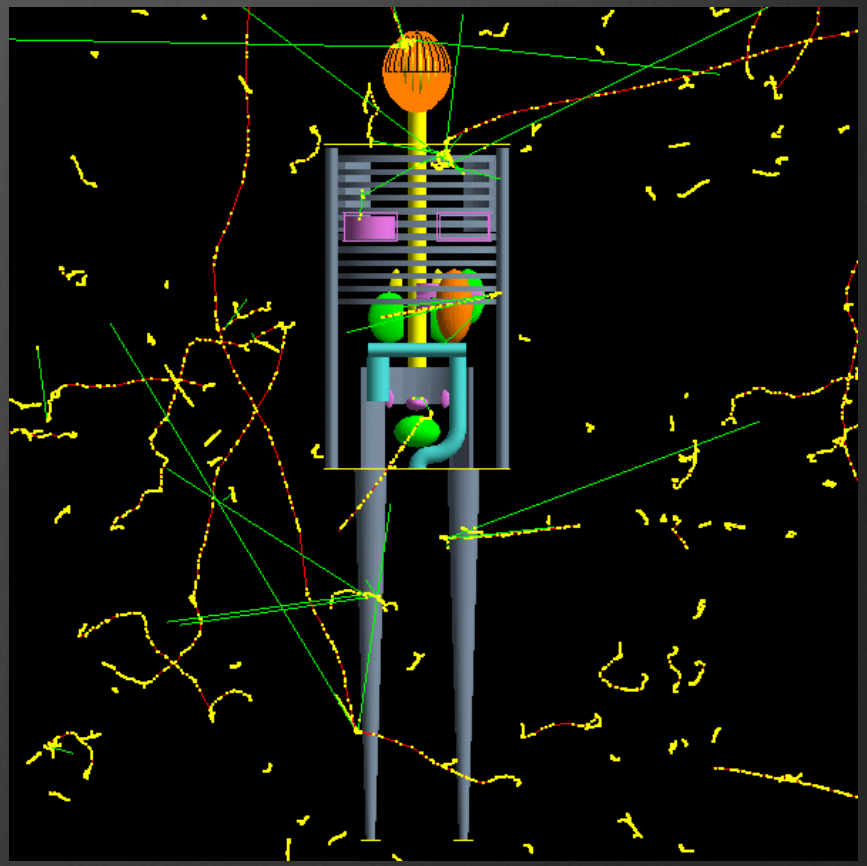
Proton beam line for eye-treatments installed at the INFN-LNS facility in Catania



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



Advanced Examples Documentation

WebPages

(UsersGuide Chapter 9.3)

http://geant4.web.cern.ch/geant4/UserDocumentation/UsersGuides/ForApplicationDeveloper/html/ch09s03.html

Advanced Examples Documentation

Advanced Examples Working Group Page:
http://geant4.web.cern.ch/geant4/collaboration/working_groups/advanced_examples/

Advanced Examples Twiki Pages:
http://geant4advancedexampleswg.wikispaces.com/

Advanced Examples Documentation:
http://geant4advancedexampleswg.wikispaces.com/ExamplesDocumentation

Summary

- Installation and Application Developers Guides tell you how to get started building and running a simulation
- There are 7 novice examples ranging from very easy to complex
  - Can use these as templates for your application
- A cross reference browser (LXR) is available for studying source code (also doxygen)
- A user forum is available for sharing ideas, asking questions