Geant4 News and Updates

Simulations Working Group
ALCPG 2004 Winter Workshop
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Outline

New Features
- Cuts per Region
- Event biasing
- Hadronic models and physics lists

Plans
- Model approach to EM processes
- JAS3 Geant4 GUI

Collaboration-related
- Technical forum
- Tutorials
**Cuts per Region**

- **Geant4** does **not** have a “cutoff” below which particles are not tracked. It has a production threshold below which no secondaries are produced.
  - Implemented as cut in range, Geant4 converts it to energy.

- **Before Geant4 5.2**, only one such threshold could be set.
  - **Now** there can be one per region (or detector subsystem, e.g.).

- **User** can set small range cut for Si tracker, large one for muon detector.
  - **=> increased precision, reduced CPU time**
Cuts in Energy vs. Production Range

500 MeV p in LAr-Pb sampling calorimeter

Cut = 2 MeV

Production range = 1.5 mm

Cut = 450 keV
Geometrical Event Biasing

In shielding studies, e.g., CPU time is saved by:
- killing tracks in un-interesting regions
- duplicating tracks in interesting regions
- assigning track weights so the final mean is unchanged but variance is reduced

Geant4 has two geometrical biasing implementations:
- importance sampling
  - pays attention only to importance values assigned to volumes
- weight windows
  - pays attention to particle energy as well
Geometrical Event Biasing

**Importance sampling**
- Importance = 1
  - Weight = 4
  - Survival = 0.5
- Importance = 2
  - Weight = 2
  - Weight = 2

**Weight windows**
- Above upper weight, duplicate particle until survival weight reached
- Upper weight
- Survival weight
- Lower weight
  - Below lower weight, kill particles with relative prob = 1/survival weight
To save CPU time, event biasing can:

- remove uninteresting tracks from the hadronic final state
- preserve only representative tracks of given particle types

Hadronic event biasing is turned off by default

- can be turned on by setting environment variable
- several levels of biasing may be applied, one after another
- currently only one biasing scheme implemented (the default)
Default Event Biasing Scheme

G4HadLeadBias biases the hadronic final state by:

- Always keeping track with biggest KE (leading particle)
- Of the remaining tracks, selecting 1 track from each of 5 particle types:
  - baryons, $\pi^0$s, all other mesons, leptons, $\gamma$s
  - e.g. If there are 6 baryons in the final state, 1 baryon is selected at random

Once the tracks have been chosen, weights are applied

- e.g. Weight for baryon track = number of baryons in final state
- Weighted tracks are propagated according to Geant4 biasing rules
Before Geant4 5.0 there was a gap in the hadronic models inventory

100 MeV – 10 GeV
covered only by low energy parameterized model (not very good at these energies)

Two models now available in this range:

- Binary cascade (for p, n, pi)
- Bertini cascade (for p, n, pi), being extended to K

Both very useful for HEP calorimetry
Hadronic Model Inventory

- **CHIPS**
  - At rest
  - Absorption
  - $\mu, \pi, K, \text{anti-p}$

- **LEP**
- **HEP** (up to 15 TeV)
- **QG String** (up to 100 TeV)
- **FTF String** (up to 20 TeV)

- **High precision neutron**
  - Evaporation
  - Fermi breakup
  - Multifragment
  - Photon Evap

- **Pre-compound**
- **Binary cascade**
- **Bertini cascade**

- **Fission**
  - LE pp, pn
  - HEP (up to 15 TeV)

- **Rad. Decay**

- **CHIPS (gamma)**

- **Photo-nuclear, electro-nuclear**

- **1 MeV, 10 MeV, 100 MeV, 1 GeV, 10 GeV, 100 GeV, 1 TeV**
Implementing hadronic physics

old way:
- select models from inventory, mix, match and adjust
- assign them to processes, processes to particles
- old way still works

new way:
- pre-packaged physics lists
- choose list according to use case

Subset of available lists:
- HEP calorimeters
- HEP trackers
- Generic HEP collider detector
- High energy shielding penetration
Model Approach to EM Processes

Current approach to EM processes:
One process, one model
But there are many different implementations for basic EM physics that do not fit into one model
Energy loss methods, fluctuations, etc

Solution:
Allow several different models to be assigned to single process
Similar to what is now done in hadronic processes

In Geant4 6.0, this approach is used for
Ionization, bremsstrahlung, multiple scattering
User interfaces are unchanged from Geant4 5.2
Example:
Model Approach to Hadron Ionization

Old Approach

- Proton
- G4hIonisation

Model Approach

- Proton
- G4hIonisation
  - Bethe-Bloch model
  - Bragg model
  - Fluctuation model
JASSimApp – An Integrated Simulation GUI

Want to build a Geant4 GUI based on JAS3

JAS3 based on FreeHEP Application Framework
Allows Geant4 plug-ins to be installed and talk to one another

Aimed at construction and running of:

Prototype detectors
Beam tests
Medical applications
Any relatively simple simulation task

Existing modules:

Event display (WIRED)
Command line interface (GAG)
Geometry/material/physics definition (MOMO)
Analysis (AIDA)
JASSimApp: MOMO Plug-in
Collaboration re-organization

- Had technical steering board (TSB)
  - Composed of developers, representatives from some experiments
- Will soon have steering board (SB)
  - Experiments no longer directly represented

Technical forum

Purpose:
- Collect requirements from users, experiments
- Developers, users discuss implementation, integration, etc.

Users present requirements at forum
- To be submitted in advance
Forum is open to all users and experiment representatives

Meets several times per year, at varying locations
Announced in advance on Geant4 home page, mailing list

Past meetings have been “prototypes”
Sep 2003, TRIUMF (Vancouver)
Oct 2003, CERN

Next meeting
May 2004, Vanderbilt (Space Users)
Fall 2004, ?
Geant4 Tutorials

A series of tutorials has been given for beginning and mid-level Geant4 users

3 days long
Focus on Geant4 basics, examples, hands-on development of simulations

Recent tutorials:
SLAC 2/02, CERN 11/02, DESY 9/03, IEEE Portland 10/03 (1 day), FNAL 10/03

Upcoming tutorials:
Vanderbilt 1/04, SLAC 3/04

Material from past tutorials available at Geant4 home page:
Go to Support -> Training Materials
Conclusions

New feature highlights:
- Cuts per region
- Event biasing (geometrical and final state)
- New hadron cascade models
- Use-case-based physics lists

Planned new features
- Model approach to EM physics (already implemented for ionization, bremsstrahlung, multiple scattering)
- JAS3-based GUI for building and running simulations

Technical forum established to improve user-developer connection
Beginner/mid-level tutorials being given