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Leda: a new low level spectrometer using gamma-gamma coincidence

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Content

The French Institute of Radioprotection and Nuclear Safety (IRSN) is responsible for performing radiological environment surveillance in France. In this context radioactivity in environment samples (e.g. soils or sediments or biota sampled in the marine or terrestrial environment, or aerosol filters in the atmospheric one) are measured at trace levels in the laboratory of environmental radioactivity measurement by low level gamma ray spectrometry.
Metrology developments have been made during the last decades in order to deal with the globally decreasing levels of the anthropogenic radioactivity in the French environment. This paper presents the latest development of a gamma ray detection system based on the use of the emissions of gamma rays in coincidence. This system called Leda consists of 2 HPGe detectors (Castor and Pollux) face to face surrounded by a NaI scintillator (Helene). The acquisition system is a digital electronics working in list mode. It records all events detected by each detector with time and energy information. Thanks to the data analysis code all the following information can be analyzed in one measurement:

1. Sum spectrum of both Ge detectors The efficiency increase leads to decrease uncertainties and detection limits and counting time for all emitters.
2. Anti-coincidence spectrum This spectrum is obtained by summing both spectra obtained by each Ge in anti-coincidence with the other Ge and the NaI. It combines anti-Compton and anti-cosmic features of particular interest for all emitters not affected by coincidence (called "single" emitters):
3. The Compton continuum decrease leads to a better determination of "single" emitters with energy lower than 1460 keV (e.g. Cs-137) in biological matrices containing much K-40, or with energy lower than 477 keV (e.g. I-131) in aerosol filters containing much 7Be.
4. The cosmic ray induced background decrease leads to a better determination of Cs-137 in aerosol filters for instance.
5. Coincidence matrices and spectra (Ge-Ge or Ge-NaI in coincidence) These 4 plots are the most powerful tools for all the coincidence emitters (e.g. Co-60, Cs-134. . .) due to a dramatically decreased background. Moreover the multiple data (peaks in spectra and fingerprints in matrices) can be accumulated to get a better determination. The choice to use one of these 4 matrices or spectra is made after an in-depth study of the radionuclide decay scheme. It is for instance the Ge-NaI matrix for 60Co or 22Na, and the Ge-Ge spectrum and matrix for Cs-134, Ag-108m and Ag-110m.

Standard sources are used to calibrate the detection system. Calibration factors are also calculated with Monte Carlo MCNP-CP code: for the radionuclides contained in the standard sources in order to validate the model of the simulated system and afterwards for radionuclides not easily available in classical standard source.
This new system is versatile since all gamma emitters can be measured: single emitters in the anti-coincidence mode and coincident emitters in the coincidence mode in the same measurement. Detection limits are improved for all radionuclides with these various detection modes either by increasing the detection efficiency (case 1) or by decreasing the background (cases 2 and 3).

About the Presenter

Hugues Paradis is a PhD student who will defend its thesis at the end of 2016. The paper presents his work on the design of a new gamma-ray spectrometer using gamma-gamma coincidence. He has also developped and validated the method by using an anti-Compton system already used in the laboratory.

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