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A COINCIDENCE BASED (GAMMA-ALPHA/BETA) SYSTEM FOR VERY-LOW BACKGROUND RADIATION MEASUREMENTS

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High-accuracy measurements of nuclear and related materials are a useful tool in nuclear forensics, in particular, the characterization of investigated radioactive samples, where very low quantities are available. As an example, the detection of certain isotopes may be used as a distinctive signature of the nuclear cycle, irradiation time, fluxes etc. for the attribution of the sample to a particular reactor facility. Low-background measurements are useful for supporting the verification regime of the Comprehensive Test Ban Treaty Organization (CTBTO), where the detection of certain fission (and/or activation) products in air filter samples can indicate the occurrence of nuclear explosions (e.g. 140Ba and 133Xe). Additional applications of low-background measurements can be found in studies involving fundamental physics and environmental radioactivity.
Traditionally, radionuclides are identified and quantified by detecting one type of their radioactive emissions. Gamma/X-rays are usually detected using high-purity germanium (HPGe) or NaI, whereas alpha and beta particles are typically detected by a proportional counter, silicon detector or plastic/liquid scintillator. Systems based on multi-particle detection in coincidence mode (alpha/gamma, beta/gamma and gamma/gamma) hold the potential for providing excellent signal-to-noise ratio, compared to the traditional (single emission-based) systems [1-3]. Another major advantage of coincidence-based systems is their relatively lower cost and competitive sensitivity compared to underground laboratories.
An innovative low-background multi-detector system is being developed in Soreq NRC. The proposed setup comprises a HPGe detector, a liquid scintillator cell read by a photomultiplier tube and plastic scintillator panels (for cosmic radiation reduction). The geometric configuration provides a detection efficiency of nearly 90% for alpha and beta particles and a typical detection efficiency of ~3% for gamma-rays in single-emission mode. Preliminary tests of a prototype system configuration in coincidence mode exhibit a minimal detection activity of 0.1 Bq for Am-241 during a measurement time of 16 hours. By incorporating dedicated electronics and software, it is possible to observe the different data aspects associated with the decay. Energy and timestamp are recorded event-by-event for each particle type, thereby allowing to perform off-line analysis of the entire dataset and make use of the various detection modes. In addition, future developments of the system will include additional features such as alpha/beta discrimination and alpha spectrometry.
Results from first characterization tests of the system will be presented and several potential applications of will be discussed.

[1] J.L. Burnett et al. Journal of Radioanalytical and Nuclear Chemistry 312, 81-86 (2017).

[2] A. Ringbom et al. Nuclear Instruments and Methods in Physics Research A 508, 542-553 (2003).

[3] P.P. Povince. Journal of Radioanalytical and Nuclear Chemistry 316, 893-931 (2018).

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