Gammas in Geant4

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Motivation

- Gadolinium is used in many experiments as it has a high neutron-capture cross section
- $^{A}Gd + n \longrightarrow ^{A+1}Gd + \gamma$
- The emission of gammas following neutron-capture is not quite correctly modeled in Geant4

Status of modeling Gd neutron-capture gammas in Geant4

- G4NeutronHPCapture model chooses one from two methods to generate the capture gammas depending on whether the data of final state gammas is available:
- If available —> Final state model based on Neutron Data Library (G4NDL):
 - Sample uncorrelated gammas from the individual gamma spectrum
 - Available for Gd since G4.9.5 with default settings
- If not \rightarrow Photon evaporation model:
 - Generate gammas with total energy conserving Q-value properly
 - Being used for Gd thru G4.9.4 or specified by flag in later versions
- Lacking of measurements of correlation between gammas following individual neutron captures

Model comparison

Photon Evaporation Model

Final State Model



Model comparison

Photon Evaporation Model

Final State Model



The individual gamma spectra given by the two models are greatly different.

Verification with measured spectrum

Energy of Individual Gammas



* Gamma-ray Rejection, or Detection, with Gadolinium as a Converter, P. Kandlakunta and L. Cao, Radiation Protection Dosimetry (2012), Vol. 151, No. 3, pp. 586-590.

** Average-Resonance Method of Neutron-Capture gamma-Ray Spectroscopy: States of 106Pd, 156Gd, 158Gd, 166Ho, and 168Er, L. M. Bollinger and G. E. Thomas, Phys. Rev. C, Vol. 2, 1951 (1970).

Issues in experiments

- The larger the detector, the greater the efficiency to collect gammas, then more sensitive to the total energy
 - Double Chooz. Have developed a modified model—Q-value conserved and high energy gammas added. The code is not compatible with recent Geant4 versions. (http://neutrino.phys.ksu.edu/~GLG4sim/Gd.html)
 - Daya Bay. Hope to get information from them.
- For small detectors, the individual gamma spectrum is more important
 - NMM, MARS, etc.
- Medium sized detectors may be sensitive to both
 - LZ outer detector
- Difficult to measure the correlation between gammas following individual neutron captures

More from the Neutron Multiplicity Meter

An example of small sized water Cerenkov detector

Energy deposited via e- ionization by electrons above Cerenkov threshold



Energy Deposited via eloni for Particles above Cerenkov Threshold

Simulated detector response of the NMM

