

Highlights from the Geant4 Radioactive Decay Mini-workshop

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Outline

- Progress since last year
- Results from meeting
- Unfinished or Unresolved Issues

Progress Since Last Year

- RDM, PhotonEvaporation and ENSDFSTATE databases now consistent with one another
 - also new fields added for correlated gammas
- “Floating” energy levels fully implemented
 - cases in which isomer levels are known to exist, but whose energies are not known
- Correlated gamma emission implemented
 - still some unresolved issues though
- Photon evaporation code improved and updated

Progress Since Last Year

- Reproducibility problems in RDM thought to be solved have returned
 - most MT features turned off in order to understand
- Partial completion of beta-delayed particle emission
 - cases where beta decay ends in discrete level handled by neutron and proton emission models
- Some progress in development of refactored biased code
 - still lots to do
- No progress in adding rare processes (double beta decay, etc.)

Results from Meeting

Consistency of Lifetime Thresholds

- There are different lifetime threshold values throughout the radioactive decay and photon evaporation code. Are they consistent or necessary?
- In ENSDFSTATE there is no threshold. If a lifetime is zero, nuclide does not appear in table
- In G4PhotonEvaporation all levels are treated, even if lifetime is zero. If $\text{lifetime} > \text{Max_Life}$, nuclide is released as trackable particle. Set this to DBL_MAX. Better to use a boolean?
- `halflifeThreshold` in `G4RadioactiveDecay` will be removed. It is not used in analogue mode.

Databases

- Implement checks (system test, user test example) for consistency between RDM, photon evaporation and ENSDFSTATE
- Study possibility of making versioned master file from which all other DBs are derived
- Explore the removal of RDM dependence on ENSDFSTATE

Beta-delayed Particle Emission

- Transition to discrete levels is already OK
 - handled by already existing beta emission and neutron/proton emission
- Transition to continuum
 - make new model G4Beta(Plus or Minus)Continuum with corresponding acronym for database entry
 - use hadronic de-excitation code to sample from continuum level density

Biasing

- Develop analog-only version of RDM, then use this as base class for biased RDM
- Check that any new biasing code is consistent with GPS methods
- Implement RDM by region as a replacement for the current use of logical volumes
- Develop methods or classes that solve the Bateman equations by
 - matrix method
 - current method

Correlated Gamma Emission

- Although code is implemented, there are two main issues:
 - many warnings appear
 - code has not been validated
- Cause of warnings now understood
 - output of Jason and Ian's original code for ^{60}Co now available to check fixes
 - provides correct nuclear polarization to compare to
- IT part of RDM code must be refactored to be more memory efficient

Validation

- Large amount of validation needed
 - many tests already exist, but need to be updated
 - also plots need to be added to validation repository
 - check with Hans and Julia about how to submit to repository
- Develop infrastructure to do validation
- Start with a representative subset of validations
 - alpha decay
 - beta decay
 - IT/IC

New Examples

- extended/radioactive_decay/activation
 - with reference files
- Example for correlated gammas
 - will have ^{60}Co , ^{133}Ba and ^{208}Th
 - and two-detector geometry
- H*10 dose example

Multithreading

- Concerns were expressed that the strong initialization required by multithreaded mode inhibits interactivity
 - is there a way to alleviate this?
- How to take more advantage of multithreading in RDM?
 - use more C+11 features
 - for decay table map use hash map instead of `std::map` now used

Unfinished or Unresolved Issues

Reproducibility

- Irreproducibility has returned at the level of 1/1000 in showers
- How to fix?
 - look at consistency in use of float and double
 - look for cases in which ordering of decay branches is different for same nuclide
 - check G4VDecayChannel
 - re-activate MT in RDM only after sequential reproducibility is solved

Atomic Deexcitation

- Current model is approximate and does not handle pick-up or loss of electrons into outer shells (e.g. for alpha, beta decay)
 - results in energy non-conservation
- Better model available
 - by T. Kibedi (written in F90) will take manpower to cast into C++
 - defer work on this but contact author, look into funding prospects

Charge Conservation

- Charge/energy/momentum non-conservation has been observed in cases where electron emission is involved (internal conversion, etc.)
 - Bertini with G4Precompound fails due to energy non-conservation for conversion e- emission
 - add flag to denote this in hadronic final state (integer)

Radioactive Decay Paper

- Propose outline
 - Introduction/history
 - description of use cases
 - design, philosophy and UI
 - databases
 - biasing
 - validation
- Authors: Pete, Fan, Laurent, Pico, Makoto, Vladimir, Dennis, Ian, Jason, Michel, Alex, Luciano, Andrea, Alberto, Tatsumi, Giovanni, Marc