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# Experimental characterization of a multi-chamber alpha spectrometry system using standard actinide sources

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A R T I C L E I N F O

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A B S T R A C T

The experimental characterization of the main parameters of a high resolution multi-chamber alpha spectrometer is performed using standard sources of $^{241}$Am, $^{233}$U and $^{244}$Cm. The following performance indicators of the spectrometer based on 8 solid state ORTEC ULTRA-AS detectors were determined for all possible distances source-to-detector: the detector resolution and efficiency for alpha lines of different sources, energy linearity, solid angles associated with different measurement geometries and the repeatability of the results. All measurements were done to accomplish the validation of the method dedicated to alpha radioactive concentration measurements of various environmental samples.



## 1. Introduction

Recently, the laboratory for α, β, γ Spectrometry and Radon Measurements (SALMROM) from the Department of Life and Environmental Sciences of the "Horia Hulubei"—National Institute for Physics and Nuclear Engineering, Bucharest (IFIN-HH), Romania, was equipped with a state-of-the-art multi-chamber alpha spectrometer, type Octête Plus from ORTEC company [1] to be used for activity measurements of alpha emitting radionuclides in environmental samples, in compliance with the laboratory's quality assurance documentation.

The aim of this paper is to characterize the alpha spectrometer applying appropriate methods for the energy and efficiency calibration, for the estimation of its main parameters using standard radioactive sources and to perform tests of repeatability of the results for method validation purposes. The proposed method could be useful for other laboratories that are involved in alpha spectrometry measurements.

## 2. Method and materials

The system is an integrated laboratory multi-detector/multi-channel analyzer alpha spectrometer based on 8 chambers, type Octête Plus, ORTEC [1], used for activity measurements of alpha emitting radionuclides from environmental samples and samples of radioactive materials [2].

Each incorporated channel is an independent alpha spectrometry system with a structure including: a high-performance ion-implanted-silicon charged-particle detector located in its own measuring chamber, operated in the energy range 0–10 MeV, type ULTRA-AS, model BU-019-300-AS, of 300 mm$^2$ active area, its associated electronics consisting of a variable detector bias supply, a preamplifier, a shaping amplifier with adjustable gain, a pulse stretcher and bias amplifier, and other components such as a test pulse generator, adjustable over the range 4–10 MeV for noise measuring and channel calibration, a monitor for detector leakage current and a vacuum gauge (Fig. 1).

The alpha spectrometer is equipped with a multi-channel analyzer including 8-input Multiplexer/Router with individual controls for each channel and a successive approximation analog digital converter with a conversion gain range from 64 to 4096 spectra acquisition channels that can be selected through the PC software platform of MAESTRO-32 [3] or Alpha Vision-32 ORTEC [4] specialized programs.

To reduce the risk of vacuum leakage, all the 8 chambers are connected to an integral vacuum manifold with a single connector. Inside each chamber there is a Sample Holder that allows the measurement of the samples at different distances sample-to-detector in the range of 4–40 mm, divided into 10 equal levels by the chamber wall slots.

The measurements for the spectrometer's characterization were performed using alpha standard electro-deposited disc sources of

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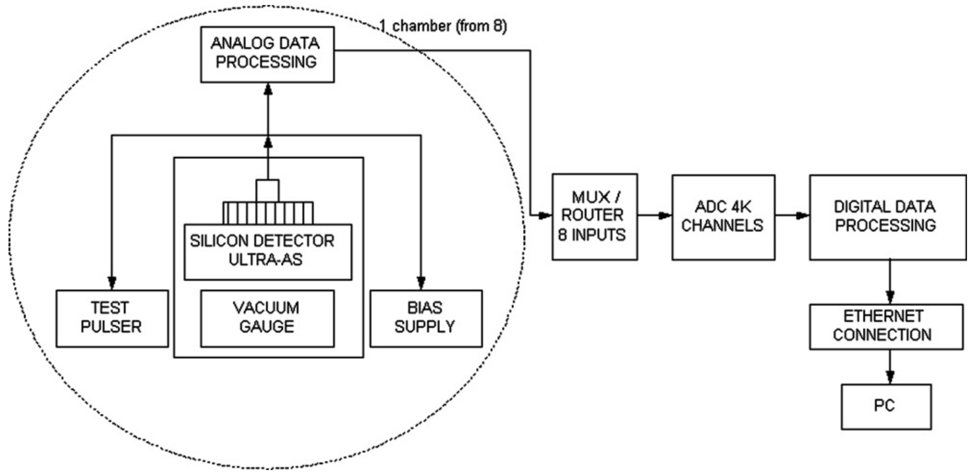


**Fig. 1.** Block diagram of the Octête Plus system.

$^{241}$Am, $^{233}$U, and $^{244}$Cm. The sources were placed on each level of the chambers for the determination of detector's efficiency and resolution at the energy lines of the certified standard disc sources, in order to perform the energy and efficiency calibrations of each channel of the alpha spectrometer.

The levels with the best resolution were considered as the optimum levels. On them, the repeatability measurements were carried out in order to study the stability of the results. The solid angles were calculated for all measurement geometries, taking into account the source and detectors characteristics and the source-to-detector distance.

## 3. Results and discussions

### 3.1. Energy calibration and resolution

The ORTEC detectors ULTRA-AS of the alpha spectrometer Octête Plus, ORTEC, were characterized by evaluating their response to alpha disc sources of $^{241}$Am, $^{233}$U and $^{244}$Cm. From the differential pulse height distributions representing the response of the alpha ULTRA-AS detectors to the energy lines of the sources, the energy calibration of the alpha spectrometer was performed and the energy resolution of the detectors was determined, by calculating the full width at half maximum (FWHM), that indicates their capability to separate close energy lines.

The energy calibration curve is described by the following linear function: energy [keV] $= a_0 + a_1 \times$ channel, where $a_0 = 37.0 \pm 4.8$ and $a_1 = 4.94 \pm 0.01$ are the coefficients of the linear fit curve shown in Fig. 2. This energy calibration is valid for all 7 chambers.

The full-width-half-maximum (FWHM) as a measure for the resolution of an alpha spectrometry system using commercially available detectors depends on the charge carrier statistics, incomplete charge collection and variations in the energy loss in the entry window thickness. The noise contributions to the energy spectrum from the non-detector system components are minimal for most alpha spectrometry systems [5]. The quality of the alpha-particle source is the main limiting factor to the resolution of the alpha-particle spectrum.

The values of the FWHM at the main energy line of the $^{241}$Am source are presented, in Fig. 3, for 7 chambers, as a function of the distance of the source-to-detector, well defined by each level of the alpha chambers. It can be noticed that the data are missing for chamber no. 7 because of the high leakage current measured for this chamber that has altered the results. As can be observed, the variation of the resolution with the source-to-detector distance has two distinct parts: a steep decreasing of the FWHM for distances corresponding to the first 5 levels and stabilized values of the FWHM for source-to-detector distances in the range 24–40 mm. The energy straggling in the source material under high

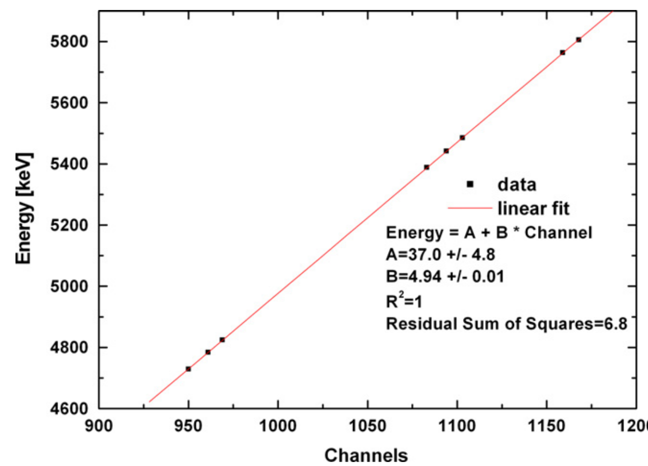


**Fig. 2.** Energy calibration curve of the alpha spectrometer (valid for 7 chambers).

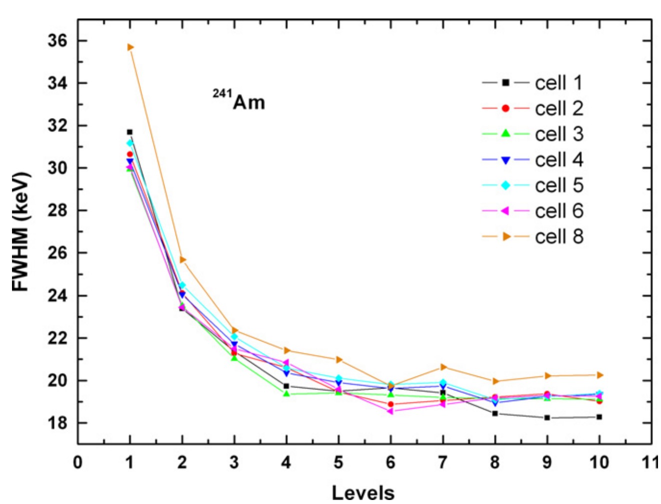


**Fig. 3.** FWHM of the $^{241}$Am energy line of 5.4856 MeV as a function of source-to-detector distance.