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Update of the Evaluated Radioxenon Nuclear Decay Data

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ABSTRACT

This work presents the last updated evaluations of the nuclear and decay data of the four radioxenons of interest for the CTBT: Xe-131m, Xe-133, Xe-133m and Xe-135. This includes the most recent measured values on the half-lives, gamma-ray emission probabilities (P_g) and internal conversion coefficients (ICC). The evaluation procedure has been made within the Decay Data Evaluation Project framework and using the ultimate available versions of different nuclear and atomic data evaluation software tools and compilations.

INTRODUCTION

Precise and high-quality decay data of specific radioxenon nuclei are fundamental for the CTBT. Radioactive decay quantities, such as half-life, gamma-ray emission probabilities (P_g), gamma energies, internal conversion coefficients (ICC), X-ray energies and emission probabilities, conversion electron emission probabilities (P_{ce}) and Auger electron emission probabilities, and branching ratios of the decay modes are used in the analysis of spectral data from the noble gas monitoring systems. Nuclear and decay data are also used in detector's calibration, or in activity concentration calculations, or in isotope activity ratio calculations which are carried out to distinguish if detected radioxenons are generated during a nuclear explosion or in a nuclear reactor operation, as well as for estimating the origin time. Therefore, high quality precise and well evaluated nuclear and decay data are crucial to be implemented in the CTBTO radionuclide library.

EVALUATION PROCEDURE

The International collaboration Decay Data Evaluated Project was formed in 1995 by different institutions and metrological laboratories, that is now joined by the CTBTO, to disseminate and recommend high-quality evaluated atomic and nuclear data used in applied research and detector calibrations. The evaluations are performed under an agreed methodology which comprises:

- Critical analysis of published results related to experimental measurements of nuclear and decay data. Discard of literature is documented.
- Adjustments and evaluation of reported uncertainties.
- If necessary, statistical rejection of data is based on the Chauvenet's criterion.
- Determination of the best value derived from experimental values or theoretical considerations.
- Checking of datasets and balanced decay schemes.
- Use of evaluated compilations: Q-values, atomic shell data, theoretical Internal Conversion Coefficients, log*ft values* or X-ray and Auger energies.

RESULTS OF THE EVALUATIONS

From their last DDEP evaluation, the most relevant results revealed in this work for each radioxenon are:

- Xe-131m: (evaluated in 2014) no relevant measurements to be included in a new evaluation have been published up to today.
- Xe-133: a variation of 0.1% in the half-life value has been determined including the corrections published in 2014. Readjustments in P_g 's and ICC's have also been done.
- Xe-133m: More precise ICC calculations derived to new absolute P_g and P_{ce} values.
- Xe-135: evaluated for the first time within the DDEP procedure. A new absolute P_g was measured in 2013. Comparison of results of this new evaluation with the ENSDF evaluation (done in 2008) revealed new recommended absolute P_g, P_{ce} and Normalization Factor.

CONCLUSIONS FOR NUCLEAR EXPLOSIONS MONITORING

In Figure 1, the different values and associated uncertainties for the Half-life in the CTBTO nuclide library and the evaluated in this work are presented. The most relevant differences were found for Xe-131m and Xe-133m with a 0.52% and 0.36% respectively. It is also remarkable the high uncertainty associated to the present Xe-131m half-life value (400% higher than the new evaluated uncertainty). Except for the Xe-131m, the new evaluated uncertainties are higher than the present ones.

Table 1, shows the difference in data used for b-g coincidence noble gas systems. Abundance are referred to X_k-rays emission probabilities for the isomers and gamma-ray emission probabilities for Xe-133 and Xe-135. Differences between 0.18 - 3.47 % are found.

Relevant radioxenon isotopes nuclear data were evaluated. Half-lives are used on the determination of the activity concentrations. Gamma-ray emission probabilities and energies are used to determine activity ratios essential to evaluate the origin time and source of a nuclear explosion. The nuclear database used for this calculations can derive to high significant different results (Yamba et al., 2015).

Due to the high importance on the use of decay and nuclear data of these radioxenon for the CTBT, it is highly recommended to adopt the new evaluated data. Results will be implemented in the CTBTO radionuclide library and are published on the homepage of the Decay Data Evaluation Project (DDEP).

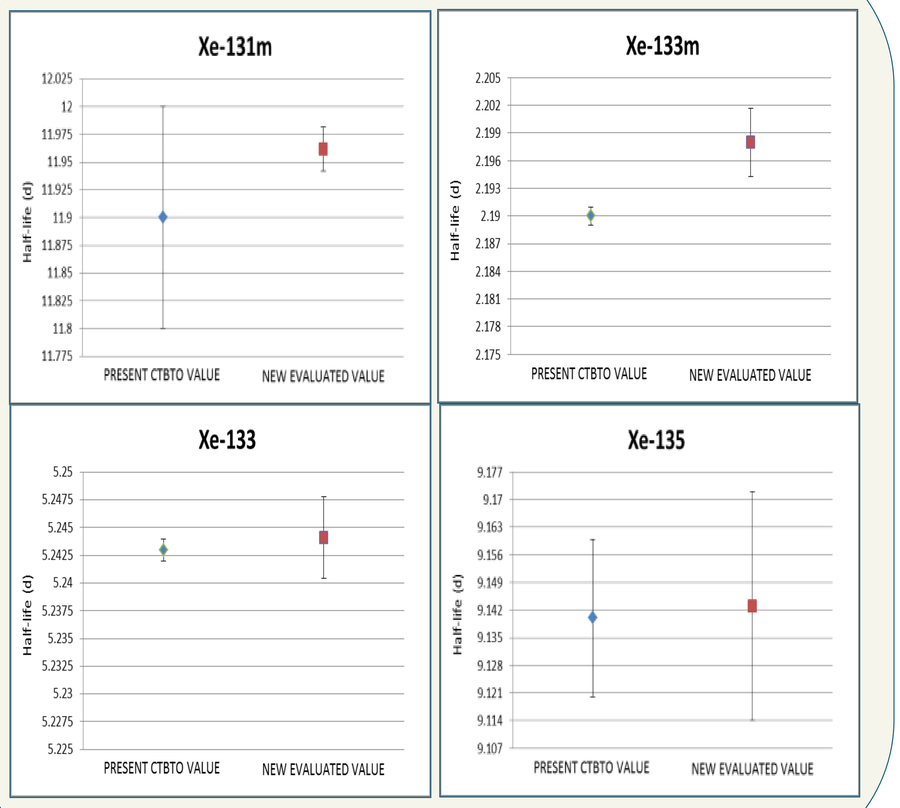

Figure 1. Present and recommended half-life values

Name	Abundance CTBTO library	Abundance recommended	Variation
Xe-131m	0.537 (4)	0.545 (8)	1.47%
Xe-133m	0.558 (13)	0.559 (8)	0.18%
Xe-133	0.380 (7)	0.367 (4)	3.54%
Xe-135	0.902 (2)	0.896 (16)	0.67%

Table 1. Abundances

REFERENCES:
CTBTO nuclide library
DDEP: Decay Data Evaluation Project, http://www.nucleide.org/DDEP_WG/DDEPdata.htm
ENSDF: Evaluated Nuclear Structure Data File, http://www.nndc.bnl.gov/ensdf/
Yamba, K., Kalinowski, M.B., Sanogo, O. "Using radioxenon concentrations for dating a nuclear event" poster T3-P4, INGE 2015, CTBTO - U-Texas (USA)