Overview of Geant4 Examples

Fermilab Geant4 Tutorial

27-29 October 2003

Dennis Wright (SLAC)

Types of Examples

* Novice
  - Simple: trivial detector with non-interacting particles
  - Detailed: complex detector with full physics

* Extended
  - Testing and validation
  - Demonstrating Geant4 tools
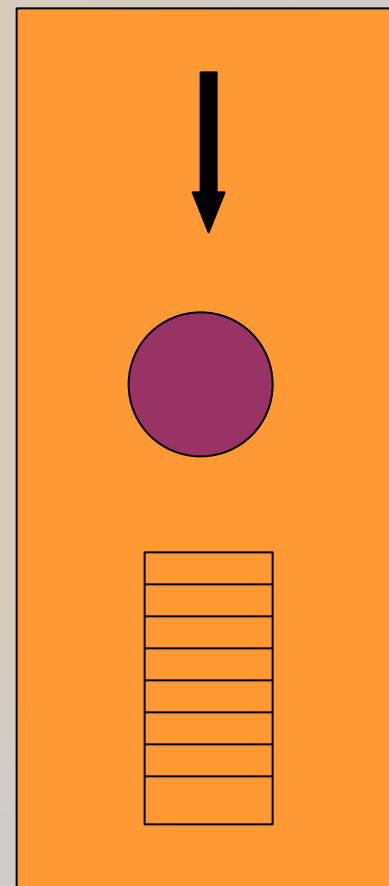 - Extending Geant4

* Advanced
  - Practical applications
 - Examples from outside HEP (space, medical, etc)

Novice Example N01

★ Fixed geometry: Ar gas mother volume with Al cylinder and Pb block with Al slices

★ Incident particle is a geantino → no physics interactions

★ No magnetic field and only the transportation process is enabled

★ Hard coded batch job and verbosity

Novice Example N02

- ★ Pb target, Xe gas chambers

- ★ All EM processes + decay included for γ, charged leptons and charged hadrons

- ★ Detector response
  - – Trajectories and chamber hit collections may be stored

- ★ Visualization of detector and event
- ★ Command interface introduced
  - – Can change target, chamber materials, incident particle type, momentum, etc. at run time
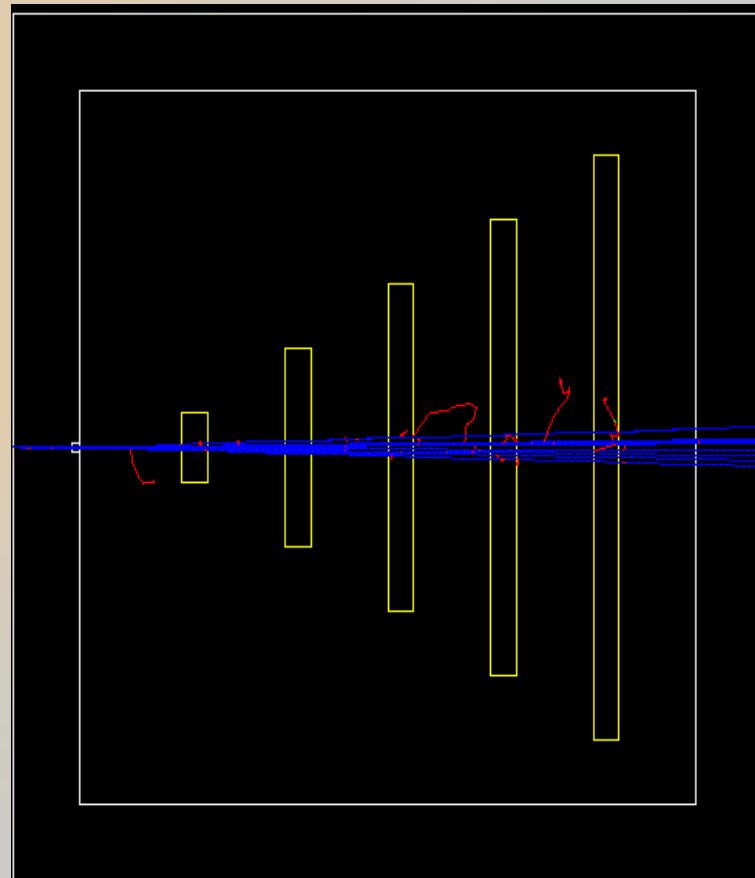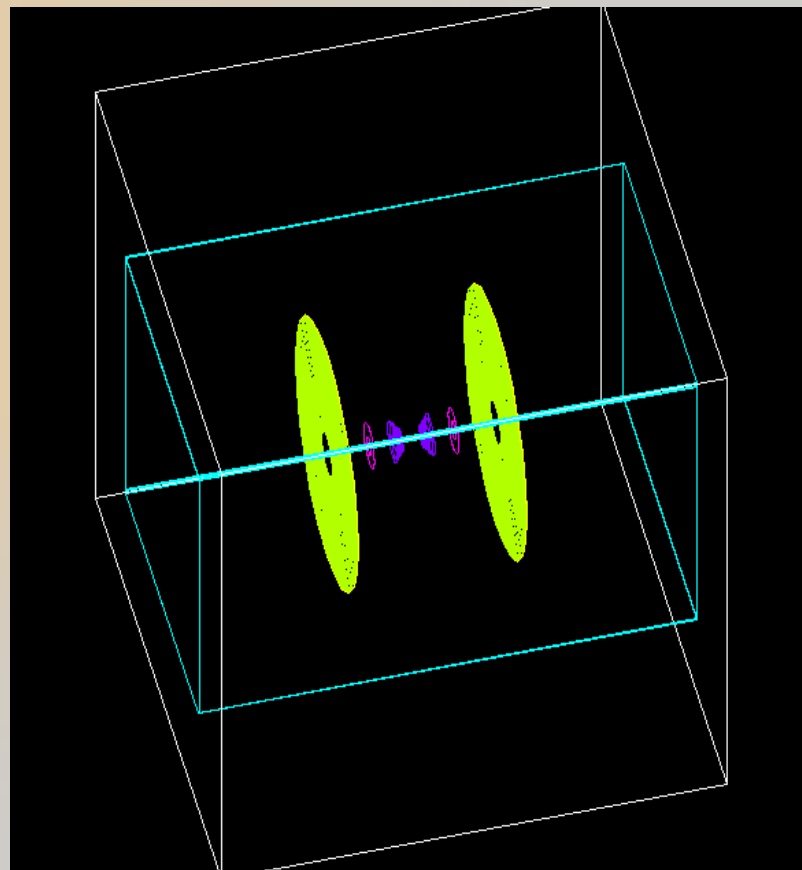
Novice Example N03

- ✶ Sampling calorimeter with layers of Pb absorber and liquid Ar detection gaps

- ✶ All EM processes + decay, with separate production cuts for γ, e+, e- (use for shower studies)

- ✶ Detector response: hit includes
  - – E deposit, track length in absorber
  - – E deposit, track length in gap

- ✶ Visualization
- ✶ Command interface
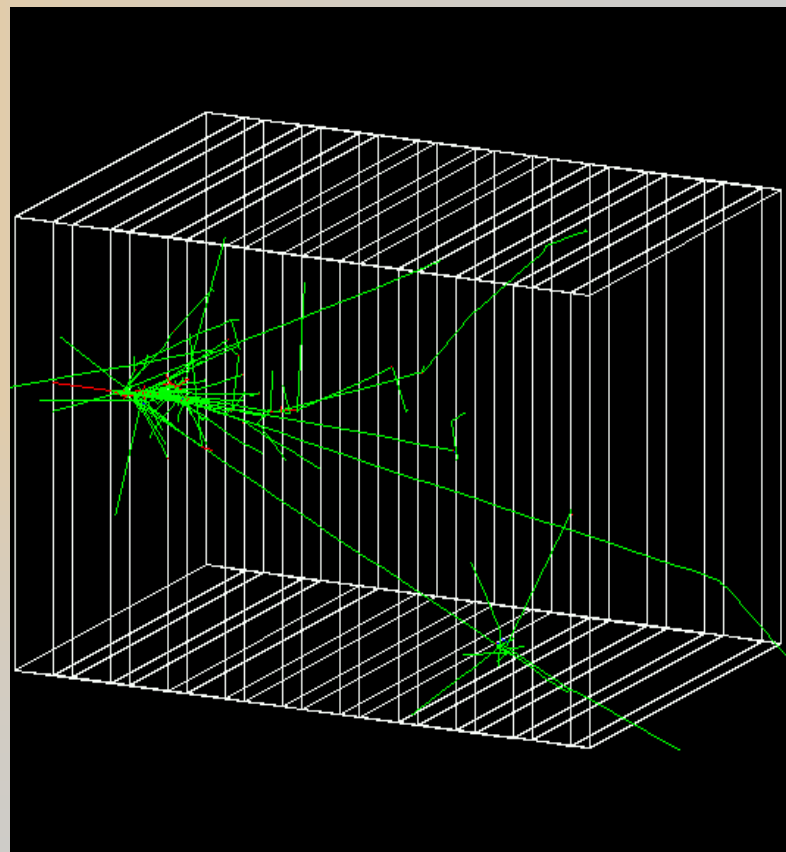
Novice Example N04

* Simplified collider detector

* PYTHIA primary event generator
  - Higgs decay by Z0, lepton pairs

* Full set of EM + hadronic processes
  - Should use updated hadronic physics lists

* Event filtering by using stacking mechanism

Novice Example N05

★ Fast simulation with parameterized showers

  – EM showers (derived from G4VFastSimulationModel)

  – Pion showers (for illustration only – not used)

★ EM physics only

  – Use of G4FastSimulationManagerProcess

★ Simplified collider detector geometry

  – Drift chamber

 – EM, hadronic calorimeter

  – Ghost volume

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 produced scintillation
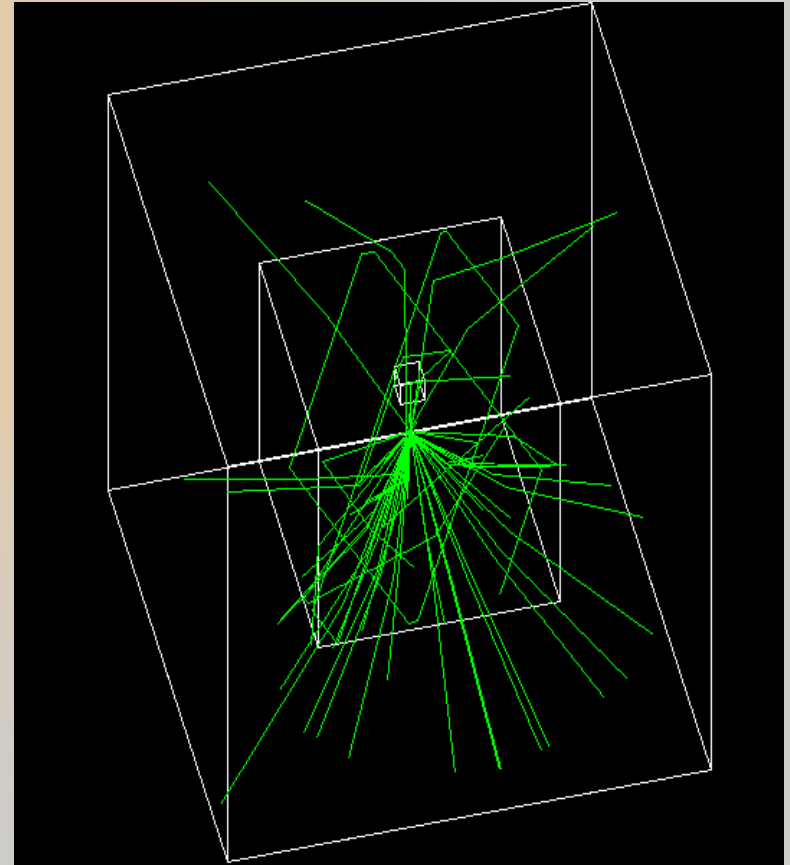
Novice Example N07

* 3 simplified sandwich calorimeters (Pb, Al, Ar)

* Run-based (as opposed to event-based) hit accumulation

* Changing geometries without re-building world

* Setting different secondary production cuts for each calorimeter using G4Region
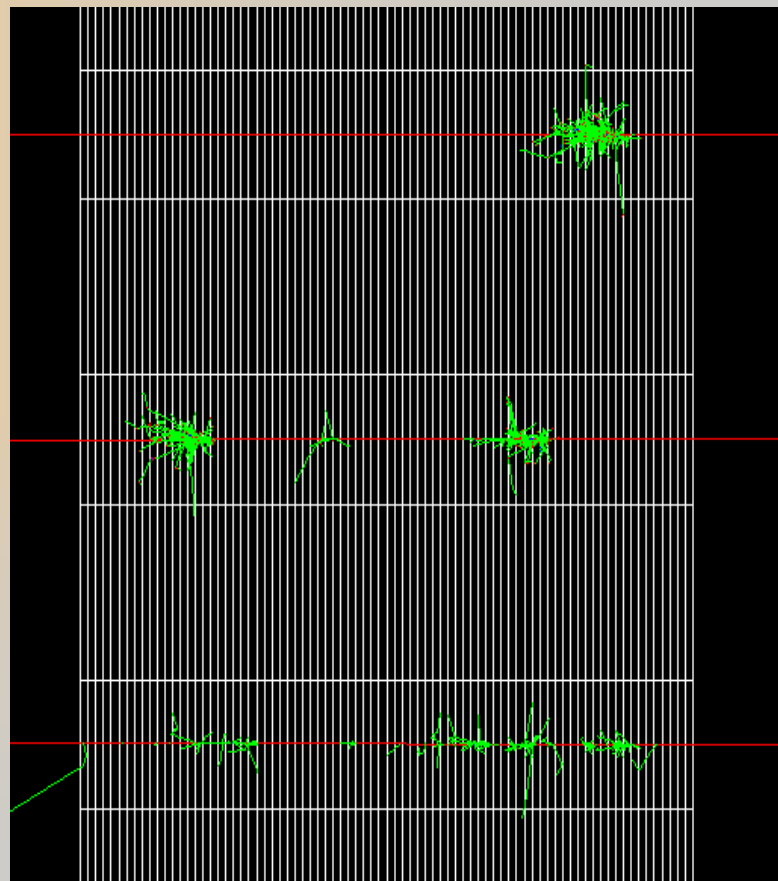
Extended Examples

* Testing and validation of processes and tracking
    – Electromagnetic (TestEm1 – TestEm10)
    – Field (field01 – field03)
    – Geometry (cad, olap)
* Demonstration of Geant4 tools
    – Analysis,eventgenerator, g3tog4, persistency
    – Biasing (B01-B03)
* Extensions of Geant4
    – GDML
    – Medical (DICOM files)
    – Parallel computing (ParN02, ParN04)

GDML Example

- Identical to example N03 (sampling calorimeter), except
  - GDML used for geometry description
- GDML schema supports:
  - Numerical expressions, constants, rotations, translations, units
  - Materials
  - CSG + boolean solids
  - Geometrical structure (volumes, placements)
- Uses Xerxes-C XML parser (linux only)
  - Installation instructions included in example

Advanced Examples

✴ HEP detectors
  – CMS hadron calorimeter test beam
  – ATLAS Forward Liquid Ar Calorimeter
  – LHCb Rich test beam

✴ Neutron Shielding

✴ Space applications
  – X-ray fluorescence
  – X-ray telescope
  – Gamma ray telescope

✴ Underground physics (liquid Xe dark matter detector)

✴ Medical (brachytherapy)
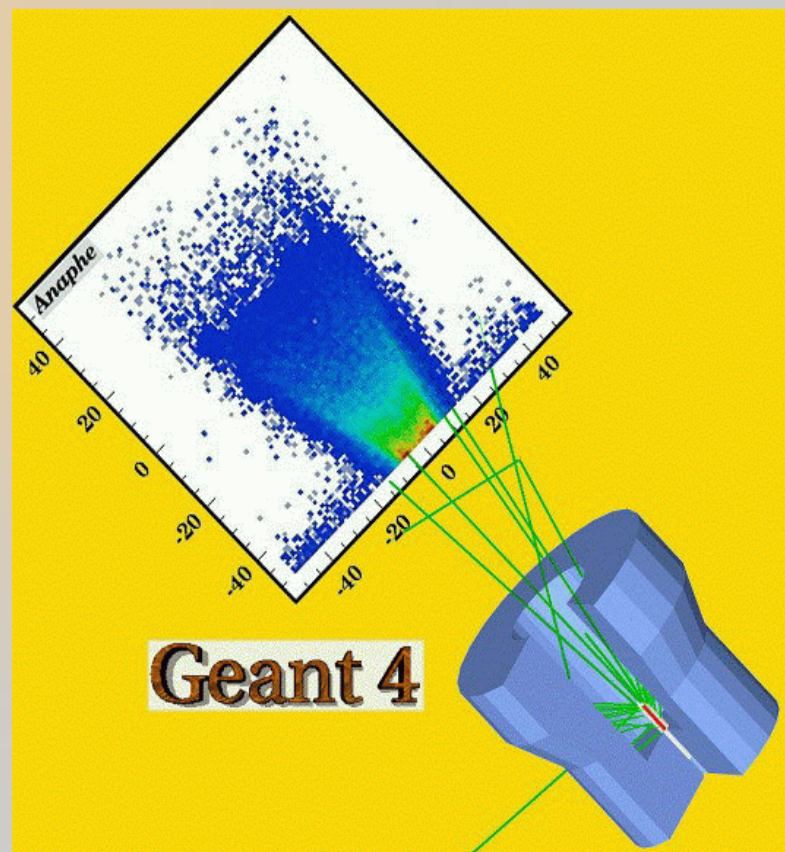
Brachytherapy Example

* Physics
  – Low energy EM processes for e-, γ
  – Standard EM for e^+
* Sensitive detector
  – "phantom" consisting of soft tissue
* Analysis
  – Energy deposition stored in n-tuple
  – Store primary particle energy spectra
  – 1D, 2D histograms of energy deposition

Summary

★ **7 novice examples**

  – Users's Guide for Application Developers, Chapter 9.1

  – Code in geant4/examples/novice

★ **7 advanced examples**

  – Users's Guide for Application Developers, Chapter 9.2

  – Code in geant4/examples/advanced

★ **Many extended examples**

  – Code in geant4/examples/extended