Assembling a Device for Measuring Alpha-Gamma Coincidences

EXPERIMENTAL NUCLEAR PHYSICS

BELÉN CARO MARROYO
ALEJANDRO MARTÍN SÁNCHEZ

DEPARTMENT OF PHYSICS
UNIVERSITY OF EXTREMADURA

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REASONS AND IMPORTANCE OF THIS WORK

- SAFEGUARD MEASUREMENTS FOR THE CONTROL OF RADIOACTIVE TRANSIT
  - K. Breitenecker, D. Donohue, H. Eisenwagner, A. P. Maddison, H. Siegmund. ***Configuration of an alpha-gamma coincidence spectrometer for utilization of safeguards measurements***. Applied Radiation and Isotopes 67. 2009. 2088-2091

- NUCLEAR DATA REVIEW AND DECAY SCHEMES
  - E. García-Toraño, M.T. Crespo, M. Roteta, G. Sibbens, S. Pommé, A. Martín Sánchez, M.P. Rubio Montero, S. Woods, A. Pearce. ***Alpha-particle emission probabilities in the decay of ^{235}U***. Nuclear Instruments and Methods in Physics Research A 550. 2005. 581-592.
  - G. Sibbens, S. Pommé, T. Altzitzoglou, E. García-Toraño, H. Janben, R. Dersch, O. Ott, A. Martín Sánchez, M. P. Rubio Montero, M. Loidl, N. Coron, P. de Marcillac, T. M. Smekow. ***Alpha-particle emission probabilities in the decay of ^{240}Pu***. Applied Radiation and Isotopes 68. 2010. 1459-1466.

AIMS

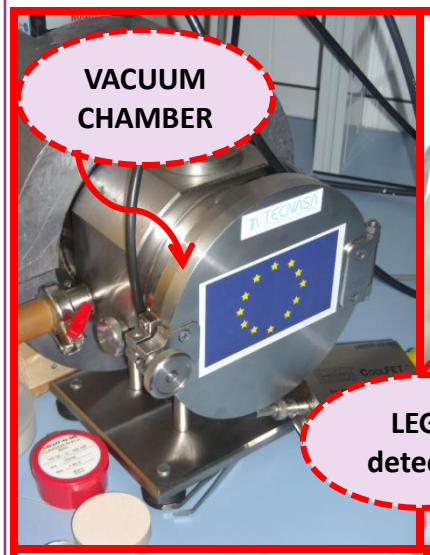
DESCRIPTION, SETTING UP AND CALIBRATION OF THE…

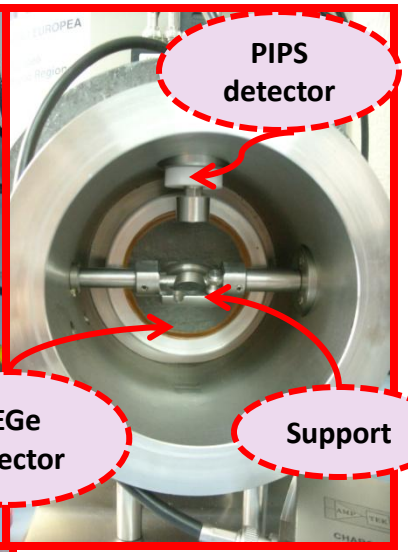
- Detector for ALPHA PARTICLES
- Detector for GAMMA RADIATION
- DUAL-PARAMETER detection system
- COLLECTION of the first SPECTRA OF ALPHA – GAMMA COINCIDENCES

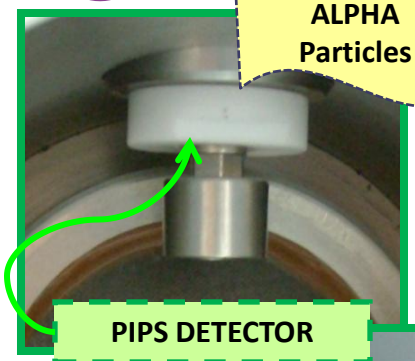
DESCRIPTION OF THE DEVICES (I)

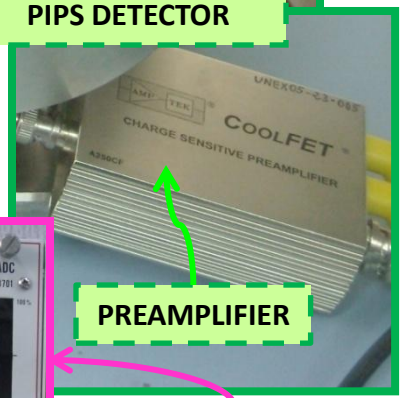
Fig. 1: Alpha - gamma coincidence chamber

DESCRIPTION OF THE DEVICES (II)



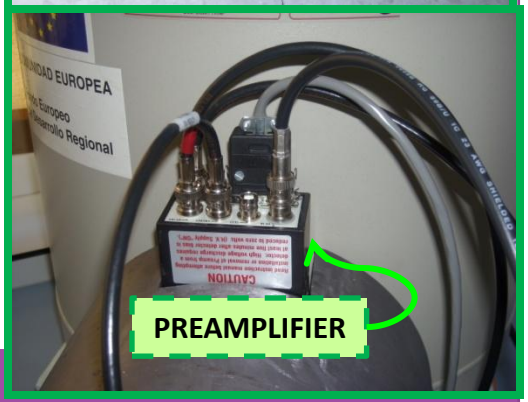






NIM MODULES for the Alpha-particles detection

NIM MODULES for the gamma-radiation detection



Software

MCDWIN v 2.93

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

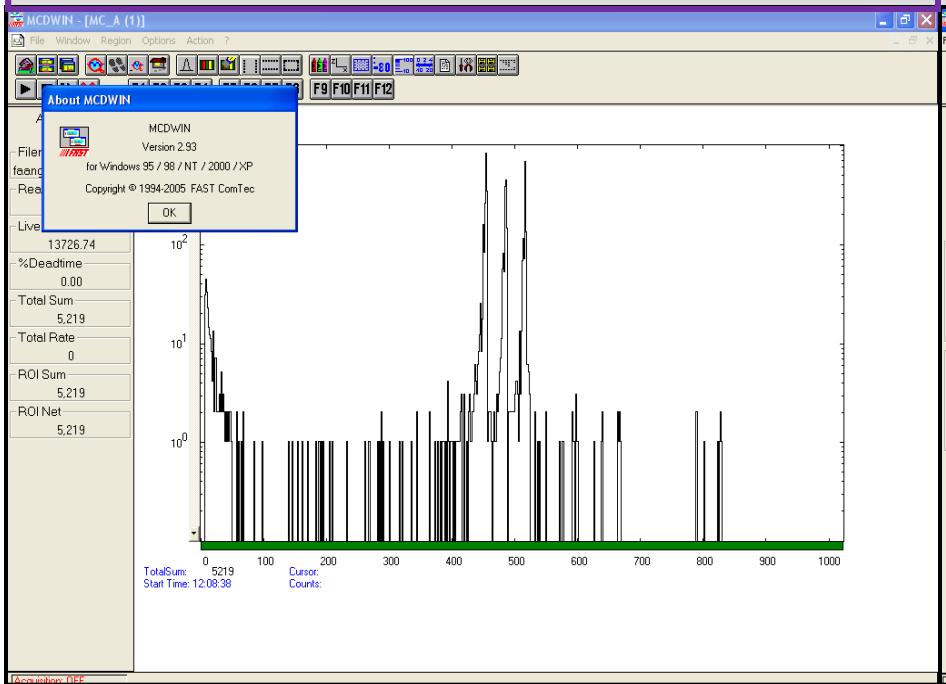


Fig.2: Screen capture of an alpha spectrum obtained by MCDWIN.

MPANT for MPA-3 v 1.6

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

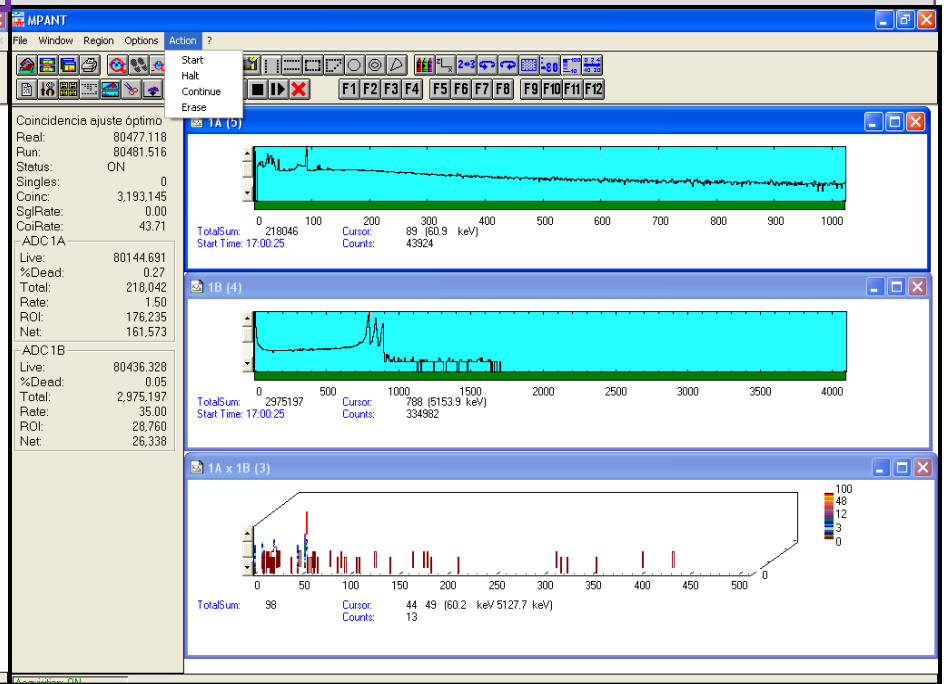


Fig.3: Screen capture of three displays showing a gamma spectrum, an alpha spectrum, and a coincidence spectrum.

ALPHA-PARTICLE STANDARDS

T-2

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

RADIONUCLIDES	HALF-LIFE(years)	ACTIVITY (Bq)
U-233	1.592×10^5	449±9
Pu-239/240	24065/6537	375±7
Am-241	432.2	438±9

3E-82

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

RADIONUCLIDES	HALF-LIFE (years)	ACTIVITY (Bq)
U-233	1.592×10^5	32.3±2.3
Pu-239/240	24065/6537	22.9±2.9
Am-241	432.2	25.0±2.5

Characteristics of sources

Calibration and identification of peaks

Fig.4: T-2 SOURCE ALPHA SPECTRUM

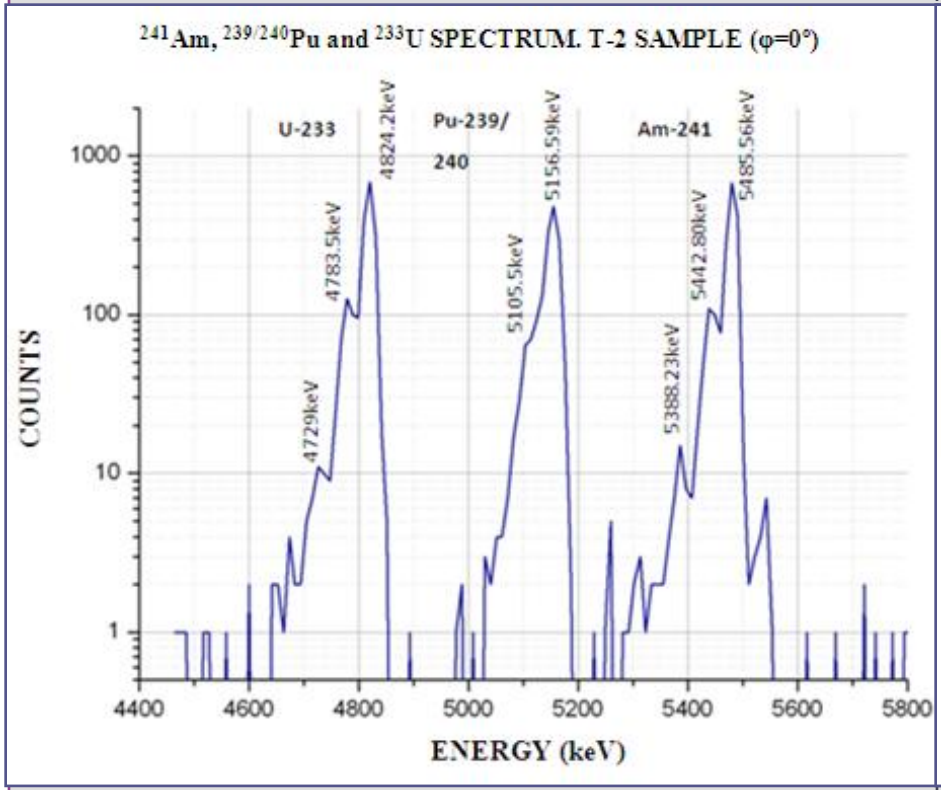
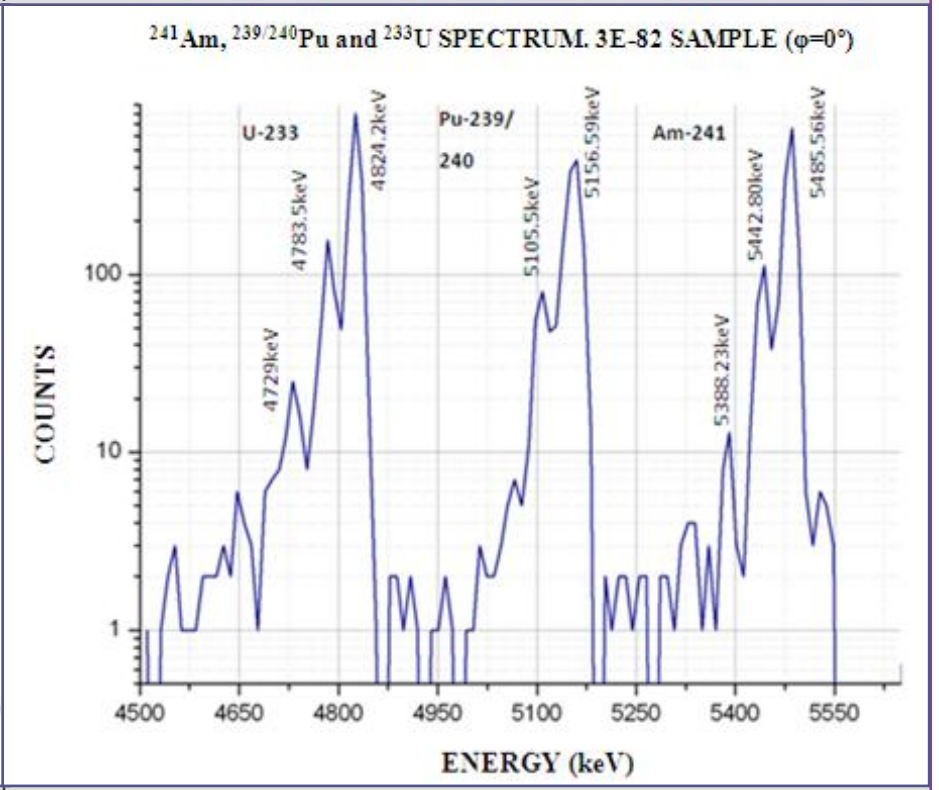


Fig.5: 3E-82 SOURCE ALPHA SPECTRUM

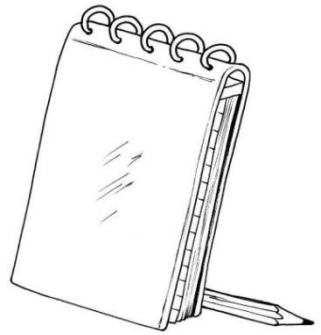


THICKNESS MEASUREMENT OF RADIOACTIVE SOURCES

- If the source is rotated an angle ϕ, alpha particles reaching the detector from the innermost part of the source will lost more energy. The result is observed in the spectrum as the **displacement** of peaks to the low energy zone.

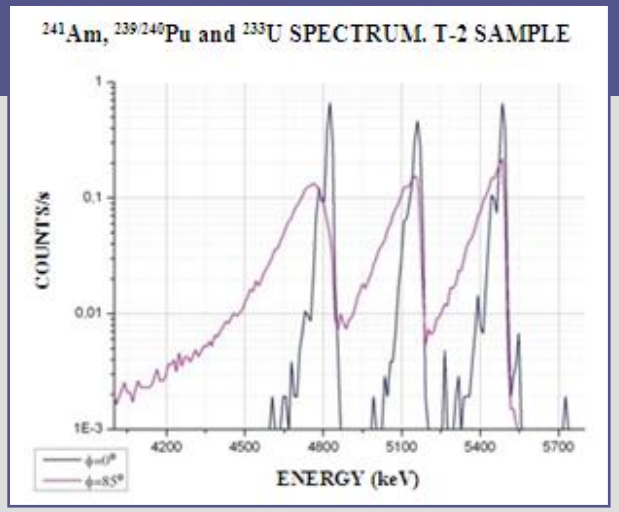
- CALCULATION OF THE THICKNESS:

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

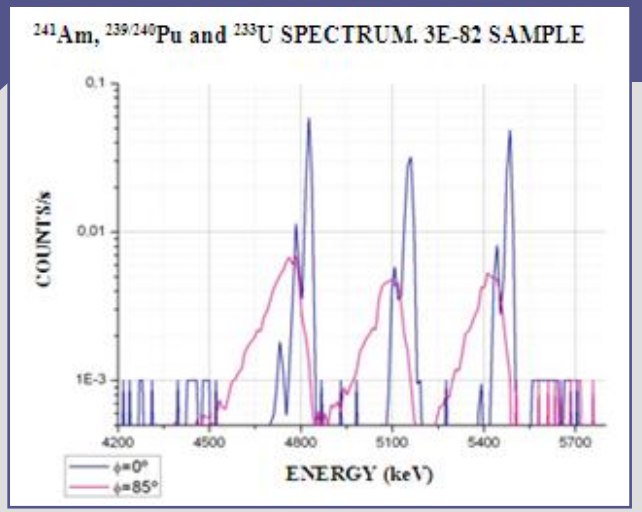


Comparison between spectra for 0° and 85°

T-2 SAMPLE

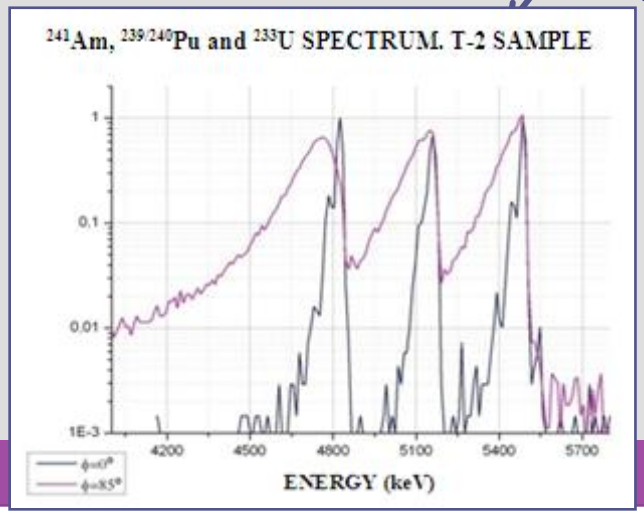


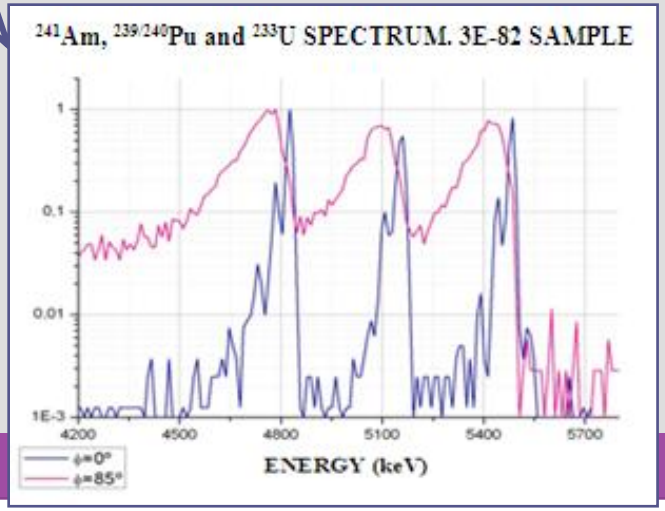
3E-82 SAMPLE



Normalized to the Measurement TIME

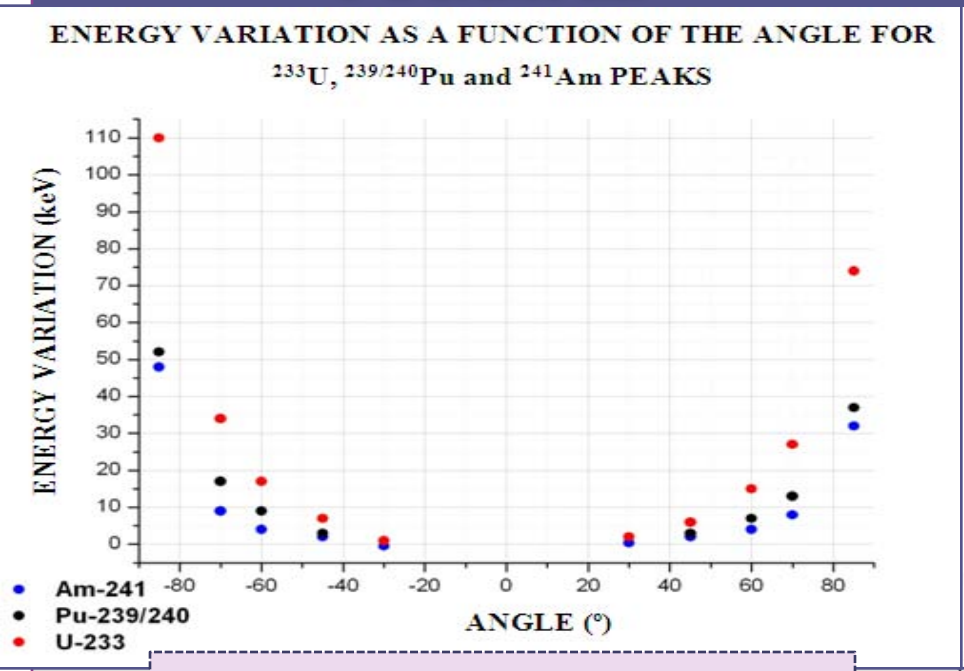
Normalized to the HIGHEST PEAK





Energy variation as a function of the angle Mass thickness

T-2 SAMPLE



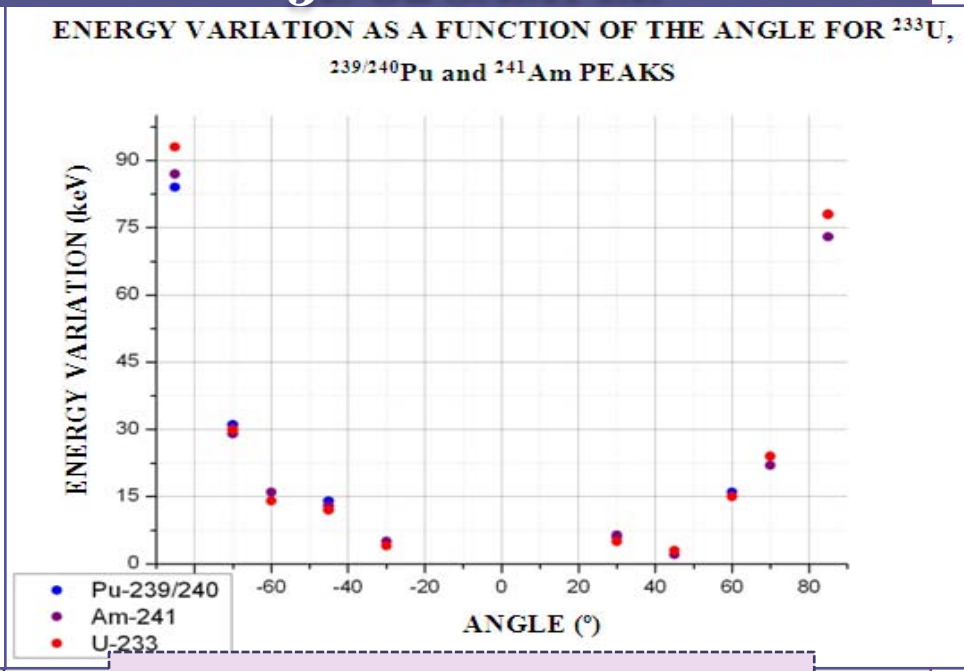
MASS THICKNESS

$$e(^{233}_{92}U) = (0,06 \pm 0,01)mg/cm^2$$

$$e(^{239}_{94}Pu) = (0,034 \pm 0,004)mg/cm^2$$

$$e(^{241}_{95}Am) = (0,021 \pm 0,002)mg/cm^2$$

3E-82 SAMPLE



MASS THICKNESS

$$e(^{233}_{92}U) = (0,08 \pm 0,02)mg/cm^2$$

$$e(^{239}_{94}Pu) = (0,09 \pm 0,02)mg/cm^2$$

$$e(^{241}_{95}Am) = (0,09 \pm 0,02)mg/cm^2$$

Are the results correct?

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

- Assuming the mass thickness for the U-233 as 0.06 ± 0.01 mg/cm² and the source is made by uranium oxide with density 10.97 g/cm³.

- The obtained average thickness results:

$$e = (547 \pm 91\dot{A})$$

GAMMA-RADIATION STANDARDS

MCR 2000-065-A

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

RADIONUCLIDES	HALF-LIFE(years)	ACTIVITY (Bq)
Am-241	432.2	305.90±4.67
Co-60	5.27	273.16±3.92
Cs-137	30.02	364.44±5.22

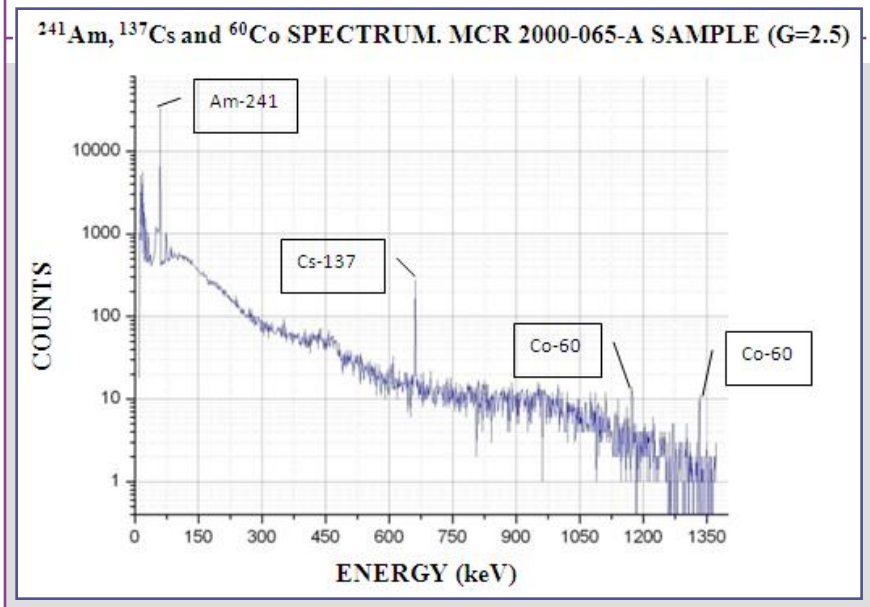
AM-25

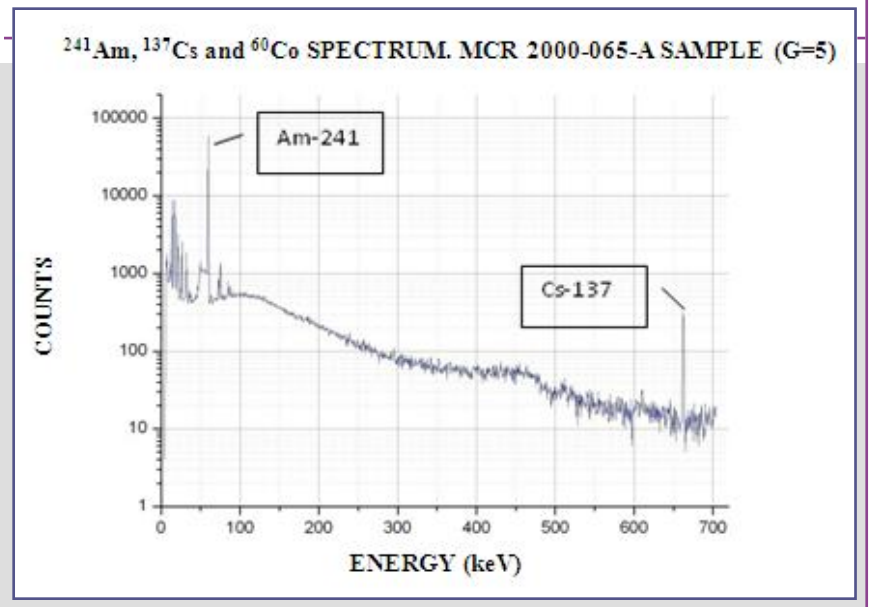
- Stainless steel collimated disk (25 mm outer diameter and 10 mm inner diameter) made at CIEMAT by deposition

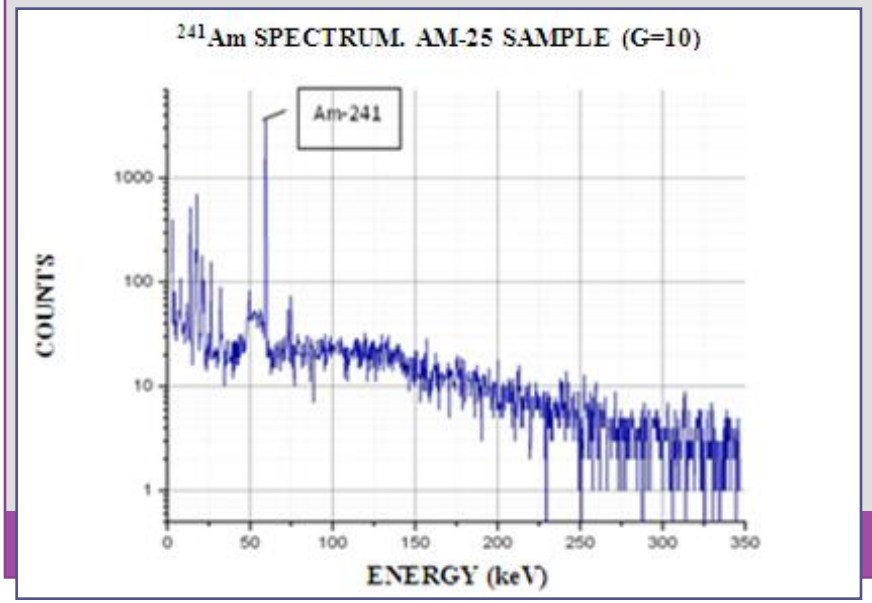
RADIONUCLIDES	HALF-LIFE(years)	ACTIVITY (Bq)
Am-241	432.2	109.2±1.4

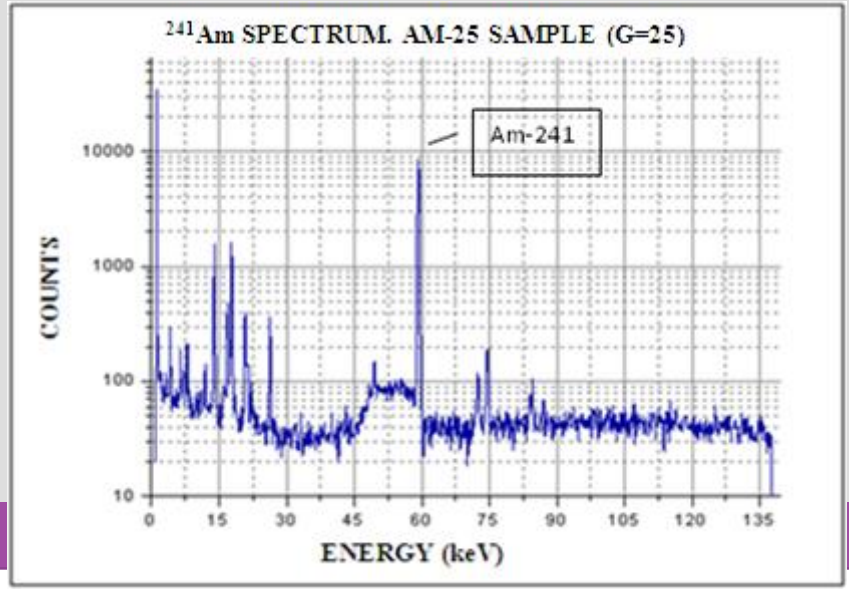
Characteristics of sources

Choice for the region of interest
Calibration and identification of the peaks (I)

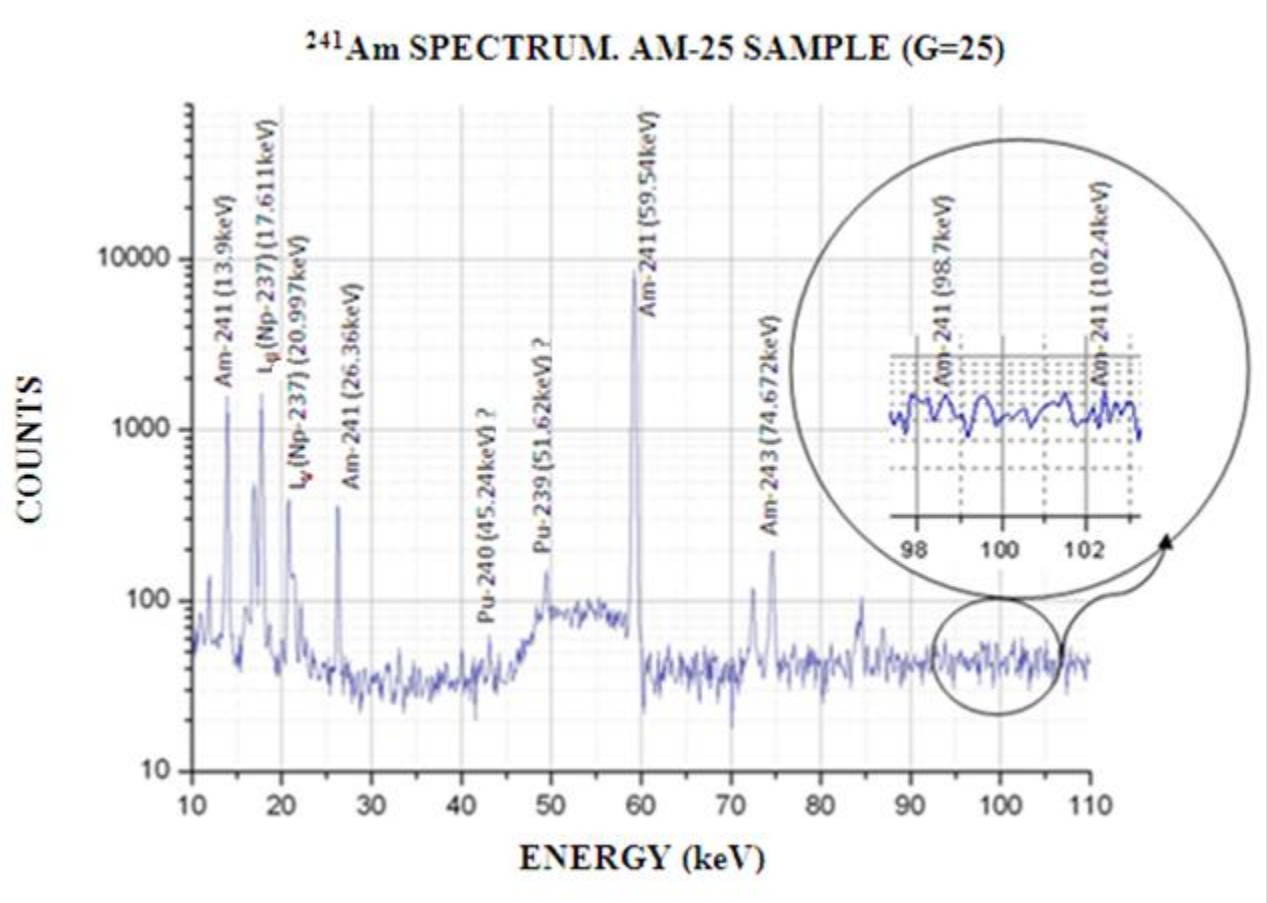








Choice for the region of interest
Calibration and identification of the peaks (II)

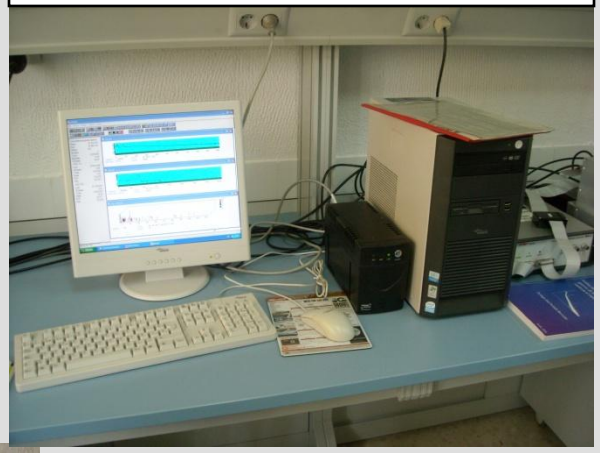


ALPHA - GAMMA COINCIDENCE MEASUREMENTS

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)

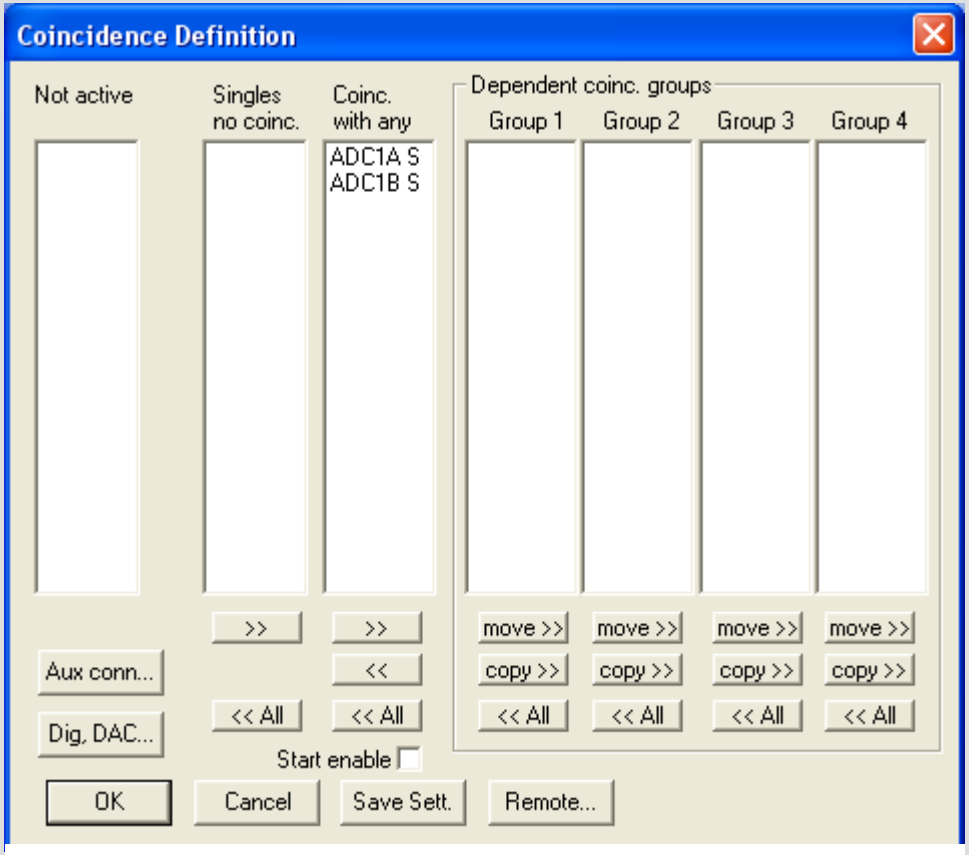


Fig. 9: Dialog for the establishment of the coincidences with the program MPANT.

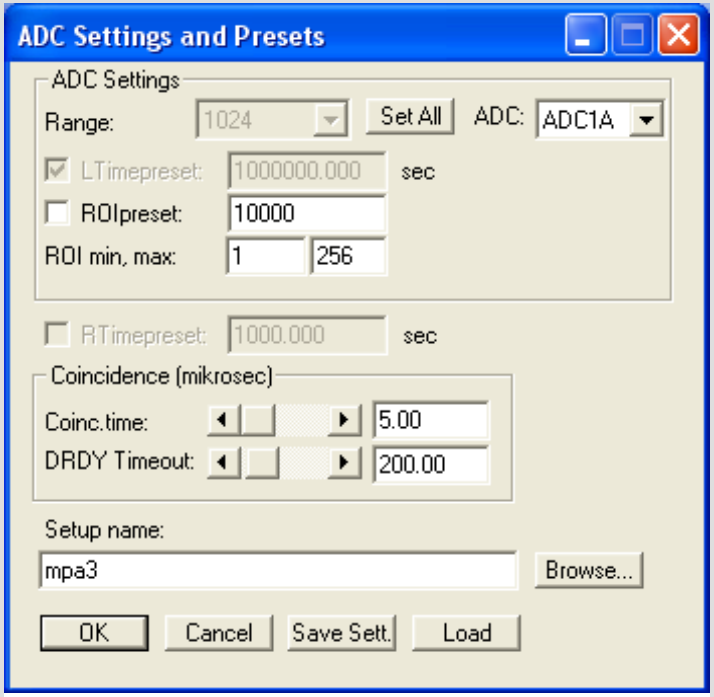


Fig. 10: Dialogue for determining the waiting time for coincidences.

Establishment of conditions for measuring coincidences with the dual parameter system (II)

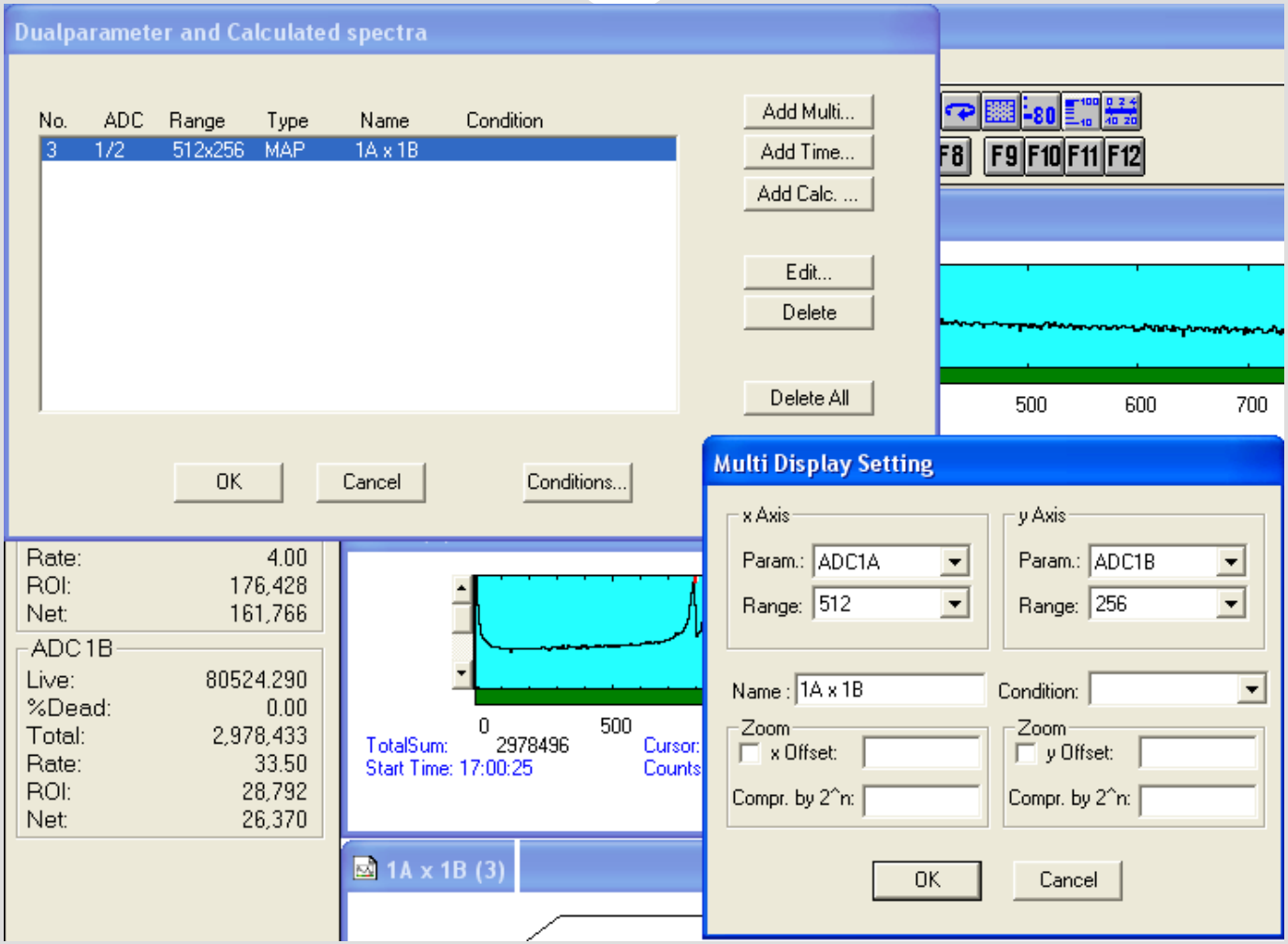


Fig. 11: Dialog for the construction of the dual parameter spectrum with the program MPANT.

Optimal configuration

DETECTING ALPHA PARTICLES

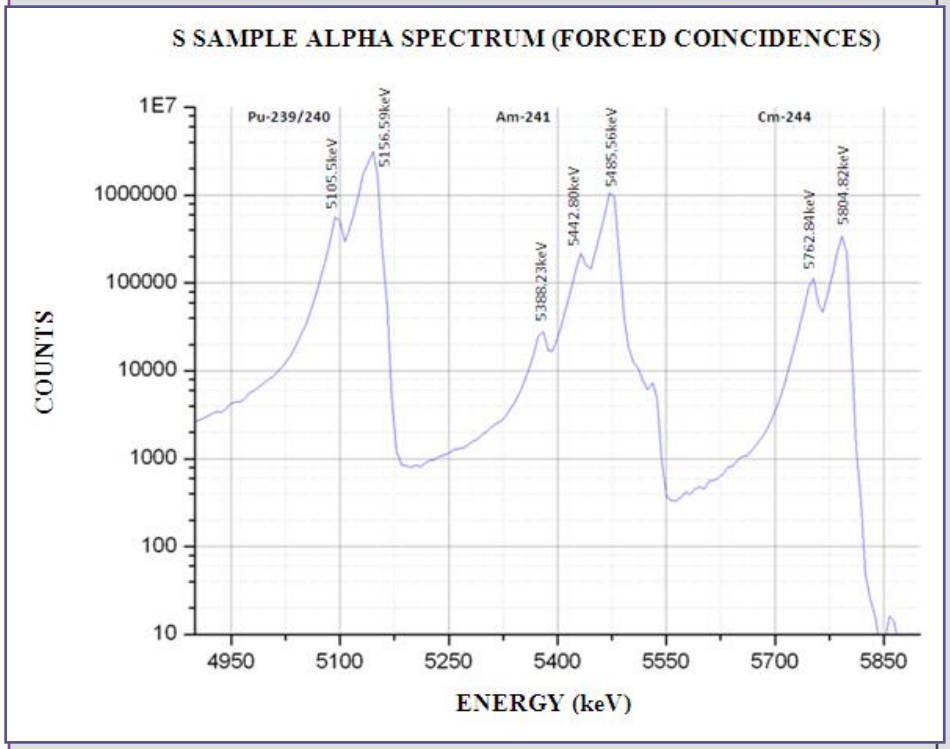
- Spectroscopy Amplifier
  - Gain:
    2.5
- ADC
  - # channel:
    4096
  - Offset:
    126

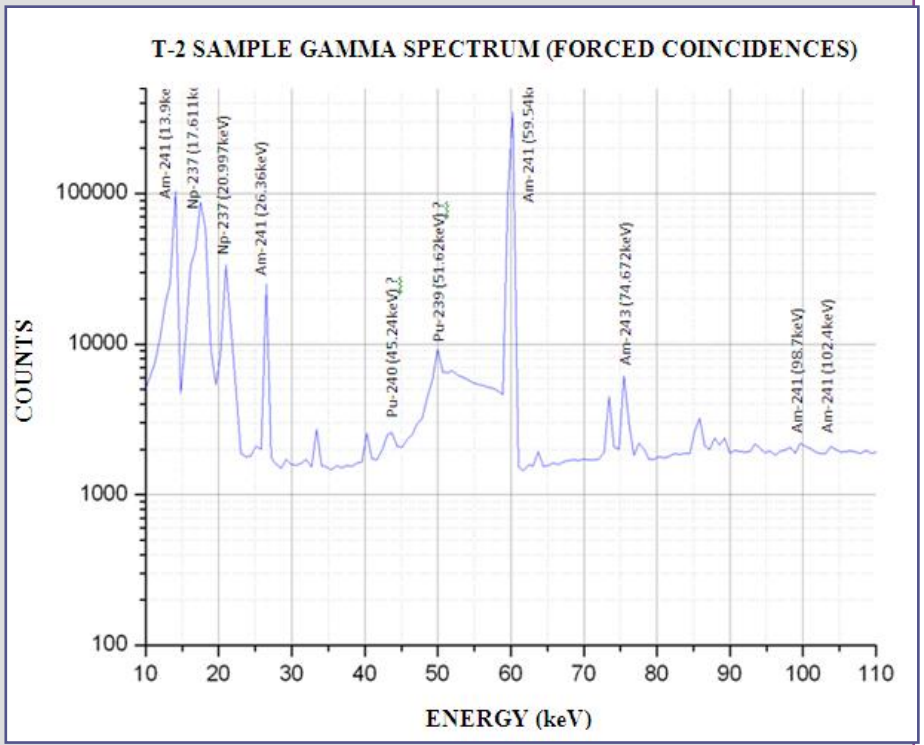
DETECTING GAMMA RADIATION

- Spectroscopy Amplifier
  - Gain:
    4.5
- ADC
  - # channel:
    1024
  - Offset:
    1

FORCED COINCIDENCES

Individual spectra





COINCIDENCE SPECTRUM

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

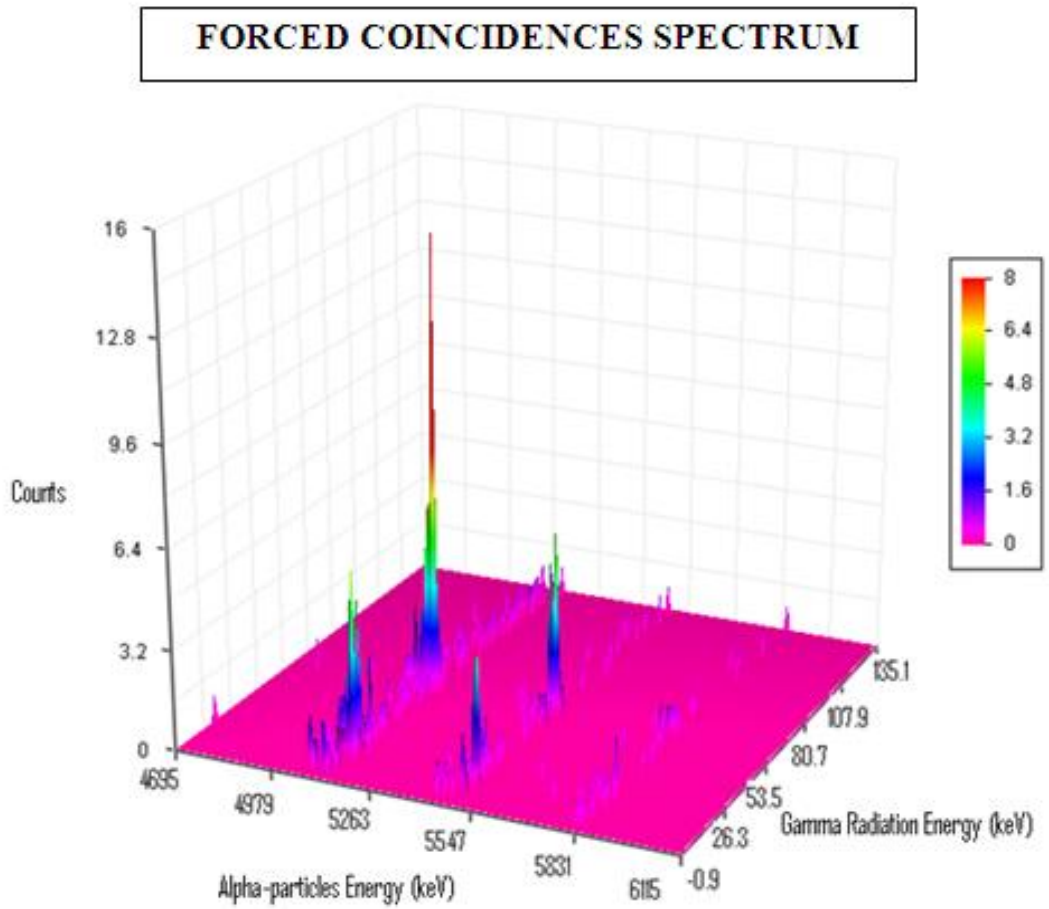
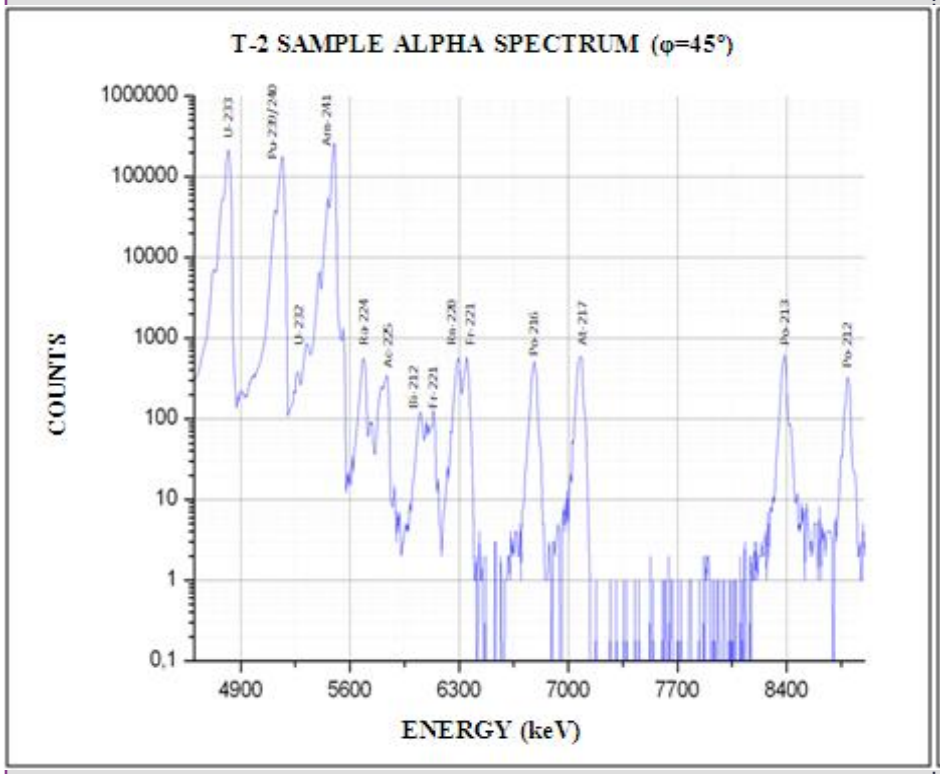
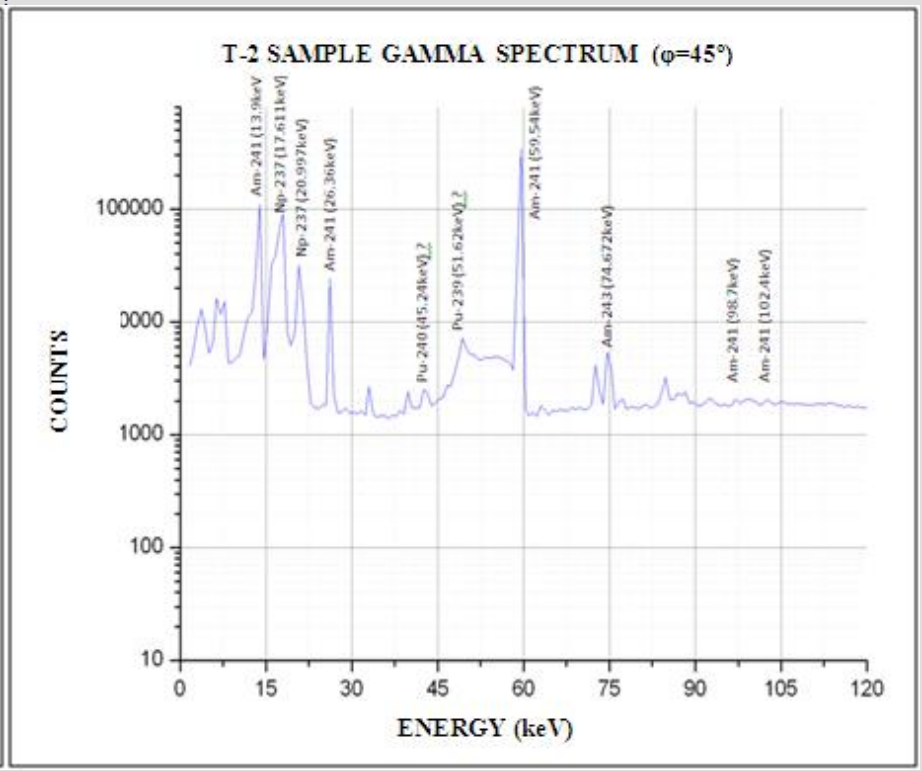


Fig-12: DUAL PARAMETER COINCIDENCE SPECTRUM.

COINCIDENCES FOR A SINGLE SAMPLE

Individual Spectra





COINCIDENCE SPECTRUM

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

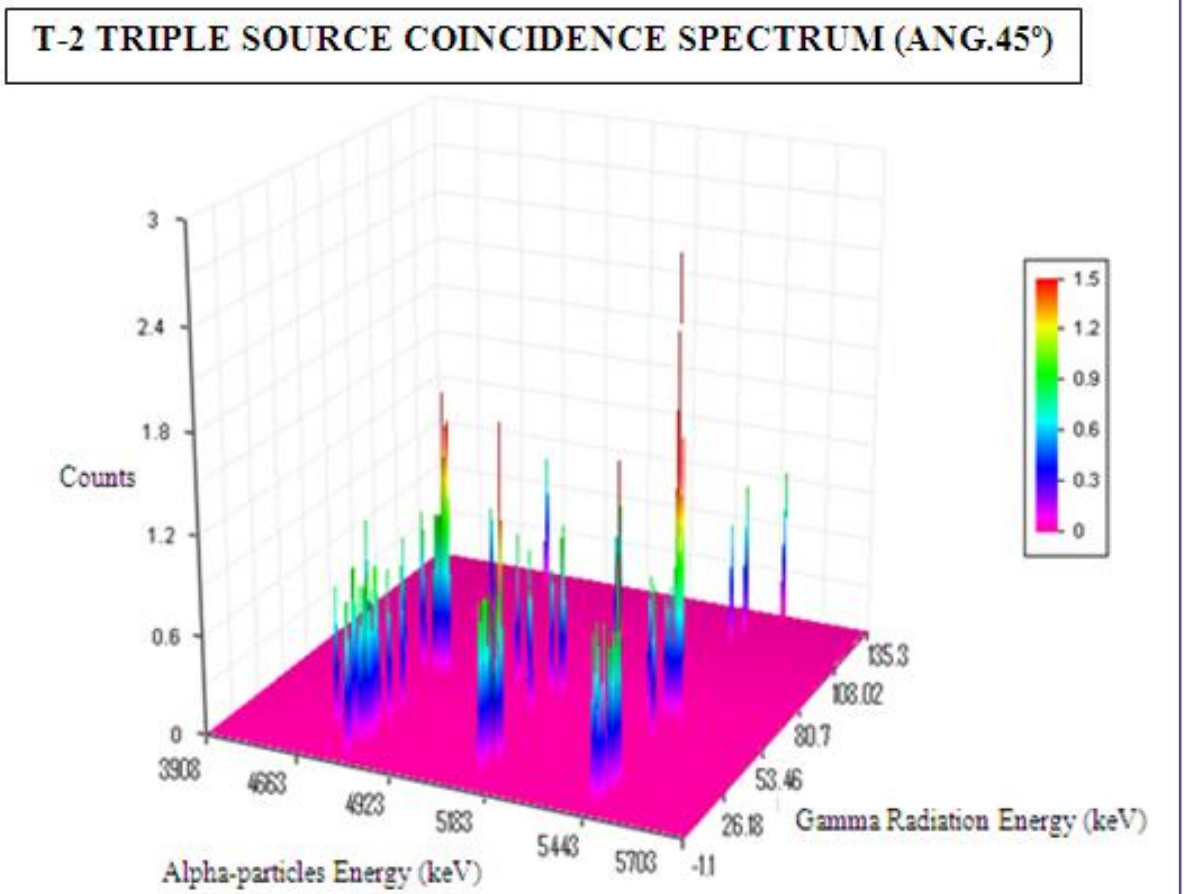


Fig.13: DUAL PARAMETER COINCIDENCE SPECTRUM OBTAINED WITH A TRIPLE SOURCE.

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
  - Special program for data processing
- NOISE IN THE LOW-ENERGY LEGe SIGNAL
- OBTAINING THE OPTIMAL CONFIGURATION

CONCLUSIONS(I)

Thickness measurements of radioactive sources

CONCLUSIONS

- 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

- CONCLUSIONS
  - 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*
      - NOT INTERESTING
    - Neccessary IMPROVEMENTS

FUTURE WORKS

IMPRO-VEMENTS

- **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)**
- **Am-241, Am-243, Np-237 y Cm-242**
- **Pu isotopes and transuranic elements**

Thank you for your attention!