Contribution ID: **247** Type: **Poster**

Spectrum Analysis for Identification of Nuclides at Radiological Crime Scene

Wednesday 3 July 2024 15:07 (1 minute)

With the increasing global emphasis on nuclear security and non-proliferation, the detection and identification of nuclear and radioactive materials at the radiological crime scene are of paramount importance. To address this need, in the past free software has been developed identifying the photopeaks of the spectrum [1], [2], [3], [4] and commercial detectors identify the nuclides [5] presented on the area under investigation. In the present work an algorithm has been developed to analyze γ-ray spectrums collected by specialized detectors, such as portable High Purity Germanium (HPGe) detectors and to attempt beyond the peak identification, identifying the nuclides that emit the photopeaks.
Initially the algorithm reads a spectrum file and extracts relevant information such as live time and photon counts for each energy channel. After that it performs a baseline correction on the spectrum, followed by peak detection. Peaks are identified with the local maximum method exploiting the 1st or 2nd order derivative [6] or with a minimum peak prominence criterion or with a minimum peak height criterion. The minimum peak height criterion identifies the local maxima in the spectrum that surpasses a specified minimum height and sorts the peaks by height. The minimum peak prominence criterion identifies the local maxima and returns only those peaks that have a relative importance bigger than a specified minimum prominence. The minimum peak prominence criterion performs better than the minimum peak height criterion.
A conventional energy calibration is performed on the spectrum data to convert channels to energy values, based on radioactive sources which emit γ-rays of known energy. Additional calibration is performed to adjust the height of the photopeaks, considering the efficiency curve of the detector.
The algorithm identifies possible nuclides associated with each peak by searching for nuclides within a specified range of energy interval, minimum half-life, and minimum fraction yield of the photopeak (i.e. intensity). The matching process involves comparing photopeaks of the spectrum under investigation with a complete dataset of energies of γ-rays and their emitters.
To exclude false positive identifications of nuclides, the first criterion considers a certain number (e.g. the first six) of the most intense γ-ray energies that each possible nuclide emits and investigates whether these energies are correlated with the photopeaks. In addition, a second criterion checks the height of the photopeaks based on their yield by their emitters. For example, if a nuclide identified on the spectrum by two photopeaks emits them with intensity 70% and 30%, respectively, but the first is shorter than the second one then the nuclide is labeled as false positive. The comparison of using both criteria than just the first one turns in favor of using both criteria, thus the number of false positive identifications decreases.

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Session Classification: Poster Session