Assembling a Device for Measuring Alpha-Gamma Coincidences
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REASONS AND IMPORTANCE OF THIS WORK

3

- SAFEGUARD MEASUREMENTS FOR THE CONTROL OF RADIOACTIVE TRANSIT

- NUCLEAR DATA REVIEW AND DECAY SCHEMES
AIMS

DESCRIPTION, SETTING UP AND CALIBRATION OF THE...

Detector for ALPHA PARTICLES

Detector for GAMMA RADIATION

DUAL-PARAMETER detection system

COLLECTION of the first SPECTRA OF ALPHA – GAMMA COINCIDENCES
Fig. 1: Alpha - gamma coincidence chamber
DESCRIPTION OF THE DEVICES (II)

- VACUUM CHAMBER
- PIPS detector
- Support
- LEGe detector
- Wheel for the ORIENTATION of the support
- PIPS DETECTOR
- GAMMA Radiation
- NIM MODULES for the Alpha-particles detection
- NIM MODULES for the gamma-radiation detection
- ALPHA Particles
- PREAMPLIFIER
- LEGe DETECTOR
- SUPPORT
Software

MCDWIN v 2.93

Software used for registering alpha particles (PIPs detector) or gamma radiation (LEGe detector) separately

MPANT for MPA-3 v 1.6

Software used for the dual parameter detection system RECORDING alpha - gamma coincidence spectra.

Fig.2: Screen capture of an alpha spectrum obtained by MCDWIN.

Fig.3: Screen capture of three displays showing a gamma spectrum, an alpha spectrum, and a coincidence spectrum.
**ALPHA-PARTICLE STANDARDS**

**T-2**
- Stainless steel disk (25mm external diameter) made by Electrodeposition at CIEMAT

**3E-82**
- Stainless steel collimated disk (25mm external diameter and 15mm internal diameter) made by deposition at CIEMAT

<table>
<thead>
<tr>
<th>RADIONUCLIDES</th>
<th>HALF-LIFE (years)</th>
<th>ACTIVITY (Bq)</th>
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<tbody>
<tr>
<td>U-233</td>
<td>1.592x10^5</td>
<td>449±9</td>
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<tr>
<td>Pu-239/240</td>
<td>24065/6537</td>
<td>375±7</td>
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<tr>
<td>Am-241</td>
<td>432.2</td>
<td>438±9</td>
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<tr>
<td>U-233</td>
<td>1.592x10^5</td>
<td>32.3±2.3</td>
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<tr>
<td>Pu-239/240</td>
<td>24065/6537</td>
<td>22.9±2.9</td>
</tr>
<tr>
<td>Am-241</td>
<td>432.2</td>
<td>25.0±2.5</td>
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</table>
Calibration and identification of peaks

**Fig. 4:** T-2 SOURCE ALPHA SPECTRUM

**Fig. 5:** 3E-82 SOURCE ALPHA SPECTRUM
• If the source is rotated an angle $\phi$, alpha particles reaching the detector from the innermost part of the source will lose more energy. The result is observed in the spectrum as the **displacement** of peaks to the low energy zone.

• **CALCULATION OF THE THICKNESS:**

\[ e = \frac{(E_0 - E_1)}{\left[ \left( \frac{1}{\cos (\phi)} \right) - 1 \right] (dE/dx)} \]  

(1)
Comparison between spectra for 0° and 85°

**T-2 SAMPLE**

**3E-82 SAMPLE**

Normalized to the Measurement TIME

Normalized to the HIGHEST PEAK
Energy variation as a function of the angle
Mass thickness

**T-2 SAMPLE**

Energy variation as a function of the angle for $^{233}\text{U}$, $^{239}/^{240}\text{Pu}$ and $^{241}\text{Am}$ peaks.

**3E-82 SAMPLE**

Energy variation as a function of the angle for $^{233}\text{U}$, $^{239}/^{240}\text{Pu}$ and $^{241}\text{Am}$ peaks.

**MASS THICKNESS**

- $e^{233\text{U}} = (0.06 \pm 0.01) \text{mg/cm}^2$
- $e^{239\text{Pu}} = (0.034 \pm 0.004) \text{mg/cm}^2$
- $e^{241\text{Am}} = (0.021 \pm 0.002) \text{mg/cm}^2$

- $e^{239\text{Pu}} = (0.09 \pm 0.02) \text{mg/cm}^2$
- $e^{241\text{Am}} = (0.09 \pm 0.02) \text{mg/cm}^2$

The graphs show the energy variation for different isotopes at various angles, with the mass thickness values listed below each graph.
Are the results correct?

- Previous studies established the thickness of the T-2 source within the range $300\text{Å} \leq e \leq 600\text{Å}$.

- Assuming the mass thickness for the U-233 as $0.06 \pm 0.01 \text{ mg/cm}^2$ and the source is made by uranium oxide with density $10.97 \text{ g/cm}^3$.

- The obtained average thickness results: $e = (547 \pm 91\text{Å})$
MCR 2000-065-A

- Petri's capsule 5 cm in external diameter made at UEX from 100 µL of MCR 2000-065 solution onto 5 cellulose filters.

AM-25

- Stainless steel collimated disk (25 mm outer diameter and 10 mm inner diameter) made at CIEMAT by deposition

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<th>ACTIVITY (Bq)</th>
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<tr>
<td>Am-241</td>
<td>432.2</td>
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<td>Co-60</td>
<td>5.27</td>
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<td>Cs-137</td>
<td>30.02</td>
<td>364.44±5.22</td>
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<th>RADIONUCLIDES</th>
<th>HALF-LIFE (years)</th>
<th>ACTIVITY (Bq)</th>
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<tr>
<td>Am-241</td>
<td>432.2</td>
<td>109.2±1.4</td>
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Choice for the region of interest
Calibration and identification of the peaks (I)

$^{241}\text{Am}$, $^{137}\text{Cs}$ and $^{60}\text{Co}$ SPECTRUM. MCR 2000-065-A SAMPLE (G=2.5)

$^{241}\text{Am}$, $^{137}\text{Cs}$ and $^{60}\text{Co}$ SPECTRUM. MCR 2000-065-A SAMPLE (G=5)

$^{241}\text{Am}$ SPECTRUM. AM-25 SAMPLE (G=10)

$^{241}\text{Am}$ SPECTRUM. AM-25 SAMPLE (G=25)
Choice for the region of interest
Calibration and identification of the peaks (II)
ALPHA - GAMMA COINCIDENCE MEASUREMENTS

Fig. 6: a. Alpha detection NIM modules. b. Gamma radiation NIM modules.

Fig. 7: Dual parameter multichannel analyzer MPA-3.

Fig. 8: Computer controlling the dual parameter system.
Establishment of conditions for measuring coincidences with the dual parameter system (I)

Fig. 9: Dialog for the establishment of the coincidences with the program MPANT.

Fig. 10: Dialogue for determining the waiting time for coincidences.
Establishment of conditions for measuring coincidences with the dual parameter system (II)

Fig. 11: Dialog for the construction of the dual parameter spectrum with the program MPANT.
## Optimal configuration

<table>
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<tr>
<th>DETECTING ALPHA PARTICLES</th>
<th>DETECTING GAMMA RADIATION</th>
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<tr>
<td><strong>Spectroscopy Amplifier</strong></td>
<td><strong>Spectroscopy Amplifier</strong></td>
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<td>Gain: 2.5</td>
<td>Gain: 4.5</td>
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<tr>
<td><strong>ADC</strong></td>
<td><strong>ADC</strong></td>
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<td># channel: 4096</td>
<td># channel: 1024</td>
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<tr>
<td>Offset: 126</td>
<td>Offset: 1</td>
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</table>
FORCED COINCIDENCES

Individual spectra

S SAMPLE ALPHA SPECTRUM (FORCED COINCIDENCES)

T-2 SAMPLE GAMMA SPECTRUM (FORCED COINCIDENCES)
COINCIDENCE SPECTRUM

The greatest number of coincidences occurs between the major emissions of alpha particles and gamma radiation.

Fig-12: DUAL PARAMETER COINCIDENCE SPECTRUM.
COINCIDENCES FOR A SINGLE SAMPLE

Individual Spectra

T-2 SAMPLE ALPHA SPECTRUM (φ=45°)

T-2 SAMPLE GAMMA SPECTRUM (φ=45°)
COINCIDENCE SPECTRUM

The peaks containing the greater number of counts are again those from the most important emissions of the involved radionuclides.

Fig.13: DUAL PARAMETER COINCIDENCE SPECTRUM OBTAINED WITH A TRIPLE SOURCE.
PROBLEMS

SETTING UP THE DETECTOR FOR ALPHA PARTICLES

SOFTWARE MCDWIN

CHECKING THICKNESS VALUES

LONG TIME EXPOSURE

SETTING UP THE DETECTOR FOR GAMMA RADIATION

SOFTWARE MCDWIN

Pu-239/240 CONTAMINATION

ALPHA–GAMMA COINCIDENCES MEASUREMENTS

SOFTWARE MPANT

NOISE IN THE LOW-ENERGY LEGe SIGNAL

OBTAINING THE OPTIMAL CONFIGURATION

Special program for data processing
CONCLUSIONS(I)

Thickness measurements of radioactive sources

HIGH ACTIVITY RADIOACTIVE SOURCE

Radionuclides seem to be deposited in DIFFERENT layers

NOT uniform distribution of radionuclides

LOW ACTIVITY RADIOACTIVE SOURCE

Radionuclides are mixed in the SAME layer

Uniform distribution of the radionuclides

SATISFACTORY RESULTS

AGREEMENT between our results and those of former works
CONCLUSIONS (II)

Alpha-gamma coincidence measurements

SETTING UP THE SYSTEM
- Alpha-particles and gamma-radiation detectors WORK well
- The dual parameter system WORKS well
- Establishment and registration of coincidences CORRECT

RESULTS
- Coincidences produced between the most important emissions
- Necessary IMPROVEMENTS

CONCLUSIONS

NOT INTERESTING
FUTURE WORKS

**IMPROVEMENTS**
- DELAY module
- Study of ANGULAR CORRELATIONS

**1st SPECTRA OF INTEREST**
- Obtaining the first SATISFACTORY coincidence spectra

**DECAY SCHEMES**
- U-235 y Pu-240 (EUROMET Projects)
- Pu isotopes and transuranic elements
Thank you for your attention!