Isomer production in v10.00

KOI, Tatsumi

U.S. DEPARTMENT OF ENERGY
Office of Science

SLAC NATIONAL ACCELERATOR LABORATORY

Background

SLAC

Most model naively generate ground state nucleus as final states

- Usually at the same position and time of the interaction

User request for transporting long lived isomer

- c*1nsec->30cm
- Some isomer has longer life time than ground state

Each model of Geant4 had own level data internally

- Sometime contradicted one another

Demand for an object which provides basic properties of state to others in toolkit wide.

- Naturally the object belongs to the particle category of Geant4
- The object has huge state data for potential requests
- User may want to add specific state to the object

G4NuclideTable

SLAC

G4NuclideTable keeps basic properties of nuclide states.

- Z and A
- excitation energy
- decay constant
- spin and dipole magnetic moment are given for some (not many) states.

24,359 states are extracted from ENSDF of August 2012.

- Basically all non-zero life time state are extracted.

Ground states and excite states having longer half-life than 1 nano second are implemented in source code.

- Total number of the hard coded states is 6807.

Full set of 24,359 states is embodied in a data file of G4ENSDFSTATE1.0

- G4ENSDFSTATEDATA is the environment variable for the file
- By default, the data file and environment variable are not necessary

To improve performance, ground states and long lived excite states are prepared in initialization and loaded into kernel.

- Half life of 1 micro second is default cut off
- User can change the value. The data file and environment variable are required to change the value to smaller than 1 nano second.

Isomer levels

SLAC

G4NuclideTable provides an integer that represents isomer level of each state.

- Because of limitation of PDG codes, only a number from 0 to 9 is allowed as the value of level.
- All ground states have 0 as the value.
- The lowest energy state isomers in preloaded states have the isomer level of 1.
- All excite states higher than 8^{th} energy state has 9 as its isomer level.

This numbering scheme of isomer levels only happens within preload states

- Value of isomer level for certain excite state depends on threshold of half-life for preloaded states.
- All excite states dynamically generated within event loop will have 9 as its isomer level.

User can add states into the table with user specific value of excitation energy, decay constant, spin and dipole magnetic moment.

- This should be done in initialization phase then user-defined states will be in preload states.
- However they always have isomer level of 9, i.e. its excitation energy is neglected in numbering scheme of isomer level.

This Isomer level will register in *G4ParticleDefinition* objects. However the number is not related to the property in *G4Isotope* objects in Material category.

Status

SLAC

G4NuclideTable is introduced v10.00

G4RadioactiveDecay and *G4PhotoEvporation* models share the basic state properties with *G4NuclideTable*.

- Decay channel and transition probability of the state is controlled by each model

Other models are encouraged to follow these.

Isomer as target

SLAC

G4Isotope, this is a class in Material category, has an integer property for isomer level.

- Supposed use for ENDF based low energy neutron transportation.
- Not related (tied) to isomer level of *G4ParticleDefinition* object.
  - Corresponding excitation energy may (probably) different.

Some isomer has longer life time than its ground state.

In such case, non negligible number of target nucleus is (excited) isomer.

- Models usually do not take into account this

Spins

SLAC

Spin information is only provided for some states in ENSDF

- ENDF decay data may have better situation
  - However cut of time is about millisecond
  - Total 3817 in ENDF.VII.1

Spin/parity constrain is not taken into account current models.

- residual production may be harmed by this

Summary

G4NuclideTable is introduce v10.00 and provides basic properties of states

- For collaborated work among models

G4RadioactiveDecay and *G4PhotoEvporation* models are migrating with *G4NuclideTable*.

- Other models are encouraged to follow these.