Geant4 Radioactive Decay for the Underground Physics Community

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Geant4 Workshop

Use cases for G4RadioactiveDecay

- In most underground physics application, the **main background** is due to **radiation** (γ) from **radioactive decays**

- Many nuclei have very complex decay schemes (many γ rays, different BR)
  - Simplest option: take a nucleus at rest as primary particle and let Geant4 decay it
  - If it works, one can get the appropriate energy and branching ratio for all relevant gamma lines.

- For dark matter experiments, also **low-energy x-rays** (and Auger electrons) are relevant
  - Interface with `G4AtomicDeexcitation` module critical

- The `G4RADIOACTIVEDECAY` and the `G4LEVELGAMMADATA` databases **look ok**: bugs in the code itself and in the interface to the de-excitation

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Radioactive decay + gamma deexcitation

- **Three** bugs (**#952** plus **other two**, that were reported informally) have been tracked and fixed in Geant4 8.0
    - Internal note available from the GERDA experiment
- **Gamma de-excitation** part following decays **satisfactory** since then, for most applications
- Still **many problems** with **x-rays** and interface to atomic de-excitation → wrong branching ratio of x-rays (as well as missing lines)

Extremely **precise** and **reliable** for most nuclei (e.g. ^{134}Cs).

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Energy (keV)	Table of Isotopes	Geant4 7.0
563.25	8.35%	8.41%
569.33	15.38%	15.35%
604.72	97.62%	97.62%
795.86	85.53%	85.45%
801.95	8.69%	8.71%
1365.19	3.01%	3.01%
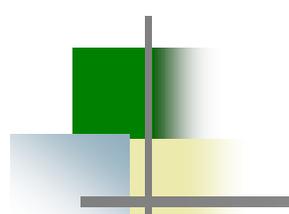
Radioactive decay and atomic deex

- Branching ratio of **x-rays** typically **under-estimated**
  - Maybe because the code does not handle **more than one atomic vacancy** at the same time
- Interface cannot handle **local energy deposit**: affects especially EC decays, which leave an atomic vacancy (and hence x-rays)
- Bug report **#1001** (open since Feb 2008)
  - **5-fold bug report** with a complete analysis and a proposed patch
  - Complex solution, affecting a number of classes ($\rightarrow$ to be analyzed carefully)
- Potentially, same problem of non-correct local energy deposition also for the photon evaporation

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