

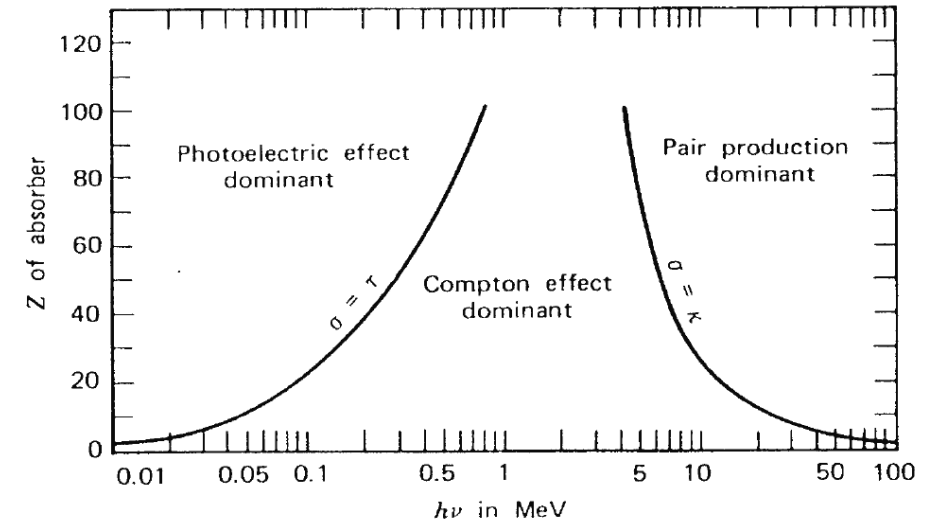
Study of a low-background gamma spectrometry system

Practical work 2, 2017.08.22.

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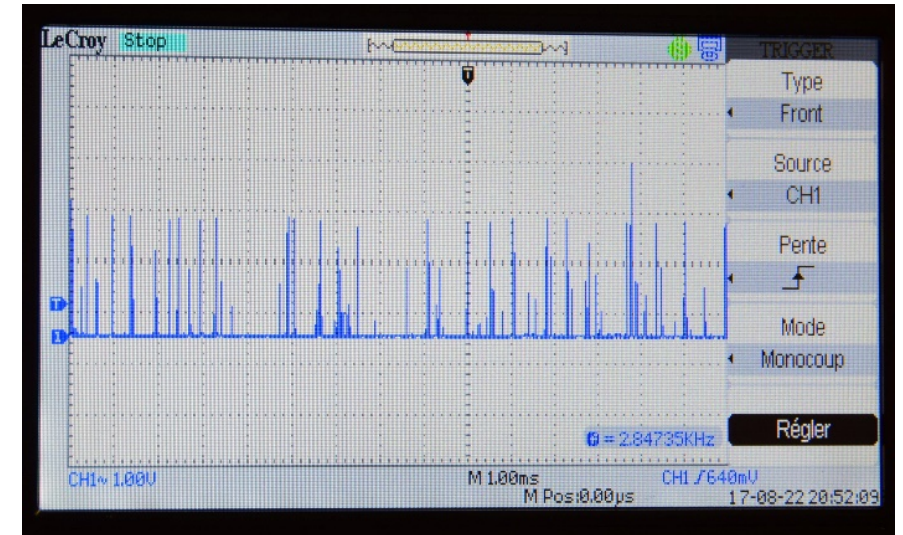
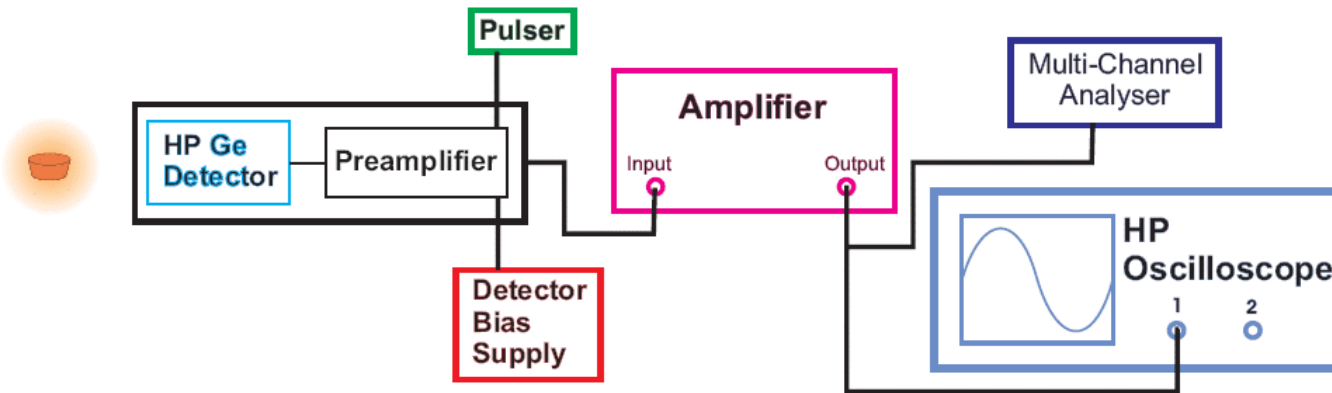
Introduction

- Interaction of EM radiation with matter
 - Photoelectric effect
 - Compton scattering
 - Pair production
- Detector Materials
 - High-purity Germanium (HPGe)
 - Thallium-activated Sodium iodide [NaI(Tl)]
- Anti-Compton System
 - Use coincidence measurement to veto signal
 - Reduces background of signal



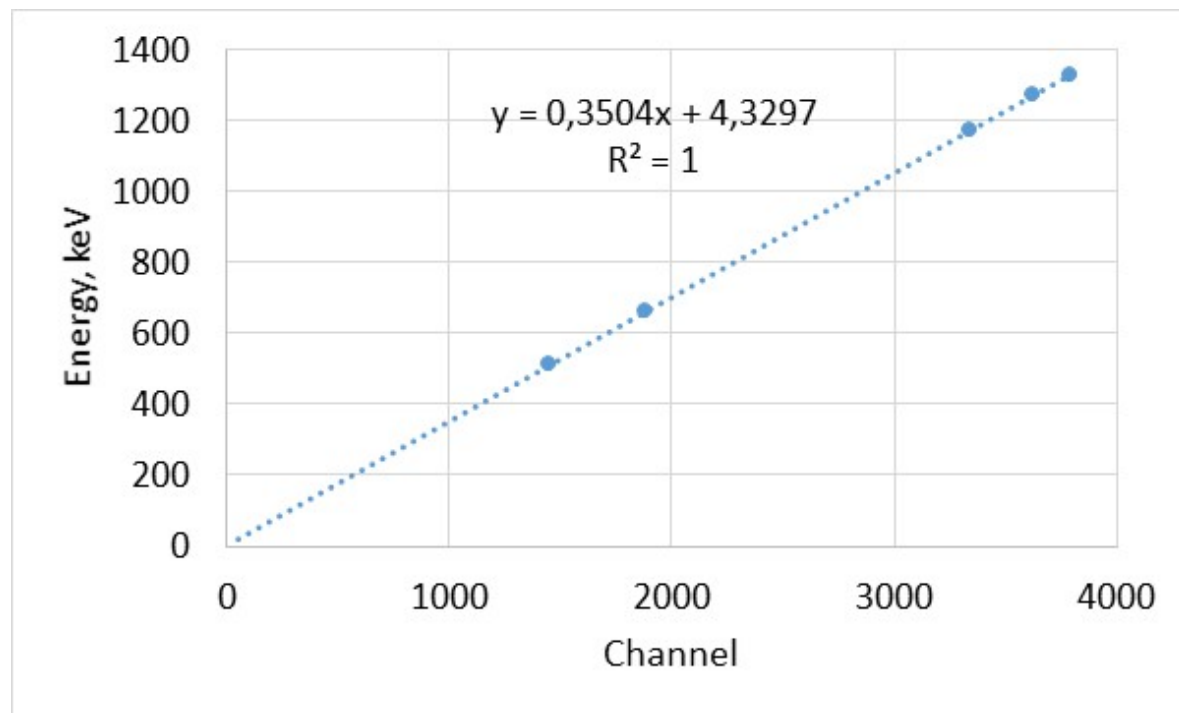
Materials and Procedure

- Pulse adjustment using oscilloscope for multi-channel analyser (MCA) and ^{137}Cs source.



Materials and Procedure

- Energy calibration using ^{137}Cs , ^{60}Co and ^{22}Na sources.



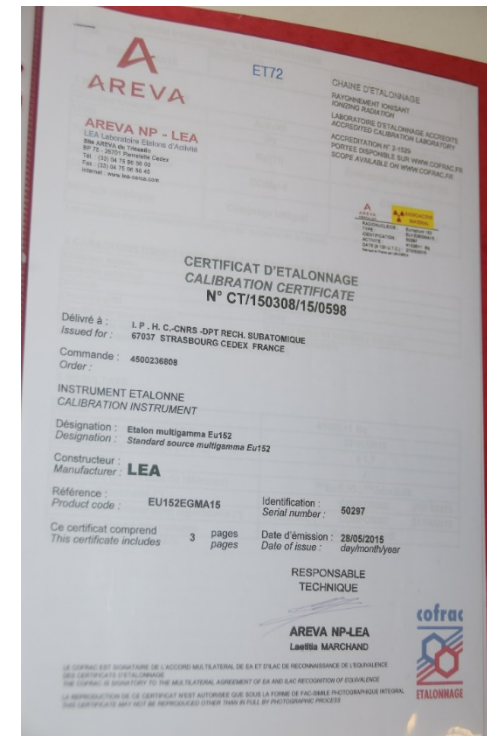
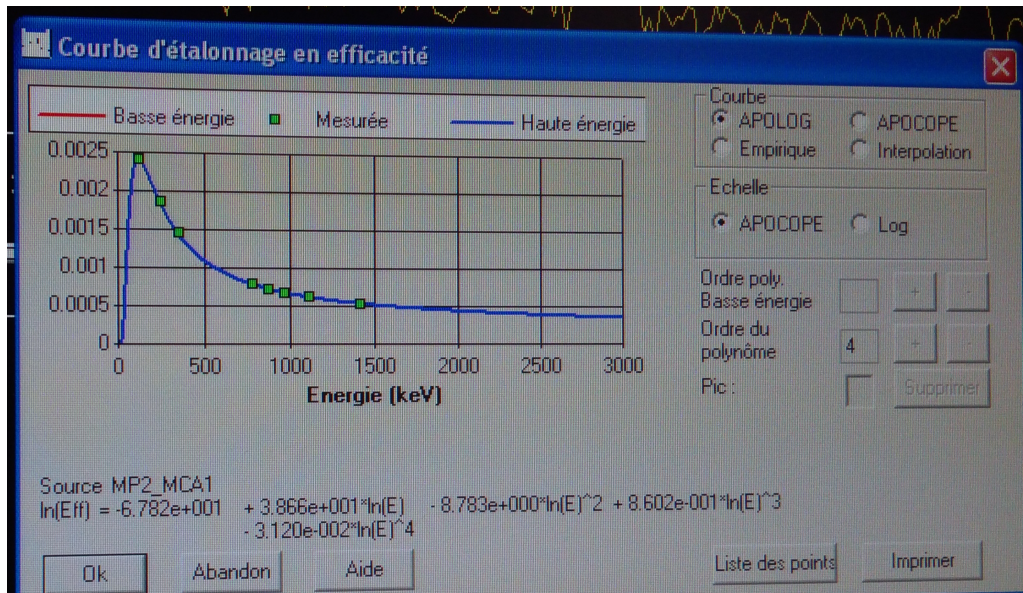
Source	Half-Life (y)	Energy of Most Intense γ Lines (keV)	Intensity (%)
^{60}Co	5.27	1173.237 1332.502	99.97 99.99
^{137}Cs	30.17	661.661	85.21
^{22}Na	2.60	1274.53	99.94
^{133}Ba	10.51	80.997	34.10
		276.398	7.16
		302.858	18.33
		356.017	62.05
		383.851	8.94

Standard point sources (for calibration)

Materials and Procedures

- Efficiency calibration using ^{152}Eu and a certificate file.

Certificate of Eu-152



This is a photograph of a table titled "3.2 Flux photonique calculé" from the same calibration certificate. The table lists the calculated photon flux for various energy levels of Eu-152. The columns are: "Energie en keV (*)", "Nombre de photons émis pour 100 désintégrations (*)", "Flux photonique en $\gamma \cdot s^{-1}$ dans 4 π sr", and "Incertitude relative élargie (k=2 %)(B)".

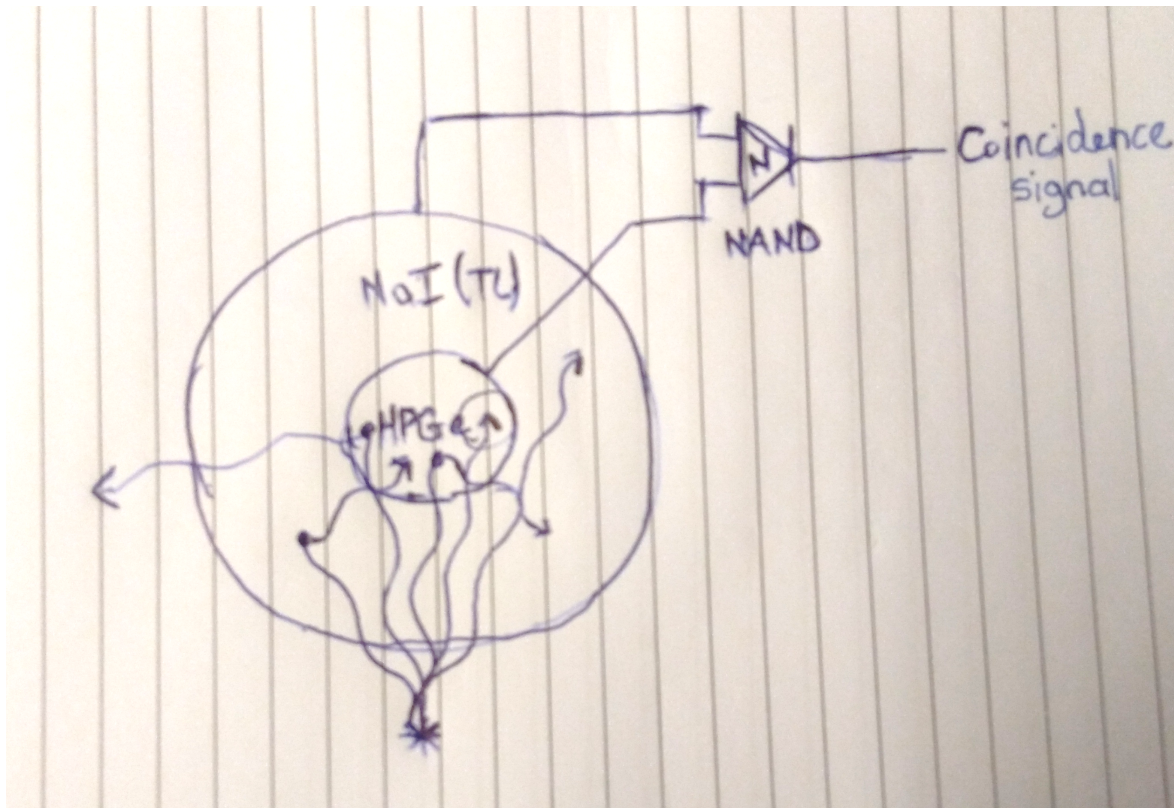
Energie en keV (*)	Nombre de photons émis pour 100 désintégrations (*)	Flux photonique en $\gamma \cdot s^{-1}$ dans 4 π sr	Incertitude relative élargie (k=2 %)(B)
121.7817 ± 0.0003	28.41 ± 0.13	1.165E+04	2.0%
244.6974 ± 0.0008	7.55 ± 0.04	3.097E+03	2.1%
295.9387 ± 0.0017	0.442 ± 0.003	1.813E+02	2.2%
344.2785 ± 0.0012	26.59 ± 0.12	1.091E+04	2.0%
367.7891 ± 0.0020	0.862 ± 0.005	3.536E+02	2.1%
411.1165 ± 0.0012	2.238 ± 0.010	9.18E+02	2.0%
443.965 ± 0.003	3.12 ± 0.028	1.280E+03	2.6%
488.6792 ± 0.002	0.4139 ± 0.0024	1.694E+02	2.1%
563.990 ± 0.007	0.457 ± 0.013	1.87E+02	6.0%
678.623 ± 0.005	0.470 ± 0.004	1.928E+02	2.5%
688.870 ± 0.005	0.841 ± 0.006	3.459E+02	2.6%
778.9045 ± 0.0024	12.97 ± 0.06	6.32E+03	2.6%
867.380 ± 0.003	4.243 ± 0.023	1.740E+03	2.9%
919.337 ± 0.004	0.429 ± 0.005	1.760E+02	1.9%
964.079 ± 0.018	14.50 ± 0.08	5.95E+03	1.9%
1005.272 ± 0.0017	0.695 ± 0.023	2.728E+02	2.1%
1085.837 ± 0.010	10.13 ± 0.08	4.155E+03	2.1%
1089.737 ± 0.005	1.73 ± 0.01	7.10E+02	2.0%
1112.076 ± 0.003	13.41 ± 0.06	5.60E+03	2.2%
1212.948 ± 0.011	1.416 ± 0.009	5.81E+02	2.1%
1299.142 ± 0.008	1.633 ± 0.009	6.70E+02	1.9%
1408.013 ± 0.003	20.85 ± 0.08	8.55E+03	2.4%
1457.643 ± 0.011	0.498 ± 0.004	2.043E+02	2.4%

$$\ln(\text{Efficiency}) = -67,82 + 38,66 * \ln(E) - 8,783 * \ln(E)^2 + 0,8602 * \ln(E)^3 - 0,0312 * \ln(E)^4$$

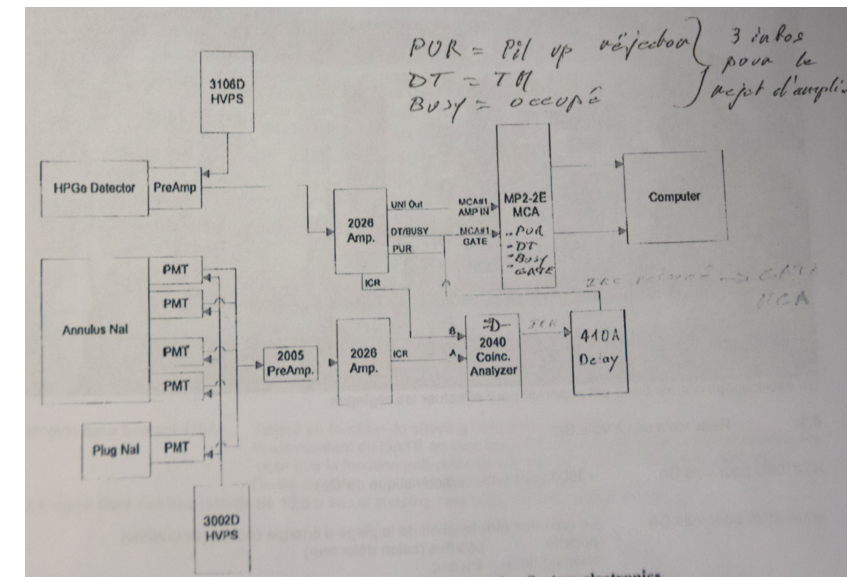
Materials and Procedures

- Digital logic and using a veto system to reduce Compton contribution.

Simplified cartoon of the anti-coincidence veto

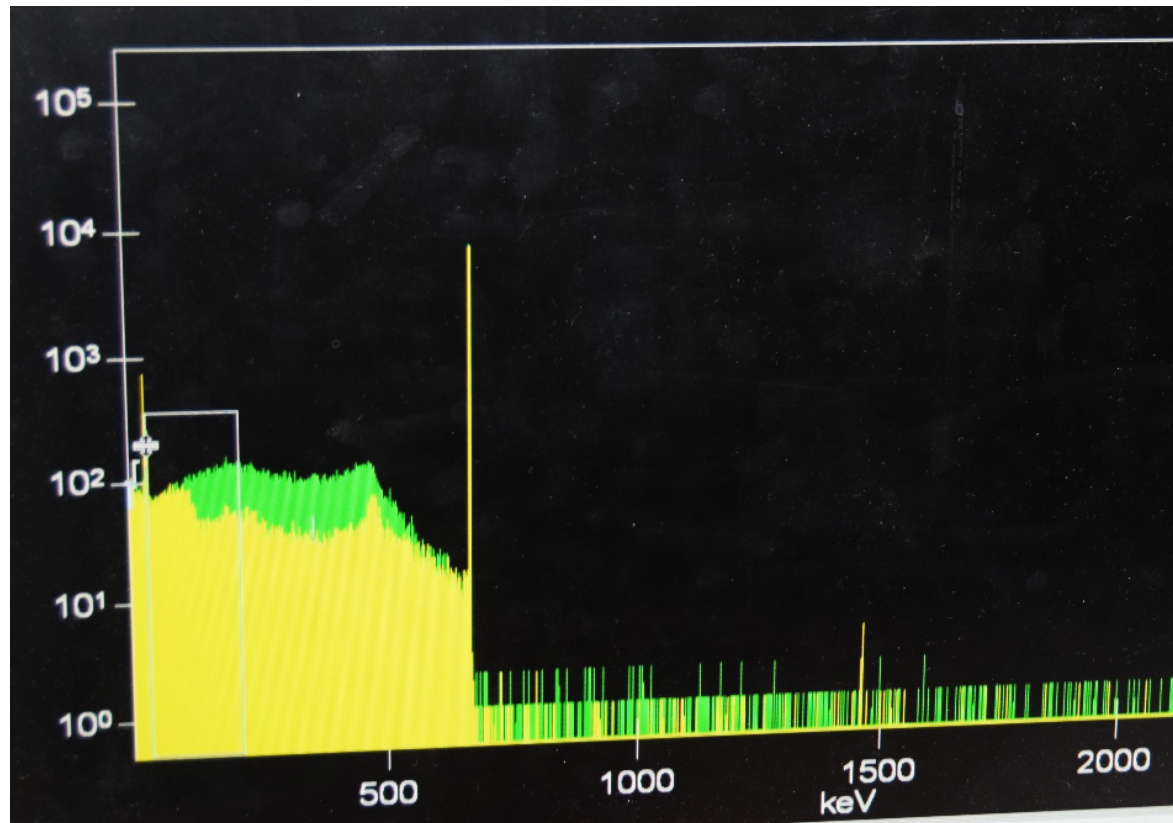


Acquisition system schematic



Results

- Comparison of ^{137}Cs spectra with (yellow) and without (green) the anti-Compton system.



Results

- Determination of a ^{133}Ba source's activity vs calculated activity:

$$A = \frac{C/t}{\varepsilon \cdot P_{\gamma}}$$

Measured $A = 28,1 \pm 0,7\%$ kBq

Calculated $A = 25,8$ kBq

Discrepancy: 8%

Energy, keV	Activity, Bq
305	27450(392)
358	28350(232)

Conclusions

- System results in $\sim 30\%$ decrease in Compton events
- Discrepancy results from uncertainty in efficiency, limited peak information, noise and remaining Comptons.
- Thanks for your attention! Questions?

