Ruminations from the Underground Community

Summary from user/developer discussions
at the GEANT4 Workshop 2007

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Priority I – Muon-induced neutrons

- **A lot at stake for next-generation experiments!**
  - Design phase for tonne-scale WIMP, double-beta, neutrino experiments
  - Assessment of new and ongoing multi-experiment underground facilities

- **Requests to GEANT4**
  - Continue development & validation of muon-nucleus models
    - QCollision + QCaptureAtRest – maybe produces those missing neutrons!
    - Validate inelastic XS, underground muon spectra, depth-intensity relation, etc
  - Consider testing for neutron yields with release
    - Simple test set-ups are available (see below)
    - Disseminate validation results
  - Hadron cascade models – too many gammas, too few fragments?
  - Ion cascade models – to cope with more fragments

- **Requests to community**
  - Produce own packaged physics lists
    - Take "underground" example underground!
  - Specify validation set-ups already used for benchmarking
    - Thick target - standard test slab + surface and underground data for CH_2 and other materials
    - ~Thin target – NA55 set-up is also possible
  - Underground experiments should release more data and simulation results
  - Test more physics models!
    - E.g. BiC is most used, but Bert may produce more!
  - Find resources!

Update after discussions with Mikahil Kosov (aka Mr CHIPS)

New CHIPS-based models already released plus those under development or planned could provide complete alternative hadronic treatment in GEANT4.

Muon-induced neutron production will be affected (confirmed during workshop by A. Howard). The community should help validate this development effort!

See talks (5) by M Kosov in the workshop programme for a description of the CHIPS approach.

Priority II – Radioactivity

- **Many items not too difficult to improve**
  - Small but relevant issues that we all face and solve indepen

- **Requests to GEANT4**
  - Open bugs should be closed out! (e.g. #952, #956)
  - Radioactive decay module
    - Refine interface to atomic de-excitation (x-rays and Auger)
    - New event generators (2ν–2β decay, non-trivial sources)
    - Small BR decay probabilities
    - Shape of beta spectrum for forbidden transitions (e.g. Ar-39)
  - Isotope production
    - G4IsotopeProduction development stopped: time to start again
  - Metastables
    - The time is right in light of PDG discussion
  - (α,n), (p,n) reactions – e.g. data-driven (HP-type model)
    - Main neutron production mechanism in most experiments (background, calibrations)
  - Angular correlation in gamma cascades

- **Requests to community**
  - RDM/GPS user requirements
    - Some codes already exist in the community (eg 2β) – liaise with G4
  - Populate Metastables - validation with neutron sources
  - Find resources!

Update after plenary discussions

Development of G4IsotopeProduction stopped a few years ago, but it is still used occasionally by the community – more often users create their own interfaces instead. The community should identify precisely the common needs in this area and pass these to G4.

A related subject is the decay of metastable states, which can be easily added in G4 if good quality data can be found for the population branching ratios (this is something experiments are doing 'by hand'...)

New requirements for the GPS/RDM modules are welcome and should be passed on to

New processes (eg alpha,n) are always welcome, but these need to come with offer of support for developing, validating and maintaining the software.

Priority III – Neutron Propagation

- **Kinematically-closed models**
  - Crucial for rare event searches!
- **Requests to GEANT4**
  - Open bugs should be closed out! (eg #821, #675,)
  - E + p conserved event-by-event in NeutronHPInelastic
  - Residual nucleus should always be emitted (when it exists)
    - e.g. Ge(n,2n), capture (n,>1γ)
  - NeutronHPInelastic produces no gammas in some channels
    - E.g. (n,α) and (n,p)
  - Clarification on HP database format (esp. final state)
    - If users want to extend it, they need to understand it!
    - Better documentation on format
    - Independent database management tool?
  - Can we avoid natural abundance elements in database?
- **Requests to community**
  - Submit bug reports!
  - Divulge existing codes to G4
  - Provide data for validation (e.g. neutron calibrations)
  - Use and validate upcoming LLNL neutron models
  - Find resources!

Update after discussions with Tatsumi Koi (NeutronHP coordinator)
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Main news is new LLBL neutron model based on ENDL database (instead of ENDF-VI). This will include more isotopes (probably all for which there is experimental data!). A new elastic model will probably be out in 1 year, with the inelastic predicted for end 2008 or a little later.

In neutronHP, energy/momentum conservation is good in HPElastic and a simple improvement has been suggested for (n,n'γ) by LP. TK will look into this, since it is the probably the most important case for the community.

Other reports regarding the missing residual nuclei will be investigated (along with bug reports). The issue of natural abundance isotopes will be looked at, it is suggested that it should generate a warning (missing isotopes already do).

On documentation, G4 notes the possibility of misuse of the code and points out that the difficulty in interpreting the final state information comes from the original ENDF-VI packaging, not from G4. This is likely to remain with the new LLBL models, but then all isotopes will be there anyway – no need to delve in the database.

So please discuss your requests with Tatsumi!

Priority IV – Event Biasing

- **Underused by the community**
- **Requests to GEANT4**
  - More BXX extended examples?
- **Requests to community**
  - Find application examples that can become extended examples
  - USE IT!

Priority V – VLE Electromagnetics

- **LE atom cascades: keeps coming up in different user communities**
  - Nuclear quenching (e.g. Dark Matter), displacement damage (e.g. space electronics)
- **Detailed tracking of charged particles near interfaces**
  - End-of-range alphas, electrons, backscattering, etc
- **Requests to GEANT4**
  - Consider user contributions in this area (e.g. Vanderbuilt & Coimbra codes)
- **Requests to community**
  - Make your case to GEANT4 or develop/maintain G4-compliant models?

This is the forum!