Atomic and Nuclear Decay Data Evaluations at the French National Metrology Laboratory for Ionising Radiation

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Introduction

As part of the activity related to atomic and nuclear decay data evaluations, the LNE-LNHB coordinates the Decay Data Evaluation Project (DDEP): an international collaboration providing easy-to-use and reliable decay data. Beyond the participation in decay data evaluation, our laboratory is in charge of the dissemination of the recommended data to the users, once the evaluation process is completed. Hereafter is presented the DDEP work as well as the various dissemination tools used to provide the recommended decay data to a wide audience.

What are decay data?

Each radionuclide decays in a specific manner, characterised by a decay scheme and specific decay parameters. These decay parameters are critical for numerous applications (ionising radiation metrology, fundamental research, nuclear medicine, nuclear industry…) and need to be evaluated with care.

Since 1993, the DDEP collaboration has developed a rigorous methodology to evaluate measurements of the various decay parameters and provide meaningful and consistent recommended values and associated uncertainties.

The main information recommended by DDEP are:

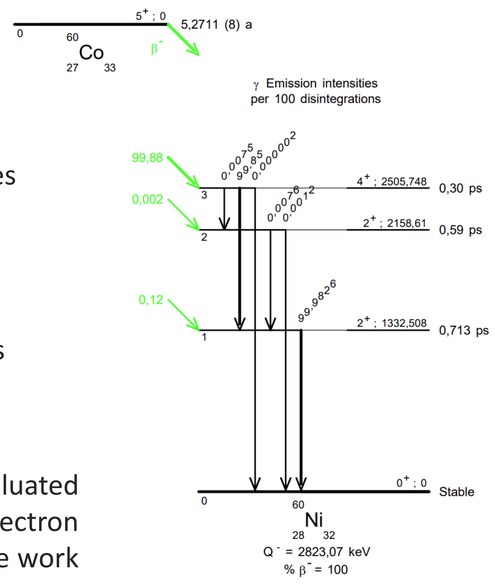
- Decay scheme
- Half-life, Q-value

→ Decay properties

- Intensities and energies of
  - Alpha / beta / electron capture
  - Gamma and internal conversion
  - X-rays & Auger electrons

→ Emitted particles

During a DDEP evaluation, all nuclear processes are evaluated however the atomic processes (X-rays and Auger electron energies and intensities) are calculated according to the work performed by E. Schönfeld *et al.* in the late 1990s.
The calculated data are compared with measured data where available – unfortunately measured data are scarce.



Decay scheme of ^{60}Co
(R.G. Helmer, DDEP 2010)

Evaluation of decay data

The typical process of a DDEP evaluation is as follows:

1. Gathering data on one subject (articles, proceedings, thesis…)
2. Refine the dataset
   - Only one publication per author / laboratory
   - Robust uncertainty estimation
   - Consistency study (Chauvenet criterion)
3. Calculate recommended values from the final dataset

DDEP main collaborators & projects

CTBTO · IAEA · METROLOGY PARTNERSHIP · EURAMET

The DDEP evaluation pipeline is:

1. Initiation of an evaluation
   - Specific needs (e.g. projects)
   - Following a user request
2. Data evaluation
   - Usually performed by 1 or 2 DDEP evaluators
   - Using DDEP guidelines and tools
3. Reviewing process
   - Performed by an independent DDEP evaluator
   - Complete verification of the evaluation
4. Editing and publication online
5. Inclusion in application libraries (e.g. JEFF)

Beginning of data evaluation

From few weeks to several months

Several weeks

Few days

Online publication & dissemination

JEFF-3.3 · NEA NUCLEAR ENERGY AGENCY

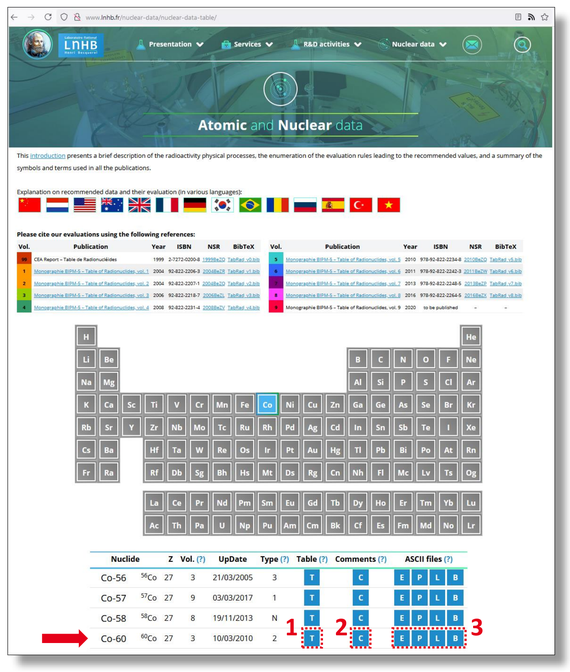
Dissemination of recommended data

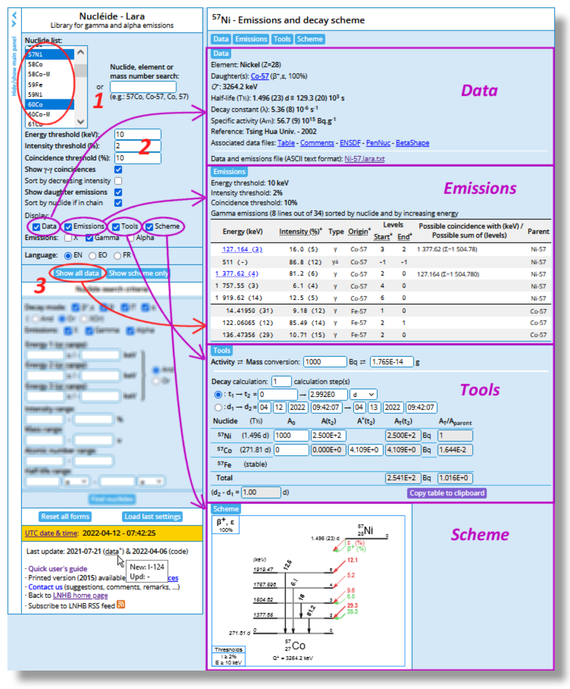
The recommended data are available through different media:

- Monographie BIPM-5 (8 volumes)
- The LNHB website **http://www.lnhb.fr/nuclear-data**
  1. Decay tables
  2. Evaluation comments file
  3. Data files (ENSDF, PENNUC, BetaShape)

  → ~ 130 accesses per day ~ 20 downloads per day ~ 20 countries
- The Nucléide-Lara web application
  - Easy access to decay data
  - Online drawing of decay schemes
  - Various calculation tools
  - Multiple search criteria

  → ~ 2000 users per day ~ 3000 requests per day ~ 60 countries
- Simulation packages
  - PENNUC for PENELOPE
  - Nuclide++ for Geant4





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PENNUC: Monte Carlo simulation of the decay of radionuclides☆

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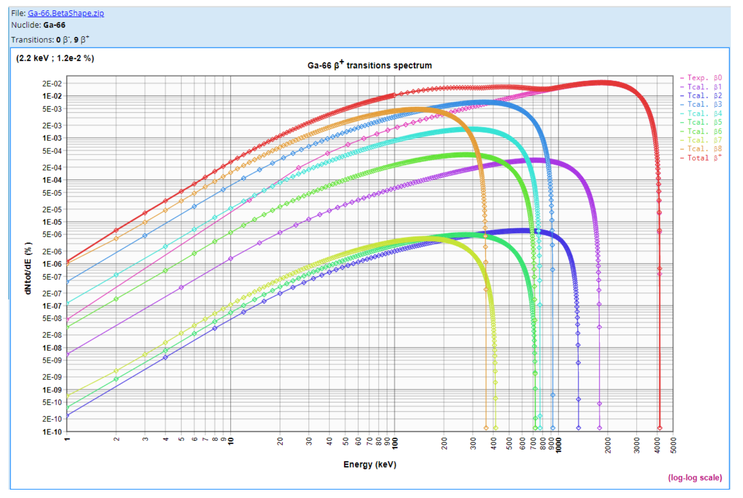
Nuclide++: A C++ module to include DDEP recommended radioactive decay Data in Geant4

C. Thiam [a,*], C. Dulieu [a], X. Mougeot [a], A. Nair [b], C. Bobin [a], M.A. Kellett [a]

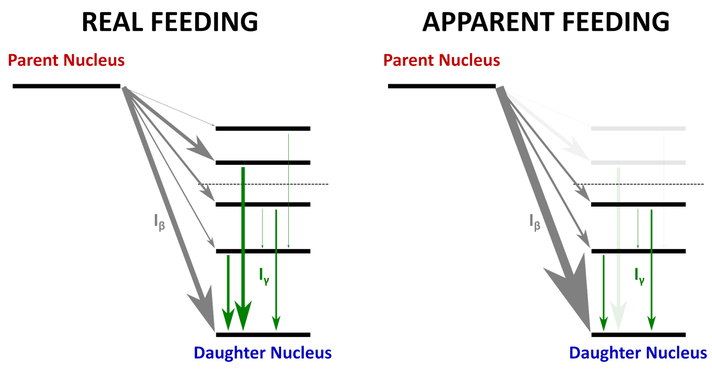
Updates & development

Recent developments and future updates include:

- Online tools
  - Continuous development of Nucléide-Lara web application
  - BetaShape on the web



- Inclusion of the latest DDEP data in JEFF4
- Inclusion of Total Absorption Gamma-ray Spectrometry (TAGS) measurements in DDEP evaluations (pandemonium effect)



Missing high energy gamma-rays lead to incorrect feeding estimation.

Conclusion

The DDEP collaboration evaluates decay data to provide recommended values for non-specialists. Since 1993, the collaboration has developed a robust methodology for these evaluations, which have been most notably used within the metrology community, and more recently have been included in the JEFF applications library. The data are available on the LNHB website, in a variety of formats, as well as through the associated online tool Nucléide-Lara. Recent improvements include the availability of calculated beta spectra, an online tool to calculate decay chain data and current development work aims to display on-the-fly results of the BetaShape code.

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