Study of a low-background gamma spectrometry system

Practical work 2, 2017.08.22.

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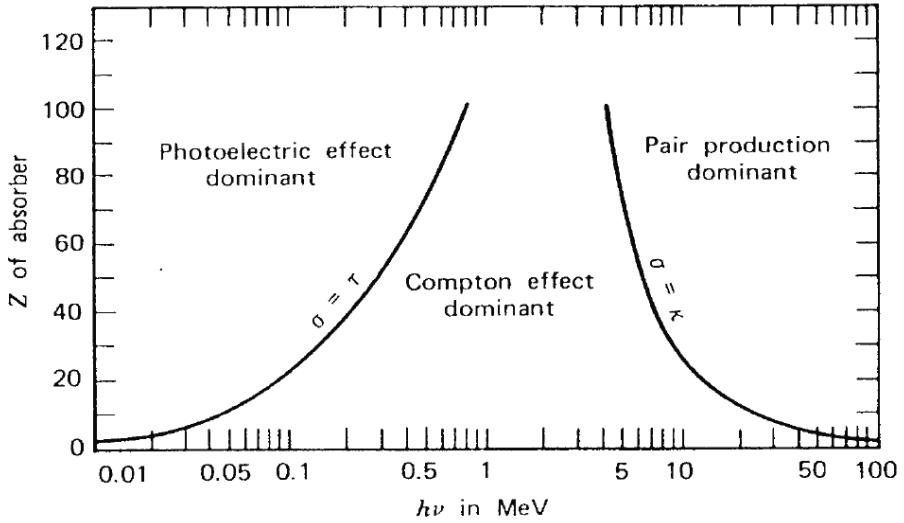
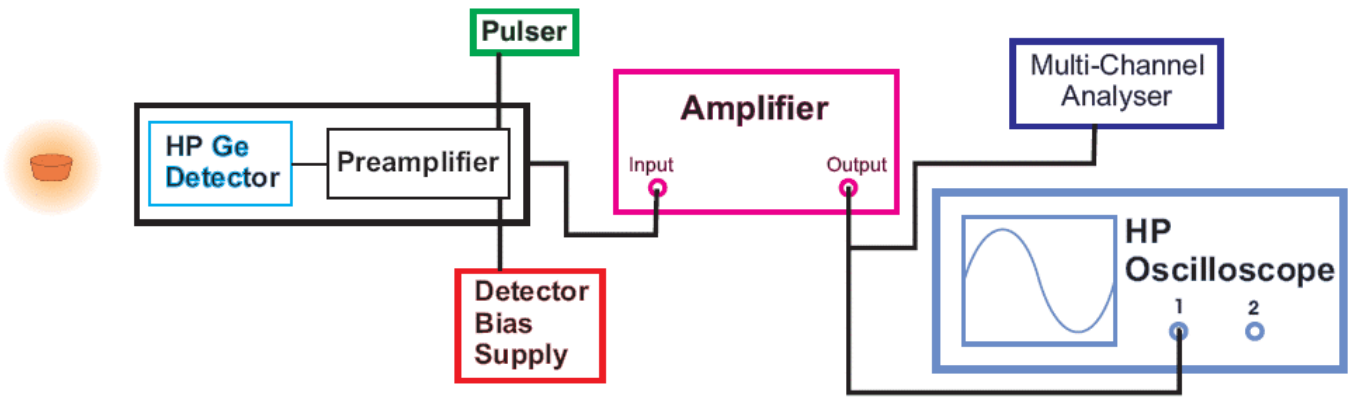
Introduction

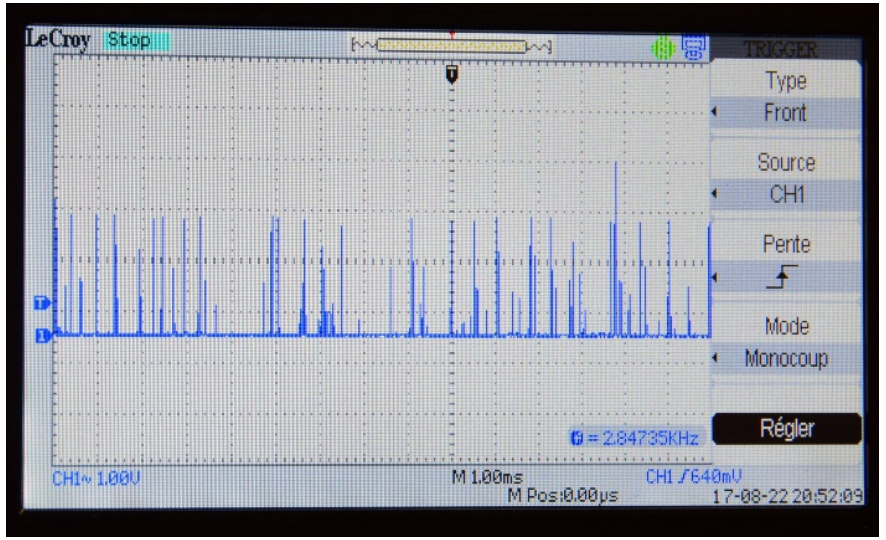
- Interaction of EM radiation with matter
  - Photoelectric effect
  - Compton scattering
  - Pair production
- Detector Materials
  - High-purity Germanium (HPGe)
  - Thallium-activated Sodium iodide [NaI(Tl)]
- Anti-Compton System
  - Use coincidence measurement to veto signal
  - Reduces background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



Materials and Procedure

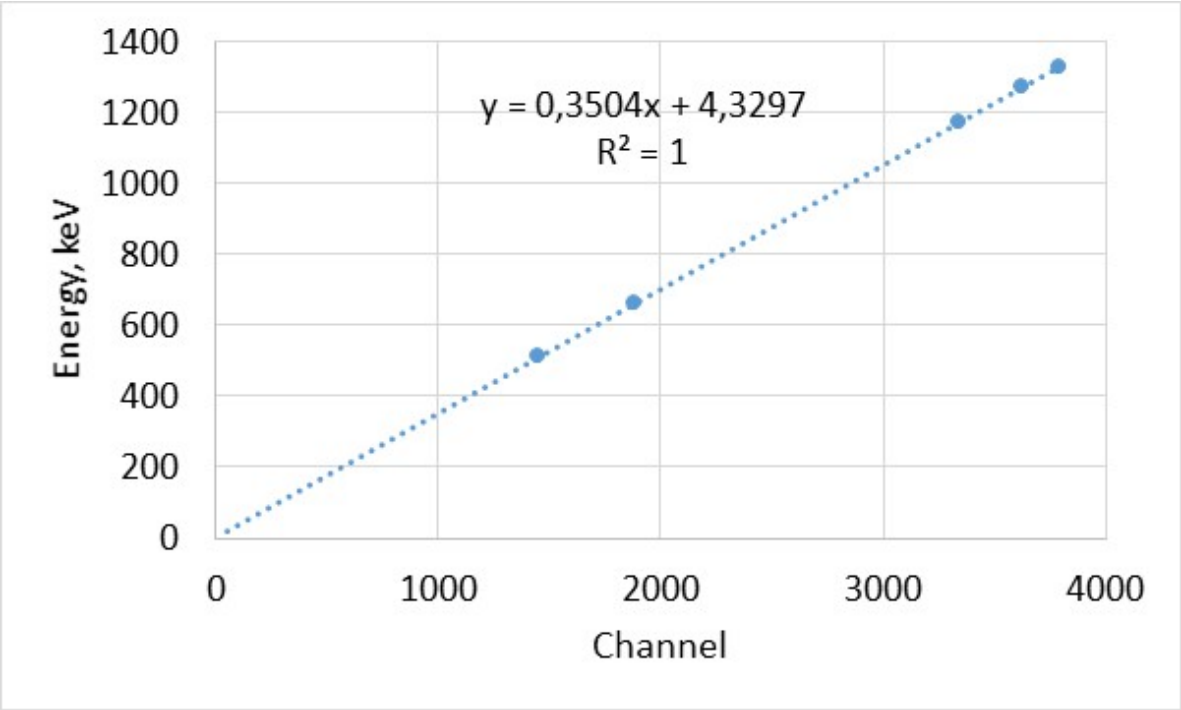
- Pulse adjustment using oscilloscope for multi-channel analyser (MCA) and ^{137}Cs source.





Materials and Procedure

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

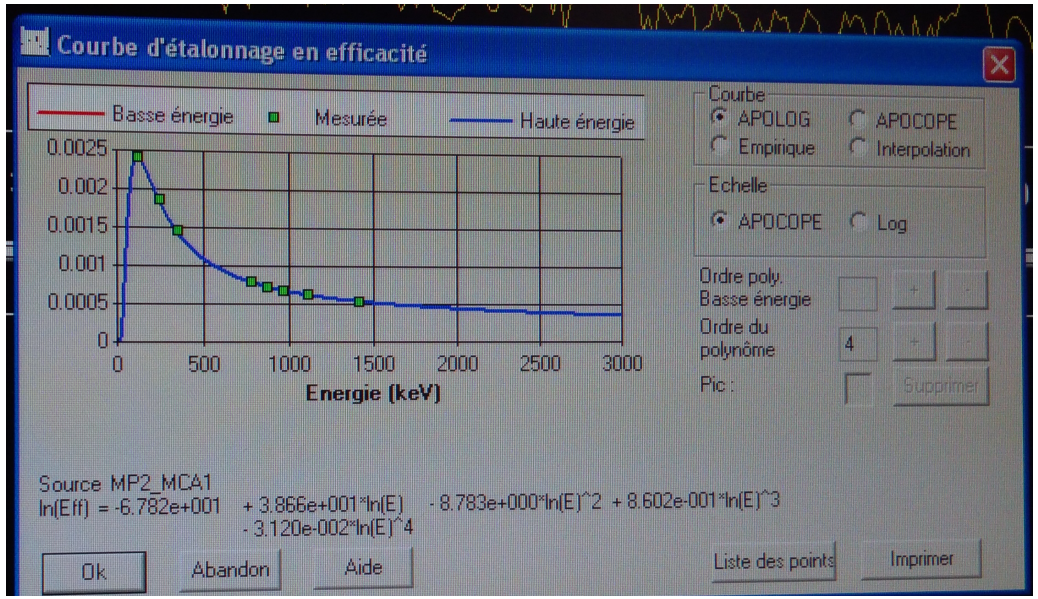


Source	Half-Life (y)	Energy of Most Intense γ Lines (keV)	Intensity (%)
^{60}Co	5.27	1173.237 1332.502	99.97 99.99
^{137}Cs	30.17	661.661	85.21
^{22}Na	2.60	1274.53	99.94
^{133}Ba	10.51	80.997 276.398 302.858 356.017 383.851	34.10 7.16 18.33 62.05 8.94

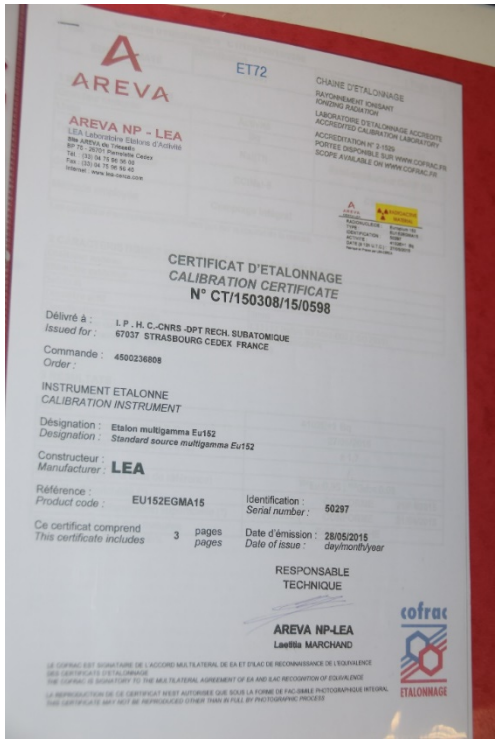
Standard point sources (for calibration)

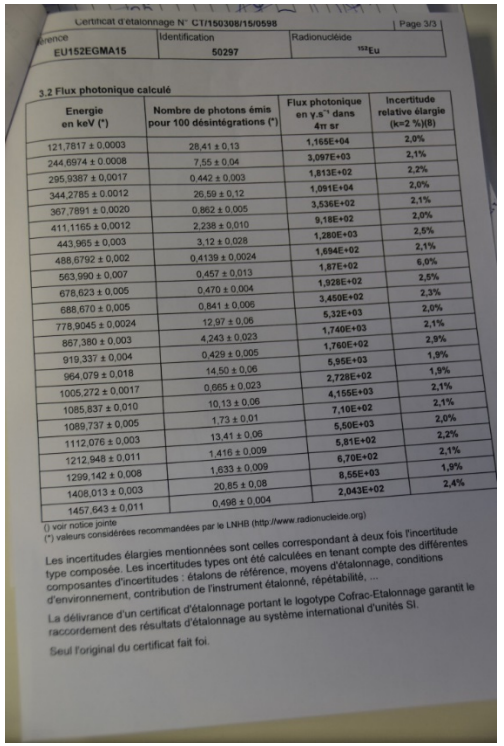
Materials and Procedures

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



Certificate of Eu-152



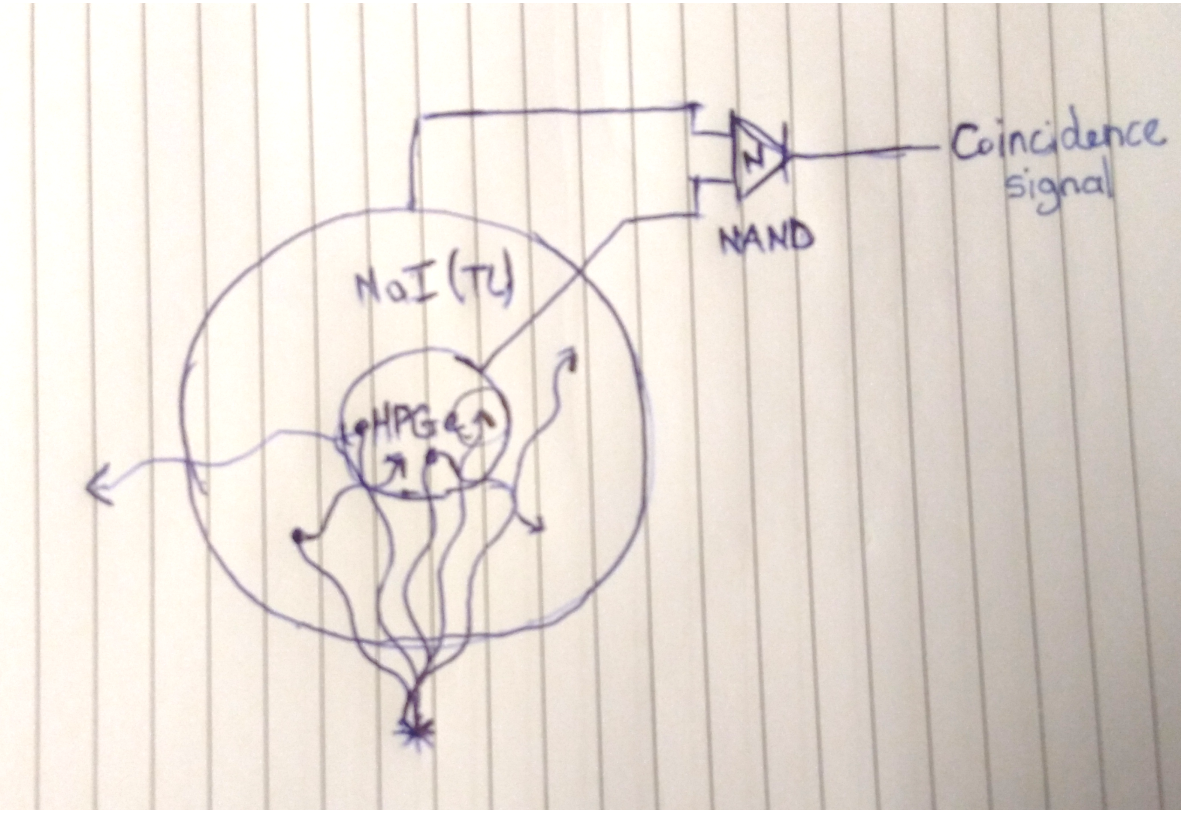


$$\ln(Effiecency) = -67{,}82 + 38{,}66 * ln(E) - 8{,}783 * ln(E)^2 + 0{,}8602 * ln(E)^3 - 0{,}0312 * ln(E)^4$$

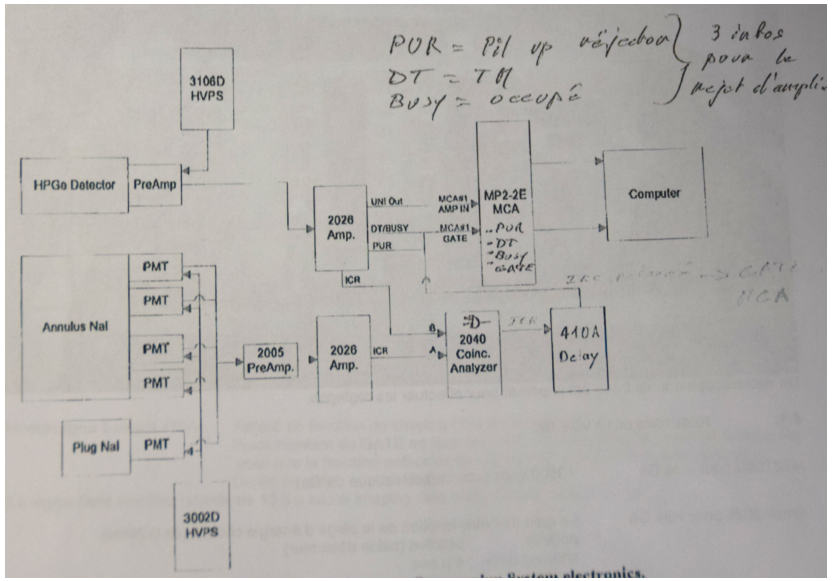
Materials and Procedures

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

Simplified cartoon of the anti-coincidence veto

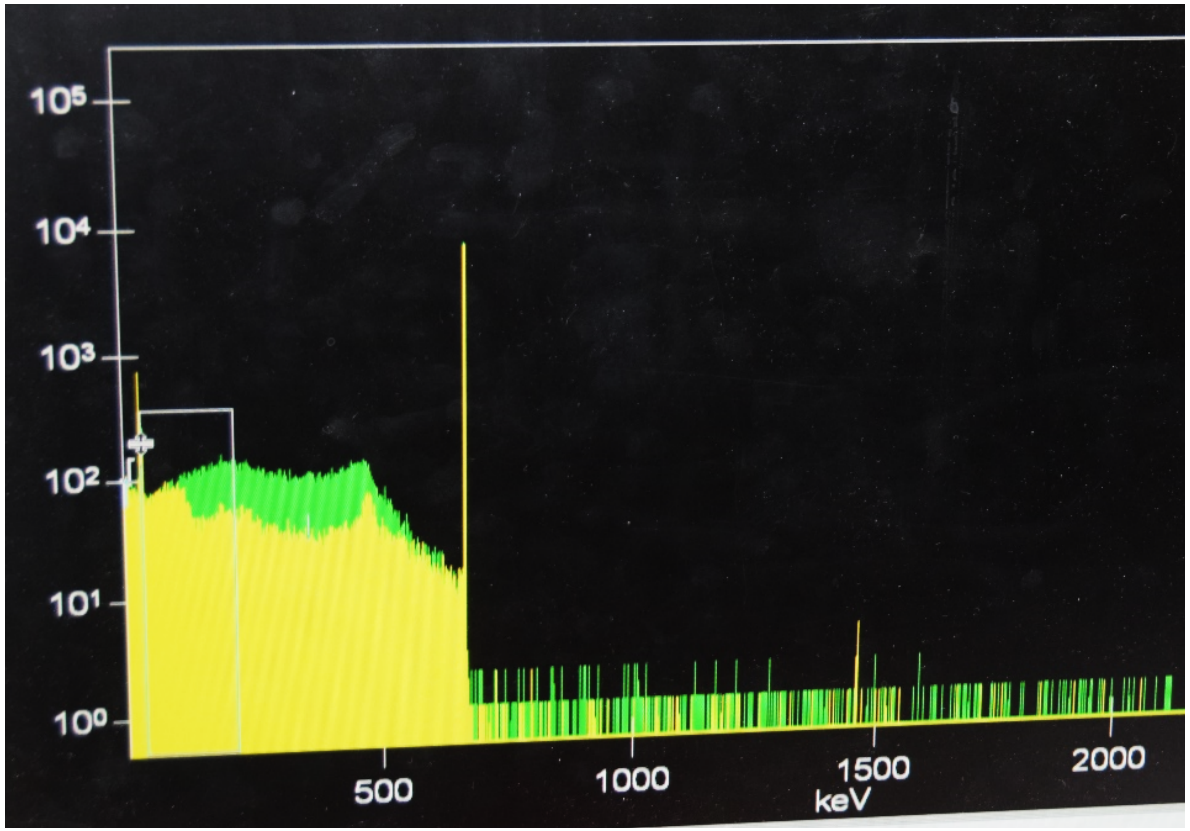


Acquisition system schematic



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:

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

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

Measured A = 28,1 ± 0,7% kBq

Calculated A = 25,8 kBq

Discrepancy: 8%

Conclusions

- System results in ~30% decrease in Compton events
- Discrepancy results from uncertainty in efficiency, limited peak information, noise and remaining Comptons.

- Thanks for your attention! Questions?