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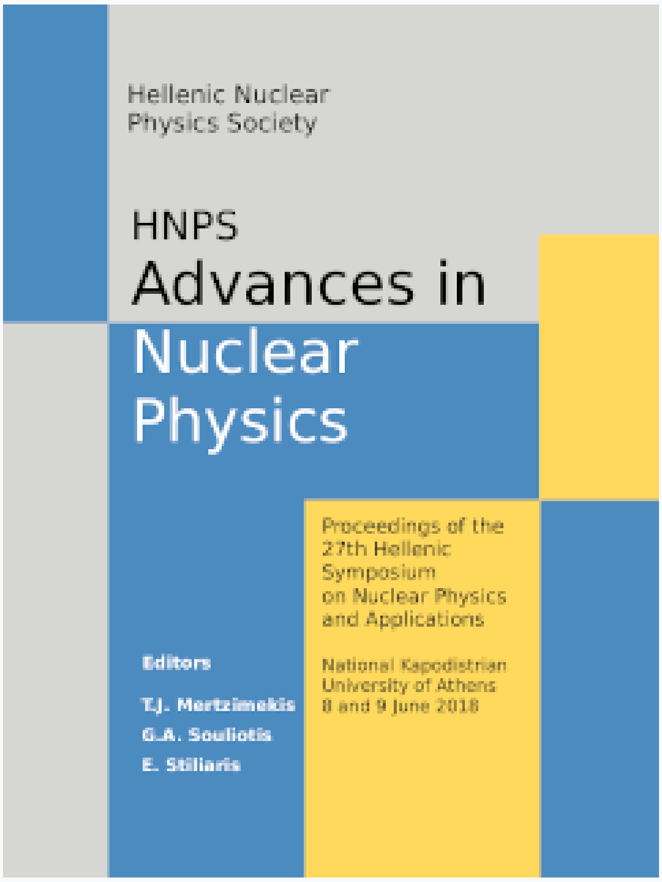

Extending the UoA Nuclear Physics Laboratory capabilities with low-γ and α spectrometers

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Extending the UoA Nuclear Physics Laboratory capabilities with low-γ and α spectrometers

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Abstract In this project the steps taken toward the characterization, calibration and testing of two spectroscopy stations are presented. The first one is suitable for alpha spectroscopy, consisting of a large-window silicon surface barrier detector (SSB), a goniometric arm and a movable multiple source-holder inside a dark vacuum chamber. The second station contains two small-size, thin-window NaI(Tl) scintillators, and it is suitable for low-γ ray spectroscopy.

Keywords alpha spectroscopy, gamma-ray spectroscopy, instrumentation

INTRODUCTION

The Nuclear Physics Laboratory (NPL) at the University of Athens is a well–established laboratory with a long record of training, educational and research activities. Recent acquisition of two small–size, thin–window NaI(Tl) scintillators and a complete alpha spectroscopy station, including a large–window surface barrier detector (SSB), a goniometric arm and a movable multiple–source holder inside a dark vacuum chamber, has provided the opportunity to extend the educational and research program of NPL. The characterization of both stations was carried out at different geometries with various point sources. Calibrations of the scintillators with low–energy γ rays from ^{241}Am (59 keV) and ^{137}Cs (32 and 662 keV) sources of known activities and the SSB detector with an unsealed ^{241}Am α source are presented. In addition, a standalone MCA unit was revived to support data acquisition.

EXPERIMENTAL DETAILS

α spectroscopy

An unsealed ^{241}Am α source was placed in front of the SSB, and the whole arrangement was put into vacuum (≈10^{-3} mbar), inside a dark vacuum chamber. The detector was biased at 15 V and each measurements lasted approximately 3.5 h. The spectra were recorded in a standalone MCA unit and were transferred via Hyperterminal to a PC for further analysis.

The low-γ spectroscopy setup

Two small–size NaI(Tl) scintillators were found in the stock of NPL, both having very thin windows. The behavior and output response of the detectors was investigated through the use of ^{137}Cs and ^{60}Co standard calibration point sources. After the initial calibration, low-energy γ rays from ^{241}Am and ^{137}Cs sources where recorded in the detectors for Δt≈30 min. The data acquisition, calibration and analysis were carried out with an Ortec Maestro 1000 v5.35.01.

Detector	H1	H2
Type	NaI(Tl)	NaI(Tl)
H.V.	700V	700V
	AMP	
Input	Positive	Positive
Coarse Gain (×)	20	10
Fine Gain (×)	0.3	0.0
Shaping Time	6μs	6μs
Pulse Output	Unipolar	Unipolar

INPUT	ULD	PHA	LENGTH
POS	110.0%	ADD	8
SHAPING		OFFSET	PARITY
SLOW		0	OFF
		ZERO	STOPBIT
PSET(T)=14400s		0%	1
MEM 1/8			

Table 2. Settings regarding the setup containing the NaI(Tl) scintillators

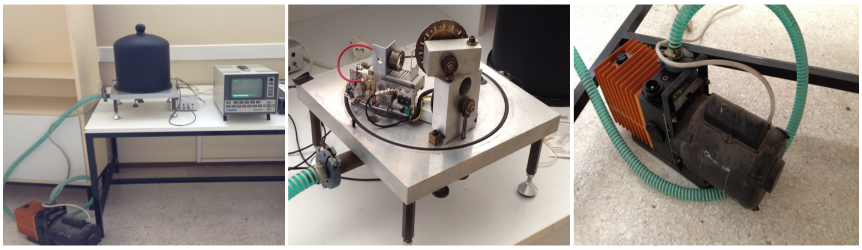

Figure 1. From left to right: The experimental setup for α spectroscopy (left), the SSB detector on its holder (center), the vacuum pump (right)

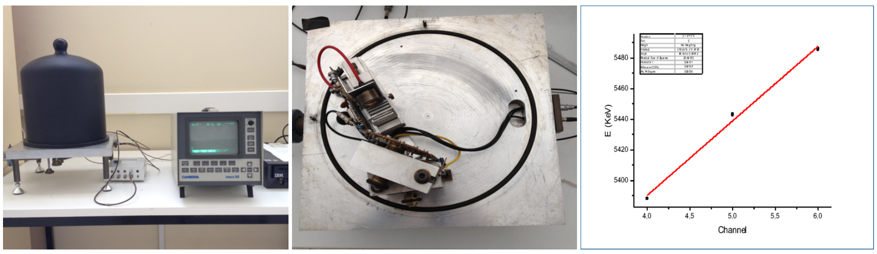

Figure 2. *Left:* The dark vacuum chamber and the MCA unit. *Center:* Geometry of the SSB setup. *Right:* Energy calibration of the SSB

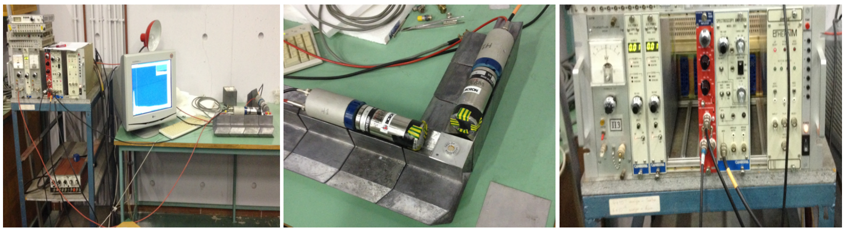

Figure 3. *Left:* The experimental setup for low–γ spectroscopy. *Center:* Geometry of the two NaI(Tl) detectors. *Right:* The NIM modules

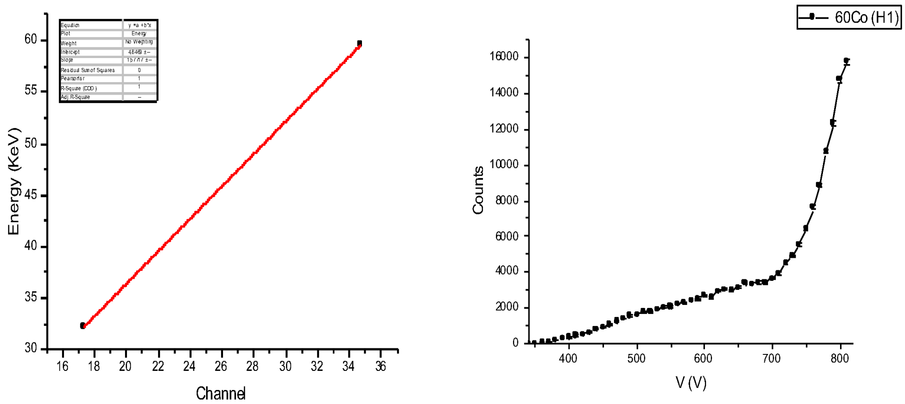

Figure 4. Left: Energy calibration of H1. Right: Characteristic curve of H1 using ^{60}Co point source

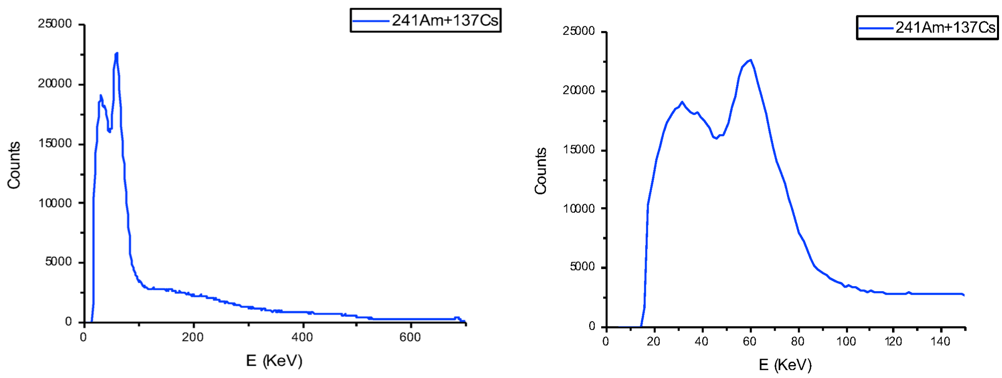

Figure 5. Left: ^{137}Cs+^{241}Am energy spectrum taken with the H1 NaI(Tl) scintillator. Right: The low energy region of the spectrum

Isotope	Eth (KeV)	Type	Eth (KeV)	Type	Eth (KeV)	Type	Eth (KeV)	Type
137Cs	31.8174(-)-32.1939(-)	$X_{K\alpha 2}$-$X_{K\alpha 1}$	36.4457(-)-37.3317(-)	$X_{K'\beta 1}$-$X_{K'\beta 2}$	661.657(3)	γ	-	-
241Am	59.5409(1)	γ	5485.56(12)	α	5442.86(12)	α	5388.25(13)	α

Table 3. Energies and types of the sources used in this analysis

RESULTS AND DISCUSSION

	H1		
E_{th} (KeV)	**E (KeV)**	**FWHM (KeV)**	**R (%)**
31.8174(-) - 32.1939(-)	32.2±1.3	12.7	39.4(16)
36.4457(-) - 37.3317(-)	36.9±0.9	12.7	34.4(8)
59.5409(1)	59.5±1.3	40.2	67.6(15)
661.657(3)	679±3	-	-
	H2		
E_{th} (KeV)	**E (KeV)**	**FWHM (KeV)**	**R (%)**
31.8174(-) - 32.1939(-)	32.2±0.9	16.8	52.2(29)
36.4457(-) - 37.3317(-)	-	-	-
59.5409(1)	59.8±0.9	43.9	73.4(14)
661.657(3)	-	-	-
	SSB		
E_{th} (KeV)	**E (KeV)**	**FWHM (KeV)**	**R (%)**
5485.56(12)	5487.55	19.43	0.35
5442.86(12)	5438.89	33.00	0.61
5388.25(13)	5390.24	38.86	0.72

Table 4. Preliminary results regarding the γ and X–rays measured with the scintillators and the alpha particle energies measured with the SSB. The table also includes FWHM values as well as resolution (R) for each detector

CONCLUSIONS

The low–γ spectrometers have poor energy resolution, despite their high efficiency at the low energy part of the spectrum. The SSB detector, on the other hand, has a high energy resolution, despite its low efficiency.

The setups can be employed in various spectroscopy applications, such as coincidence measurements (low–γ setup), scattering (SSB setup) and angular distribution experiments (low–γ and SSB setups). Further testing is currently in progress.

References

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