

GEANT4 Radioactive Decay

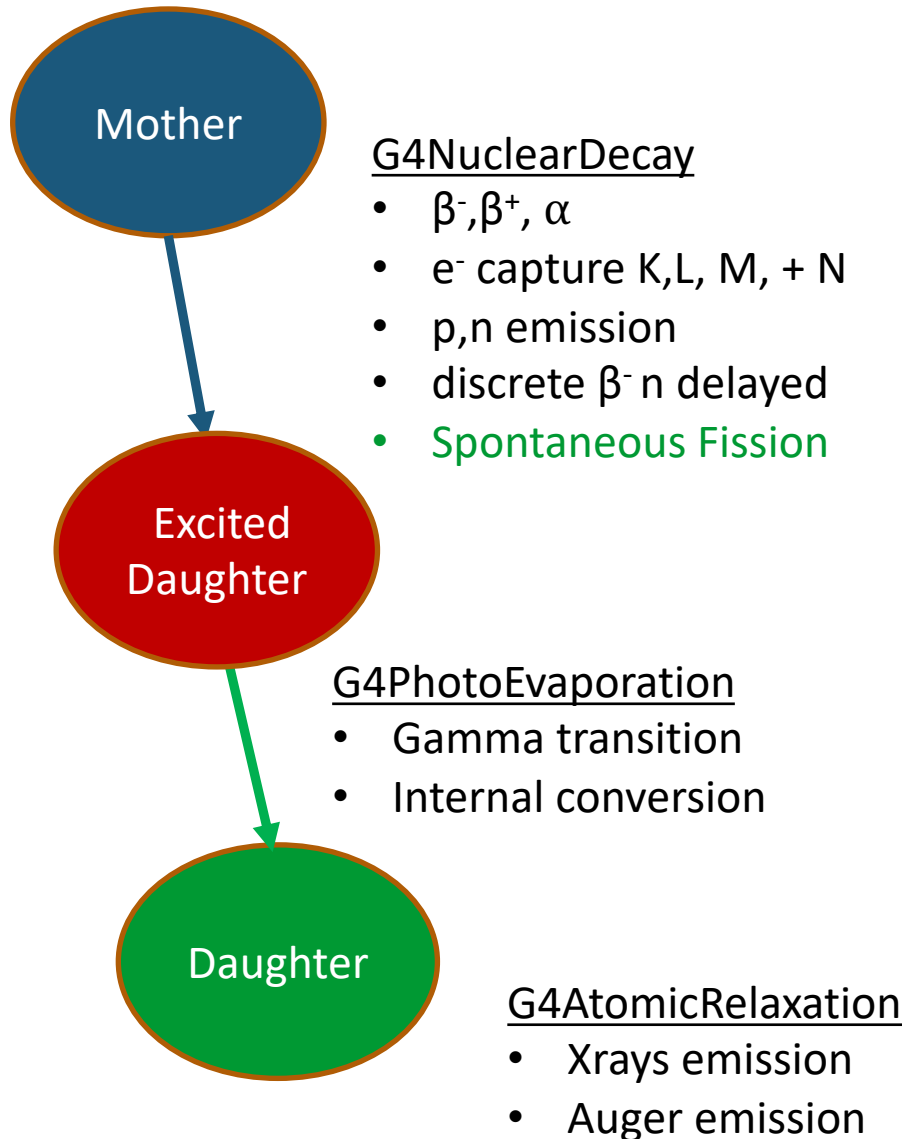
L. Desorgher and D.H. Wright



Outline

- Overview Radioactive decay in GEANT4
- Recent developments of the code
- Status of the databases and updates
- Test suite for the G4RadioactiveDecay code and the G4Databases

Radioactive module in Geant4



Two simulation modes

- Analog
- Biased

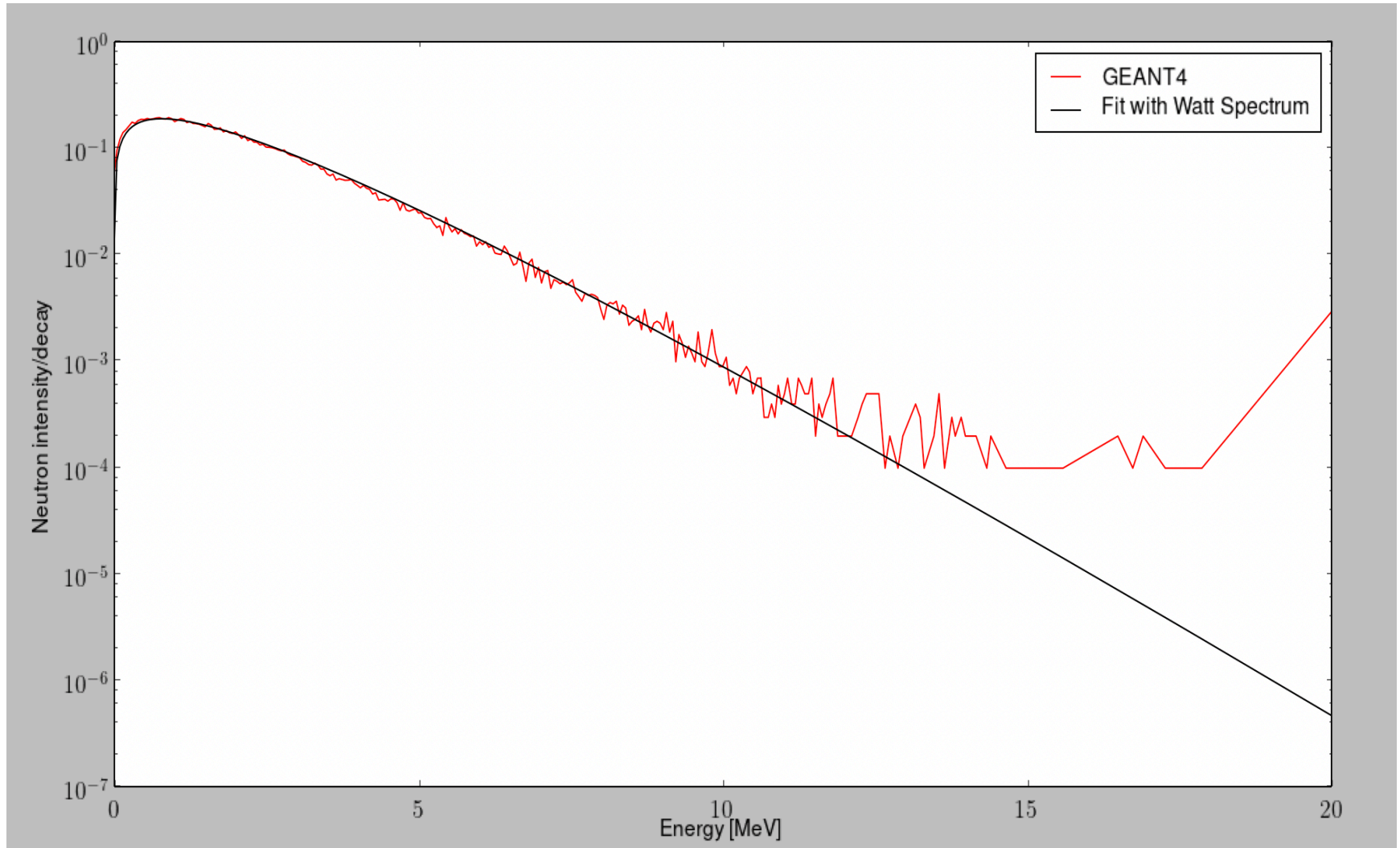
Contributors

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Recent Code Developments

- Add spontaneous fission to the code (D. Wright)
- Completed code separation of analogue and biased mode (D. Wright)

^{252}Cf Spontaneous fission



Minor updates of the databases

RadioactiveDecay5.4

- Add missing nucleus with N shell electron capture in the database :
 ^{44}Sc
 - Few nuclei corrected

PhotoEvaporation 5.4
Few nuclei corrected

G4ENSDFSTATE2.2
No changes

Testing Suite for Radioactive Decay

PYTHON code G4DatabaseUtilities

- Compute analytically secondary spectra directly from the databases
- Alpha, gamma, conversion electron, X-rays, Auger electrons

Validation G4 code

G4Raddecay test code

- Based on RDecay example 2
- Set energy of recoil nucleus to avoid doppler broadening of the lines
- Comparison MC spectra with analytical spectra

Validation of the Databases

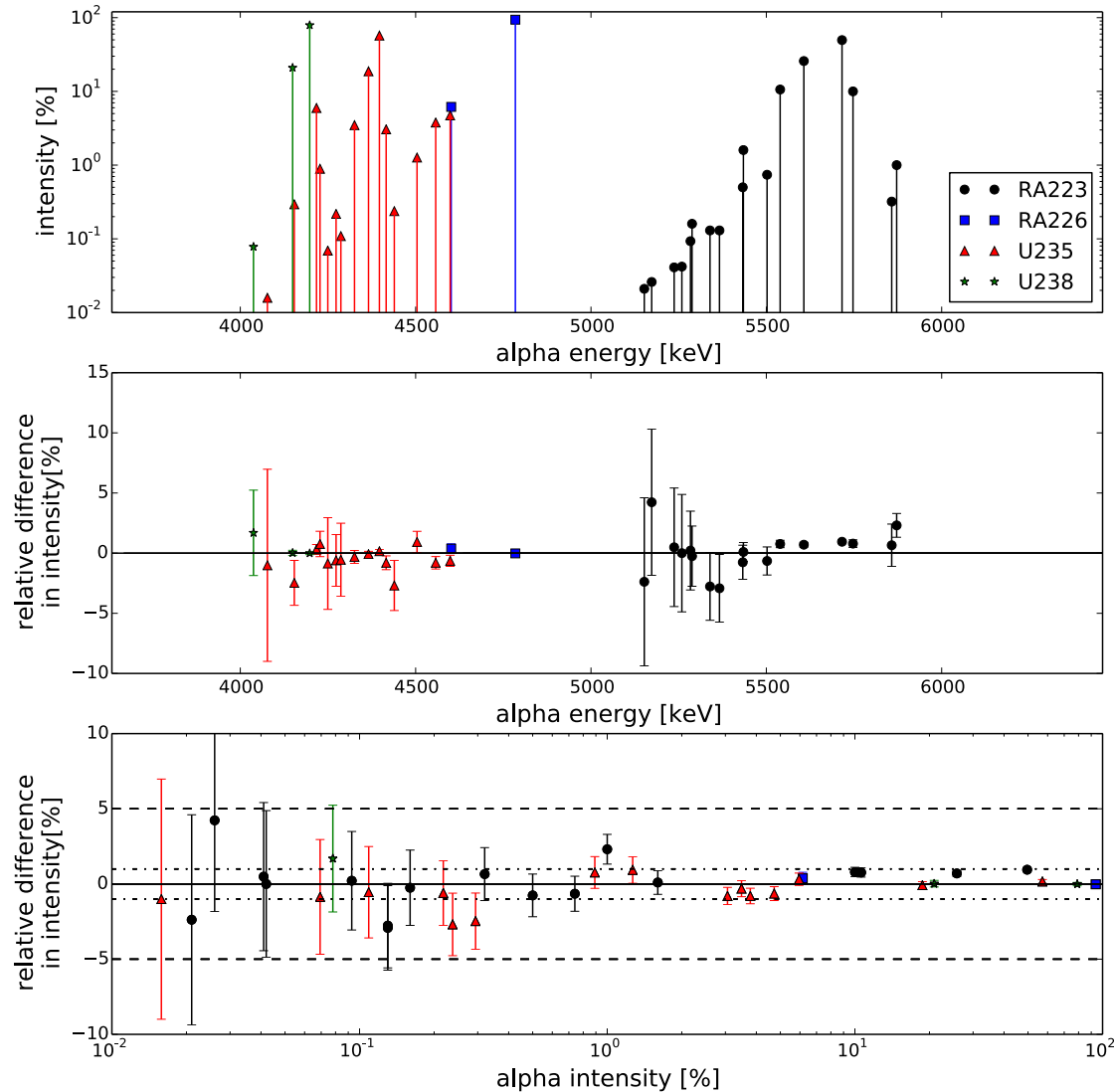
Reference spectra

- ENSDF spectra from NUDAT2
- DDEP spectra
- Comparison G4database spectra vs reference data

Comparison of Alpha Spectra

G4 code (symbols) vs G4 database (lines)

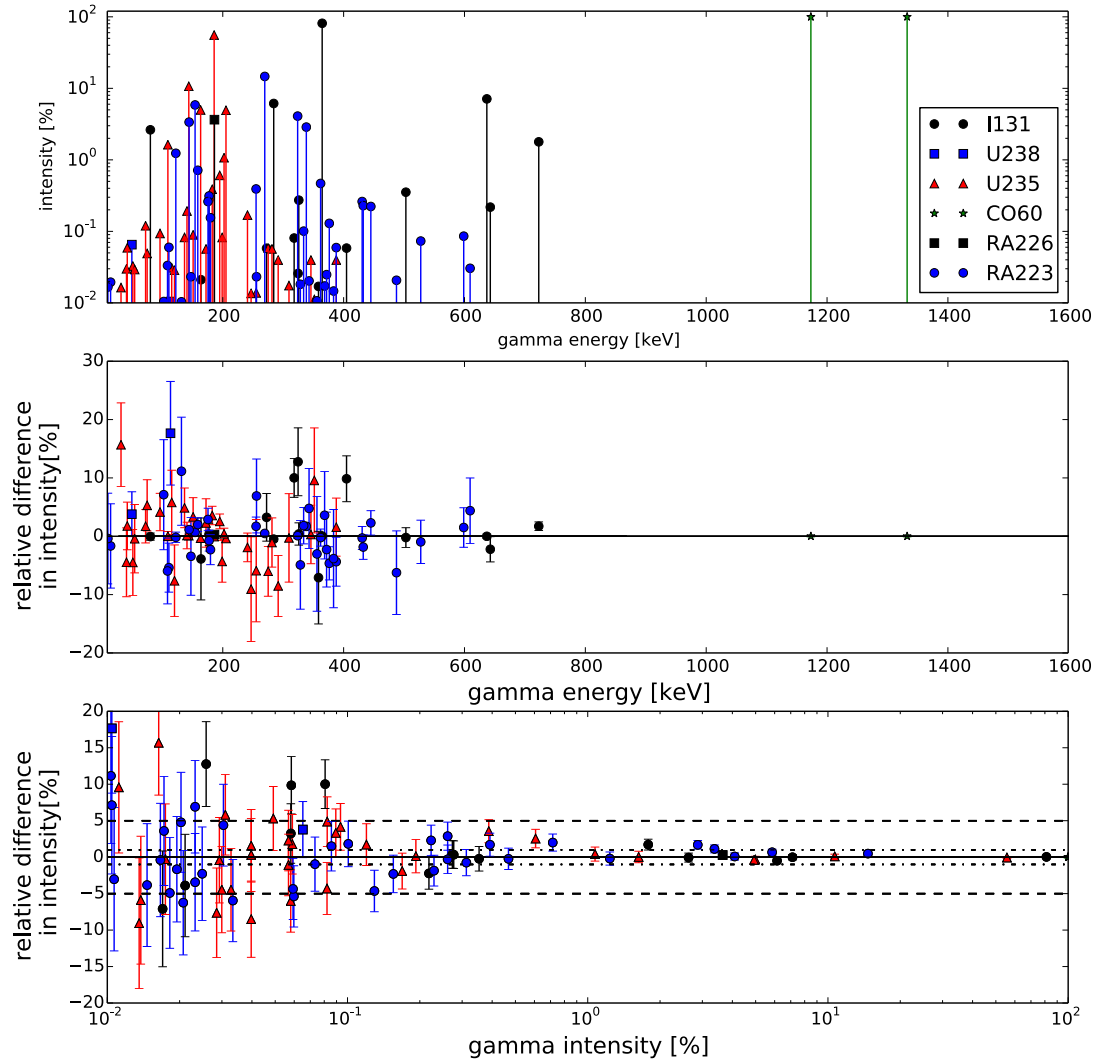
10^6 decays



Comparison of Gamma Spectra

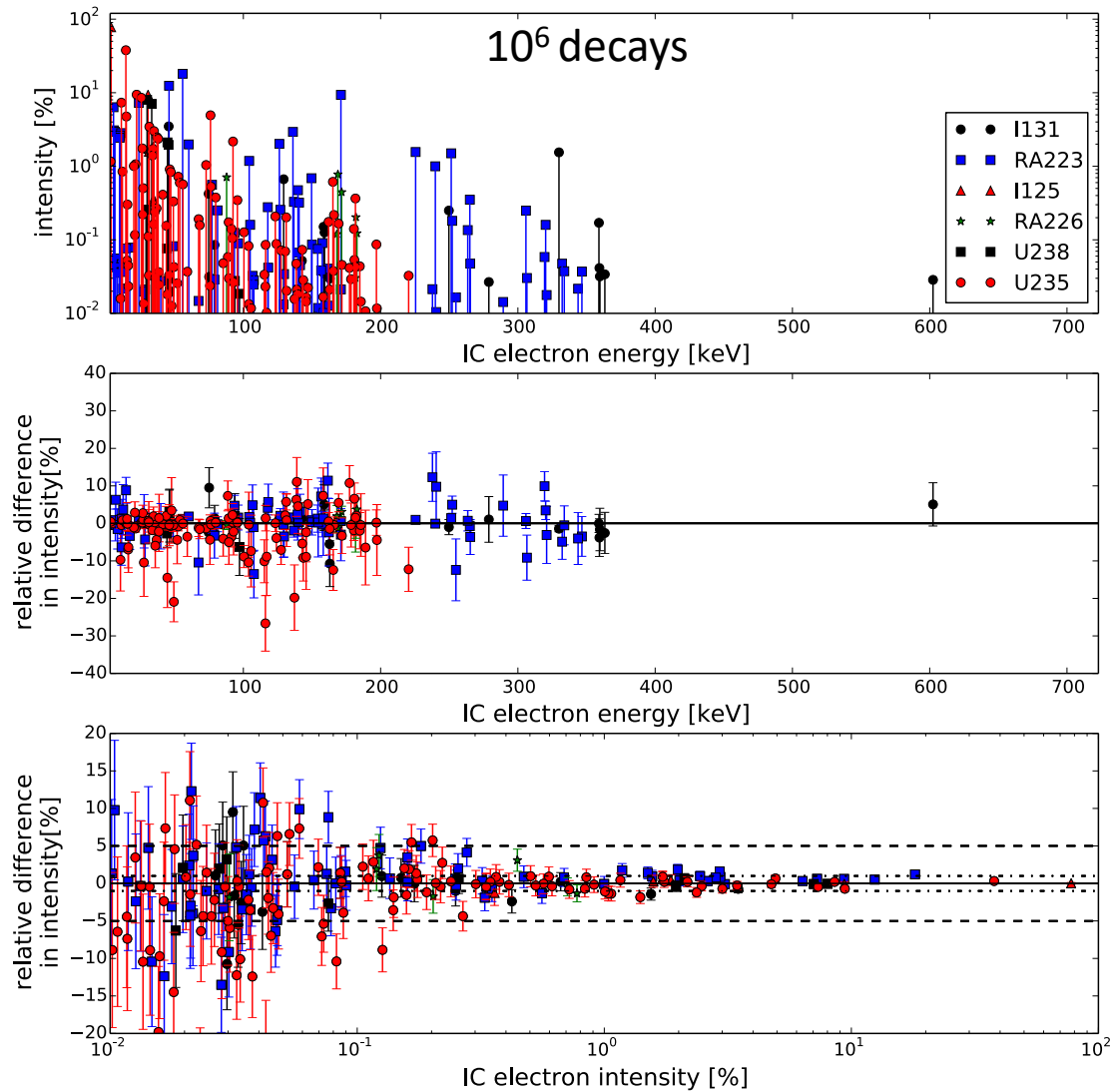
G4 code vs G4 database

10^6 decays



Comparison of e^- Conversion Spectra

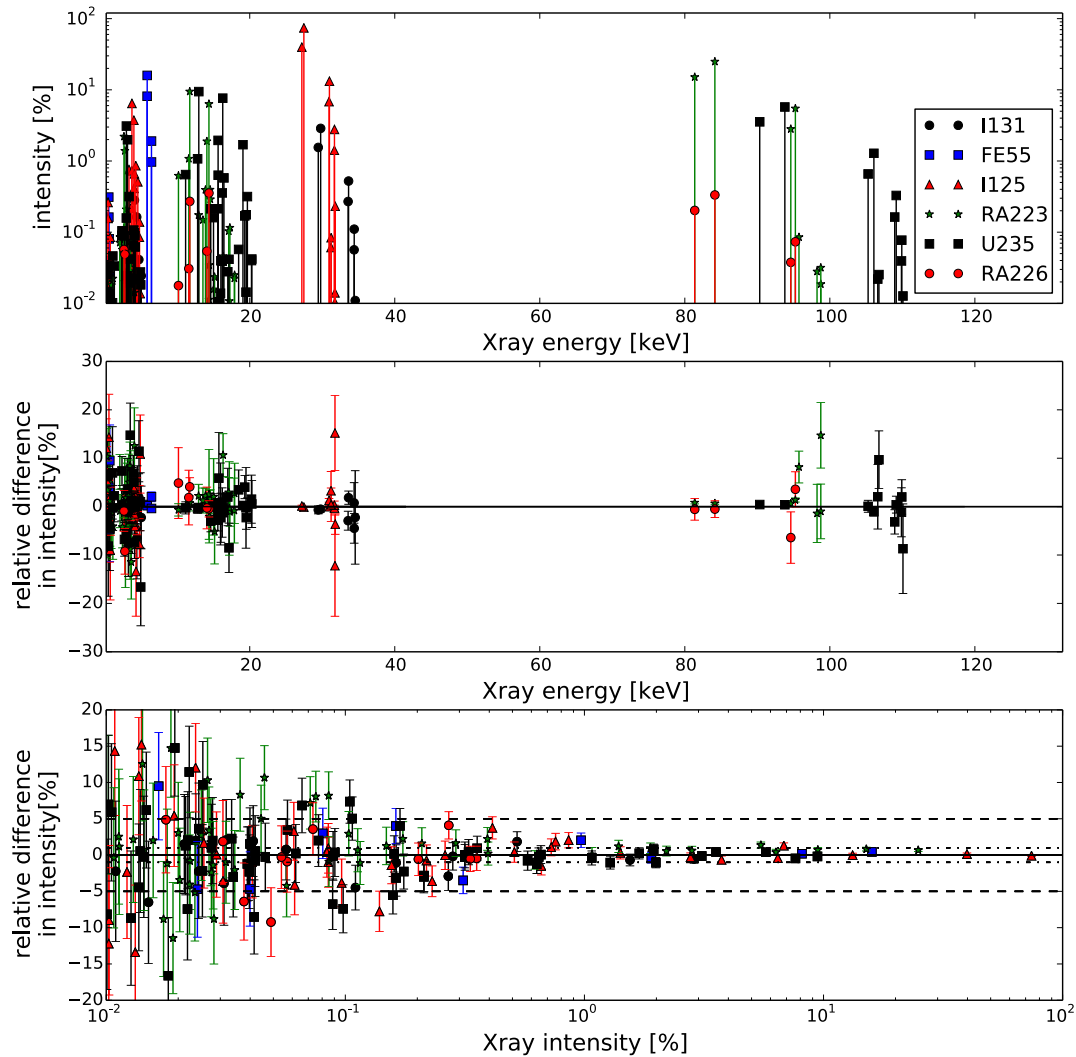
G4 code vs G4 database



Comparison of X-ray Spectra

G4 code vs G4 database

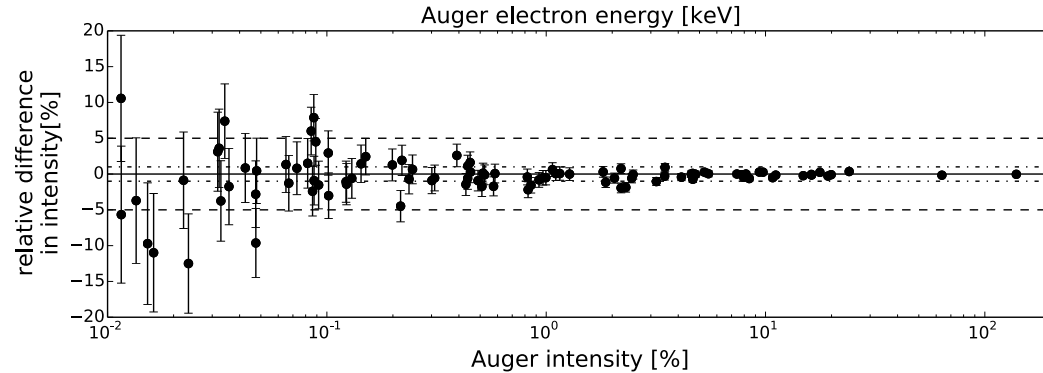
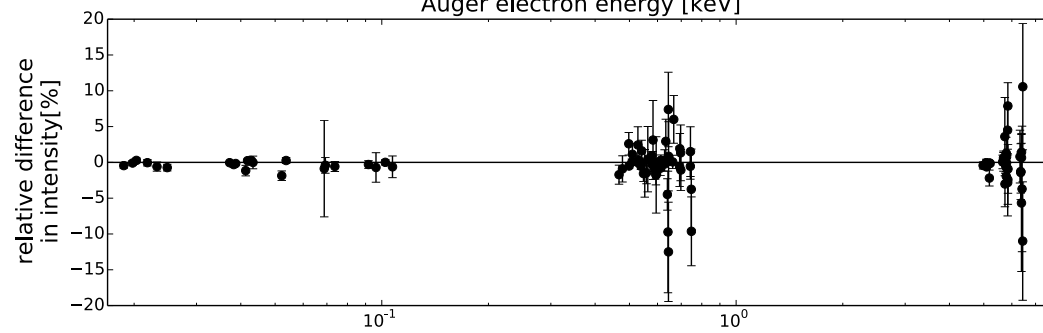
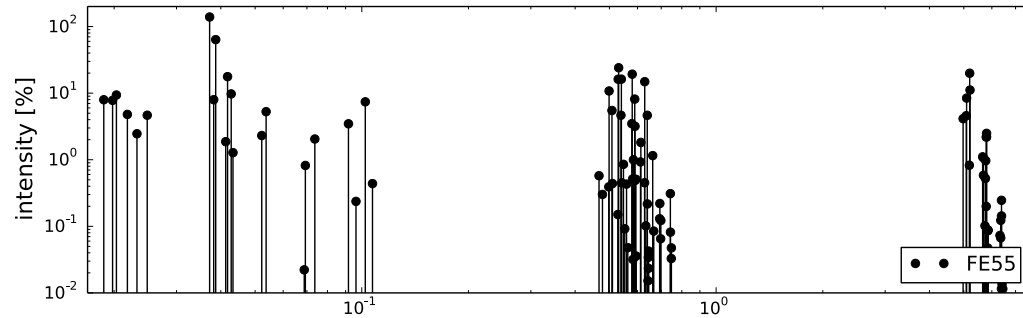
10^6 decays



Comparison of Auger Electron Spectra

G4 code vs G4 database

10^6 decays



Comparison G4 Code vs G4 Database

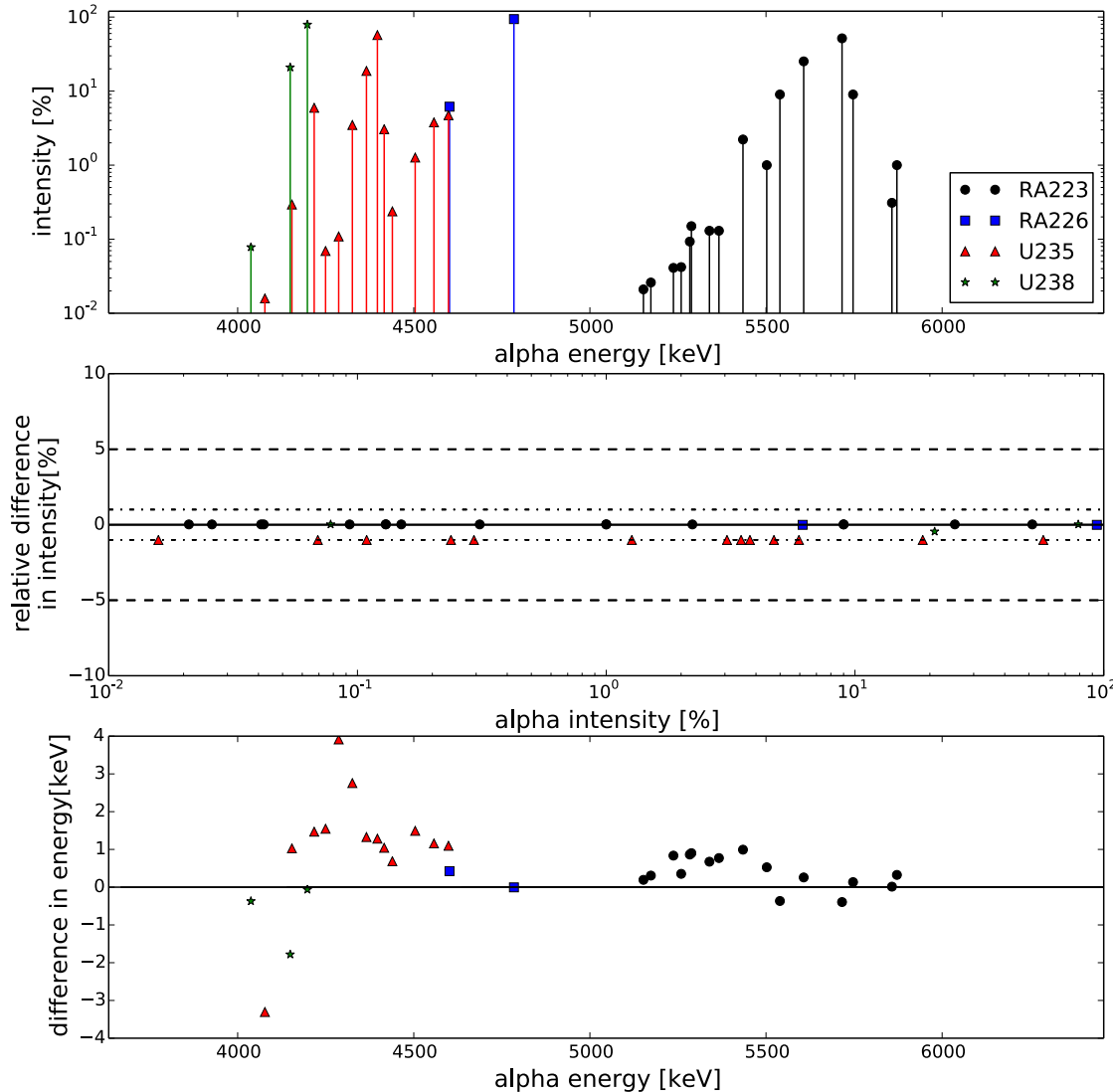
Conclusions

- Excellent agreement between GEANT4 computed spectra and spectra computed analytically from the database for all particles
- Geant4 radioactive decay, photon-evaporation and atomic relaxation C++ are working correctly

Comparison of G4 Database Spectra vs. NUDAT2 (ENSDF)

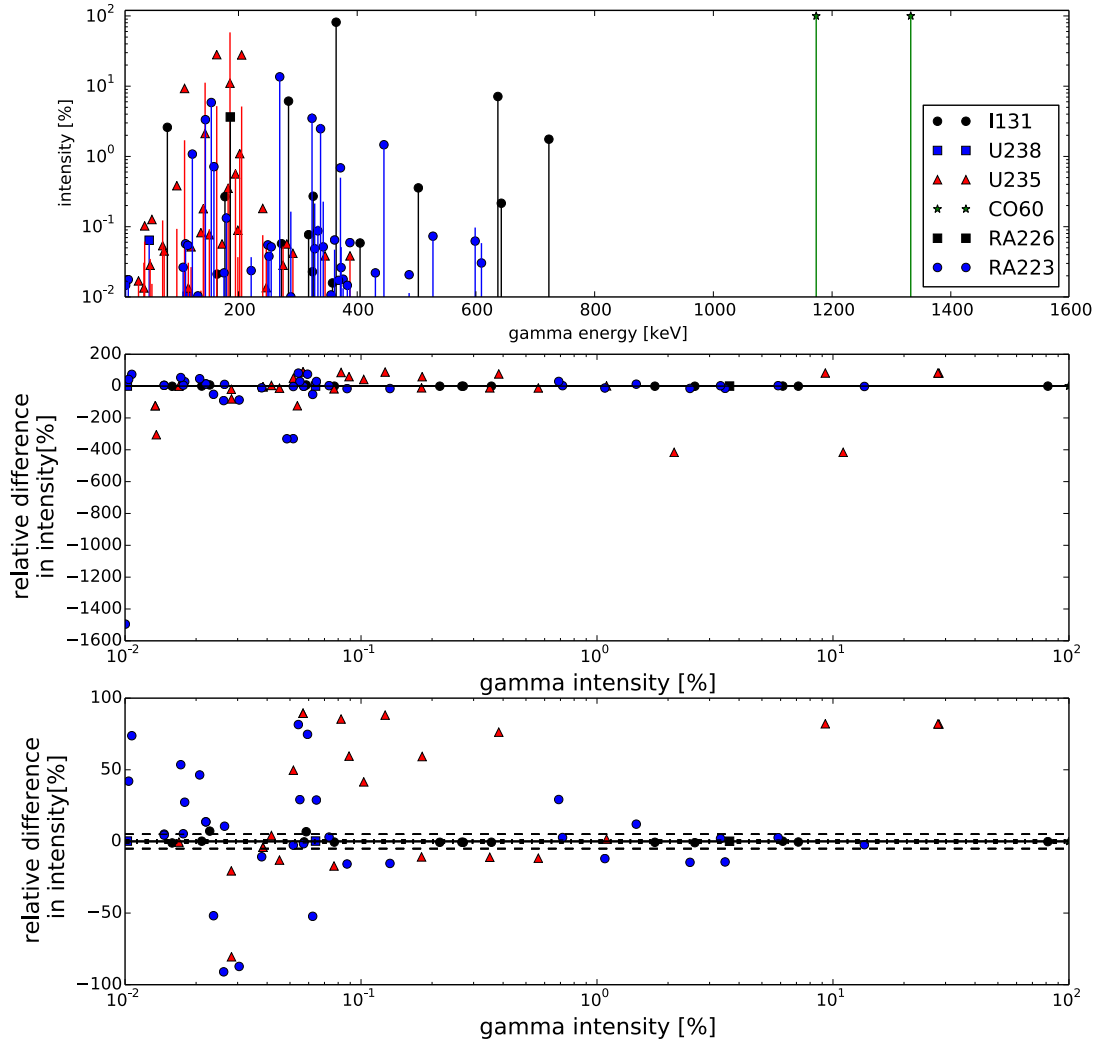
- Recompute for each tested nucleus the G4Database files from ENSDF
- Compute analytically spectra from the database
- Comparison secondary spectra from the G4Database and NUDAT2 (ENSDF)
 - Alpha
 - Gamma
 - Electron conversion on-going
- Auger and Xrays not compared as atomic relaxation model used in NUDAT2 is not based on EADL

Comparison of Alpha Spectra in G4 Database vs NUDAT2



- Excellent agreement in intensity
- Difference in energy up to 4 keV
- Non-conservation of energy in ENSDF experimental alpha data

Comparison of Gamma Spectra in G4 Database vs NUDAT2

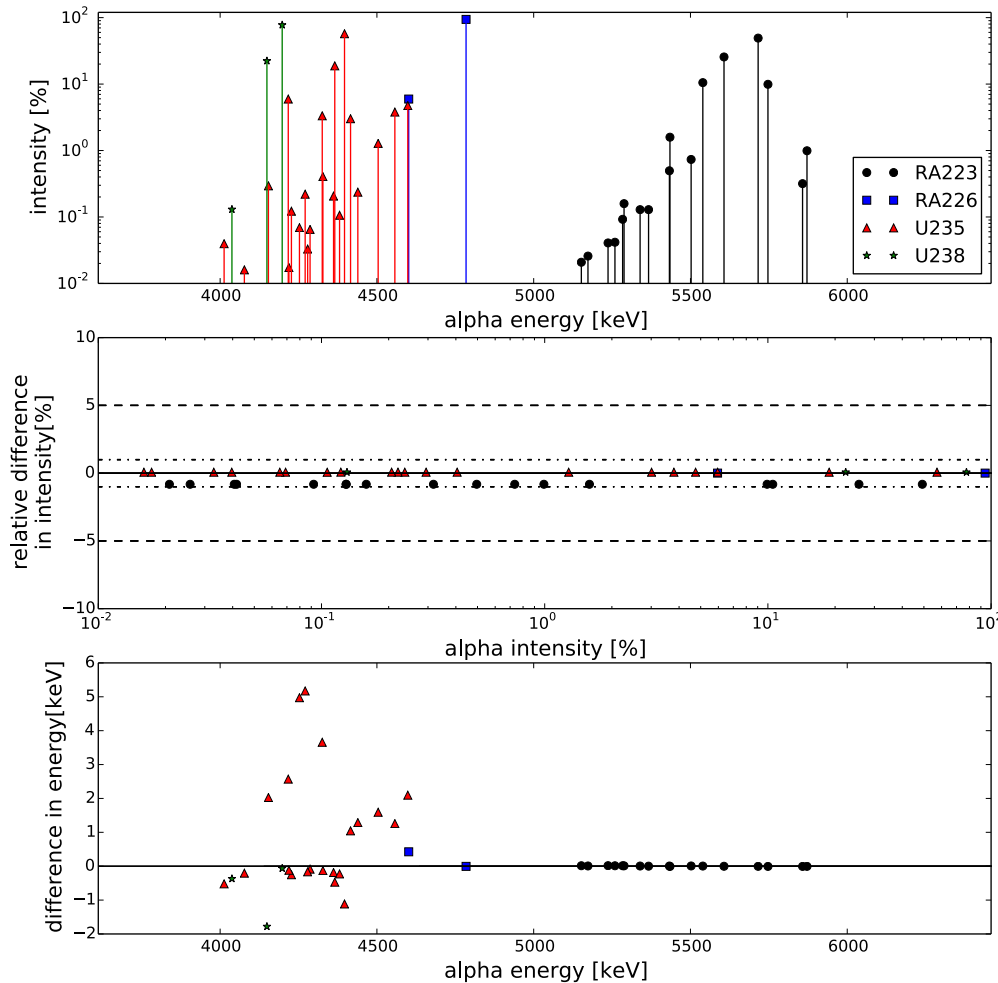


- Some significant differences in intensity for some nuclei
- ENSDF gamma and electron conversion data not always consistent

Comparison of G4 Database vs DDEP data

- Regenerate for each tested nucleus the G4 Database files from DDEP-ENSDF files
- Compare secondary spectra from the G4 Database and DDEP
 - Alpha
 - Gamma
 - Electron conversion on-going
- Auger and x-rays not compared as atomic relaxation model used in DDEP is not based on EADL

Comparison of Alpha Spectra in G4 Database (line) vs DDEP (symbols)

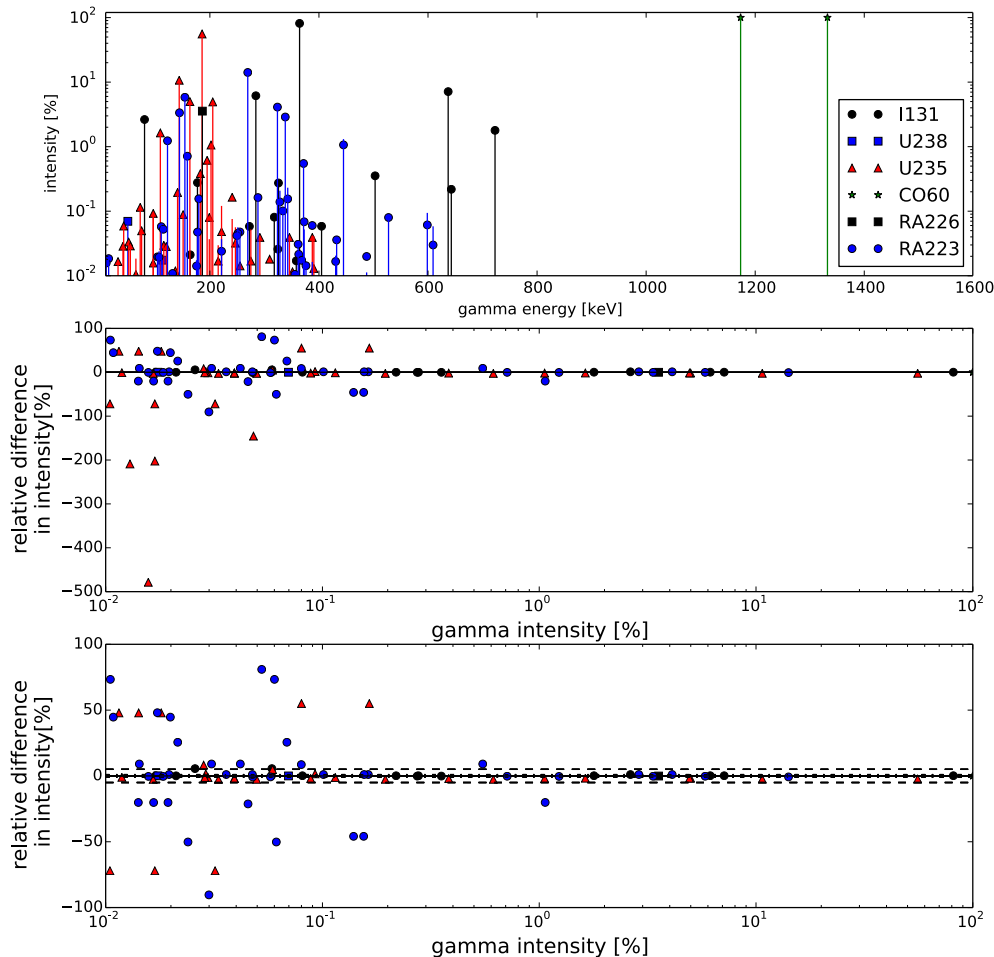


Excellent agreement in intensity

Difference in energy up to 7 keV for ^{235}U

Non-conservation of energy in some DDEP experimental alpha energies

Comparison of Gamma Spectra in G4 Database vs DDEP



- Better agreement than with NUDAT2 but still some significant differences in intensity for some nuclei
- DDEP gamma and Electron conversion data not always consistent

Conclusions on Validation (1)

Comparison between GEANT4 computed spectra and spectra computed analytically from the G4 database

- Excellent agreement for all type of particles
- Geant4 radioactive decay, photon-evaporation and atomic relaxation C++ are working correctly

Conclusions on Validation (2)

Comparison between spectra computed analytically from the G4 database and spectra obtained from NUDAT2 and DDEP

- Very good agreement for alpha intensities, few keV differences for alpha energies
- Significant differences in gamma spectra for some nuclei, with a better match between DDEP and GEANT4 spectra
- Some inconsistencies exist in ENSDF but also DDEP data that make difficult a 100 % match of GEANT4 with these data

We propose to add the validation code in Geant4-val