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#07-252 Passive neutron multiplicity counting with PVT plastic scintillators for plutonium characterization in radioactive waste drums

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In the framework of plutonium characterization in radioactive waste drums by passive neutron coincidence counting, the Nuclear Measurement Laboratory of CEA Cadarache is studying plastic scintillators as a cheaper alternative to ^{3}He gas proportional counters. Plastic scintillators offer a three order of magnitude faster time response than ^{3}He detectors, larger volumes and a similar neutron detection efficiency. However, the high sensitivity to gamma rays and crosstalk make this technology difficult to use in neutron-gamma mixed field and for large detectors without PSD capabilities. A new patent-pending data processing, based on a time discrimination of triple coincidences, permits to isolate useful fission coincidences from parasitic ones, such as those due to (α,n) reactions and gamma-ray cascades. The performances are studied with an experimental setup designed for 100L to 200L waste drum measurements, and composed of sixteen 10x10x100 cm^3 plastic scintillators positioned in circle around the package. MCNPX-PoliMi simulations are also performed and compared to experimental data, first to validate the numerical model, then to optimize data processing, and finally to study main causes of uncertainties. For instance, we investigate the linearity of the method with the plutonium quantity, in presence of increasing background noises and matrix effects. To this purpose, different neutron and gamma calibration sources (^{252}Cf for the useful signal, AmBe, ^{60}Co and ^{137}Cs for the background) are placed in mockup drums filled with metallic (iron) or organic (wood, polyethylene, PVC⋯) materials mimicking common technological waste. Without unfolding real and accidental coincidences at this step, the new data processing increases the signal-to-noise ratio (SNR) recorded with bare calibration sources (no drum) by up to 50% compared to classical triple coincidence calculation with the shift register method. On the other hand, MCNPX-PoliMi simulations are in good agreement with experiment, with a relative difference between the measured and calculated number of coincidences lower than 20%, whatever the coincidence order from total counting to triples. Then a linear response is observed by simulation with the equivalent mass of ^{240}Pu. In addition, this linearity is preserved up to an "alpha ratio"of 100 between (α,n) and fission neutrons. We are currently studying the deconvolution of real and accidental coincidences at high count rate, especially due to high gamma-ray fields, as it is frequently the case with radioactive waste (^{60}Co, ^{137}Cs). We will also discuss the benefit of crosstalk rejection algorithms, as well as the ^{240}Pu detection limit with different waste matrices, plutonium localization and background noise level. The ultimate goal of this work is to reduce the cost of passive neutron coincidence collars for radioactive waste drums by approximately a factor five, compared to ^{3}He-based systems.

Primary author: BOTTAU, Vincent (CEA)

Co-authors: Dr PEROT, Bertrand (CEA, DES, IRESNE, Nuclear Measurement Laboratory, F-13108 Saint--Paul-Lez-Durance, France); Dr ELEON, Cyrille (CEA, DES, IRESNE, Nuclear Measurement Laboratory, F-13108 Saint-Paul-lez-Durance, France); Dr CARASCO, Cédric (CEA, DES, IRESNE, Nuclear Measurement Laboratory, F-13108 Saint-Paul-Lez-Durance, France); DE STEFANO, Roberto (CEA); TSEKHANOVICH, Igor (CENBG)

Presenter: BOTTAU, Vincent (CEA)

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