

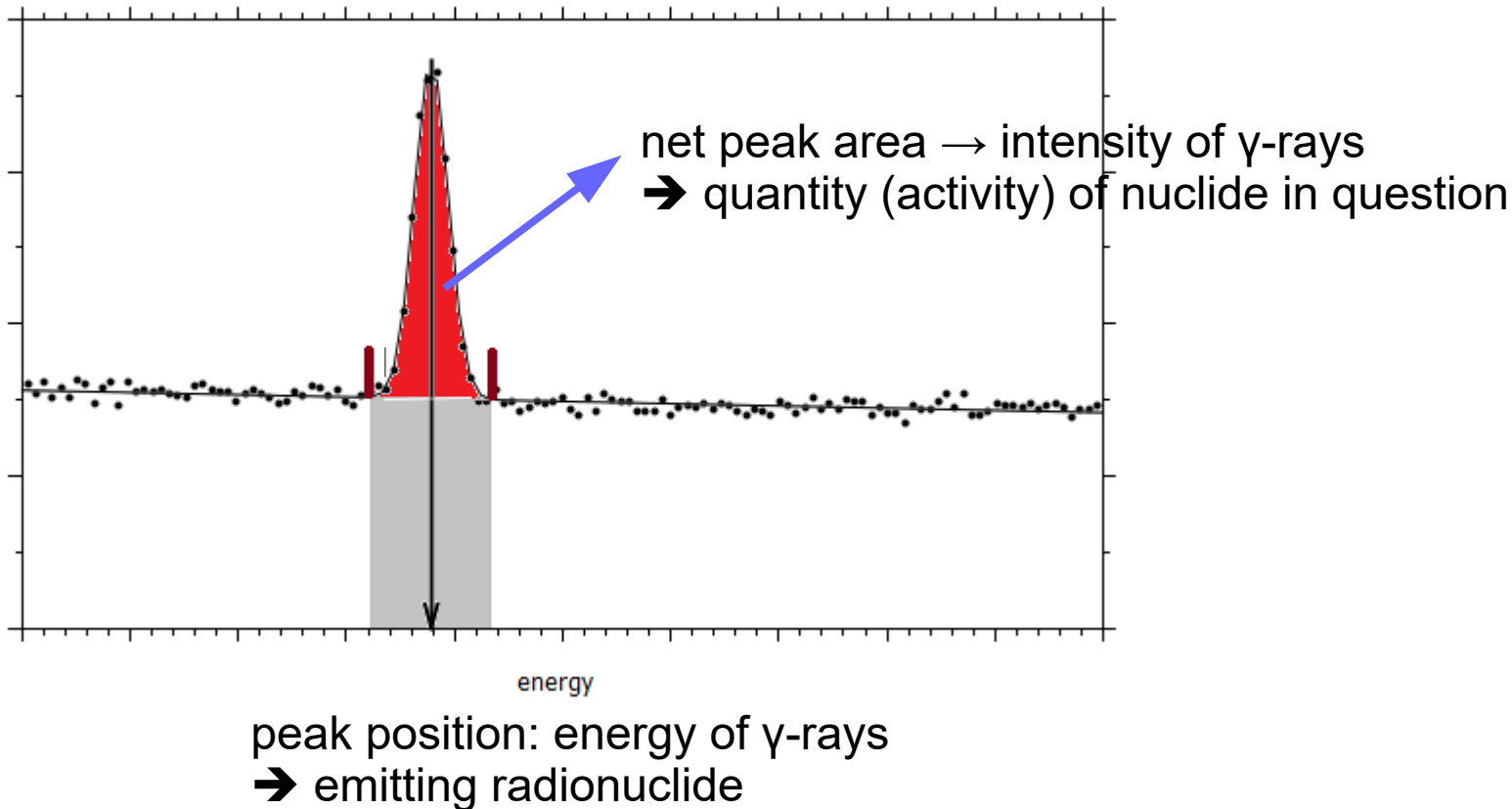
# **Failed peak identifications caused by peak overlaps in gamma-spectrometry and how to resolve them?**



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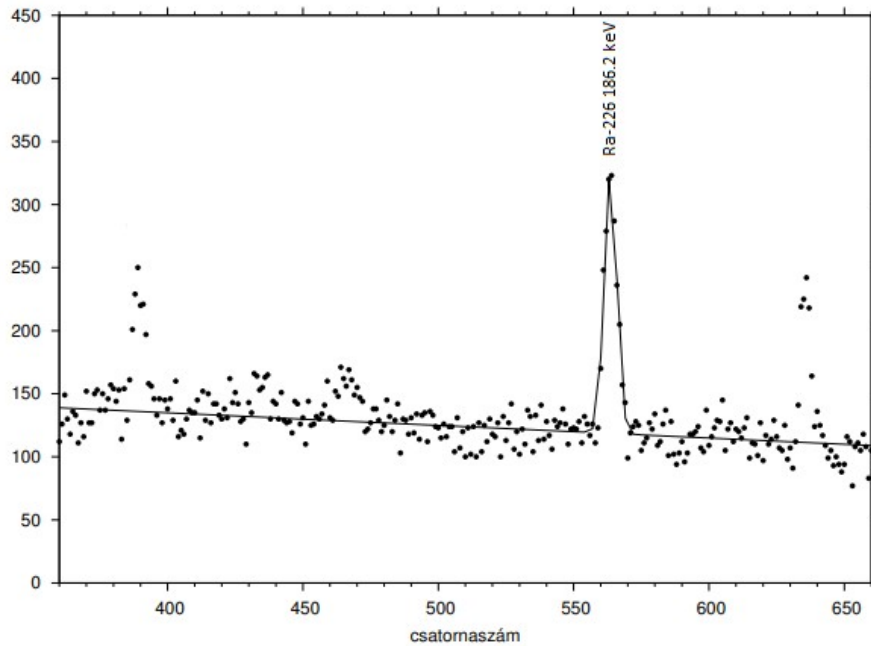
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# Qualitative and quantitative analysis



However the the relationship between the peak energy and the emitting radionuclide is not always straightforward and unambiguous.

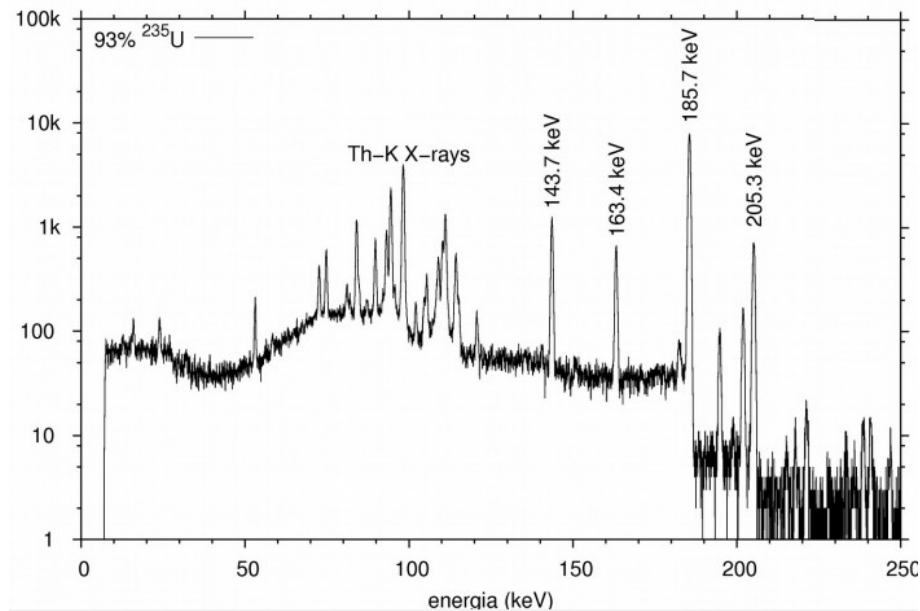
# $^{226}\text{Ra} \leftrightarrow ^{235}\text{U}$ line overlap



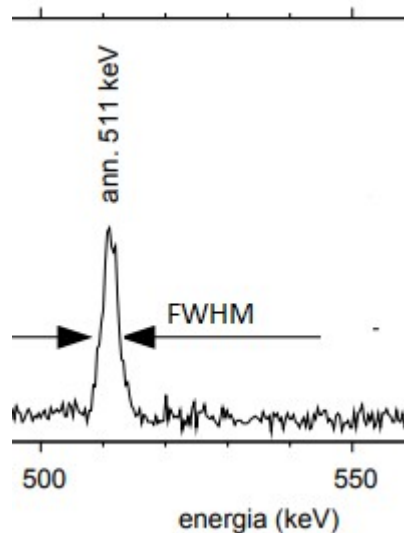
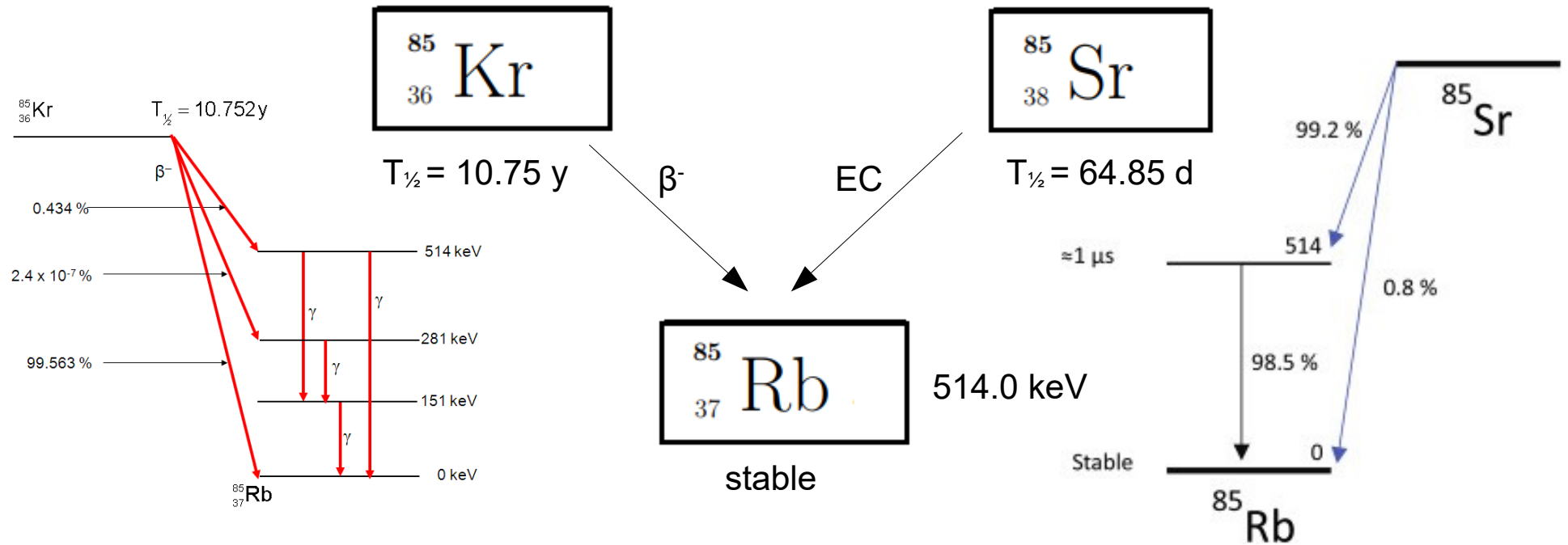
$^{226}\text{Ra}$ : 186.2 keV  $\leftrightarrow$   $^{235}\text{U}$  185.7 keV

$^{226}\text{Ra}$ : this is the only gamma-line

$^{235}\text{U}$ : more gamma-lines:  
4 most intense lines are easy to identify



# $^{85}\text{Sr}$ , $^{85}\text{Kr}$ – or annihilation peak?

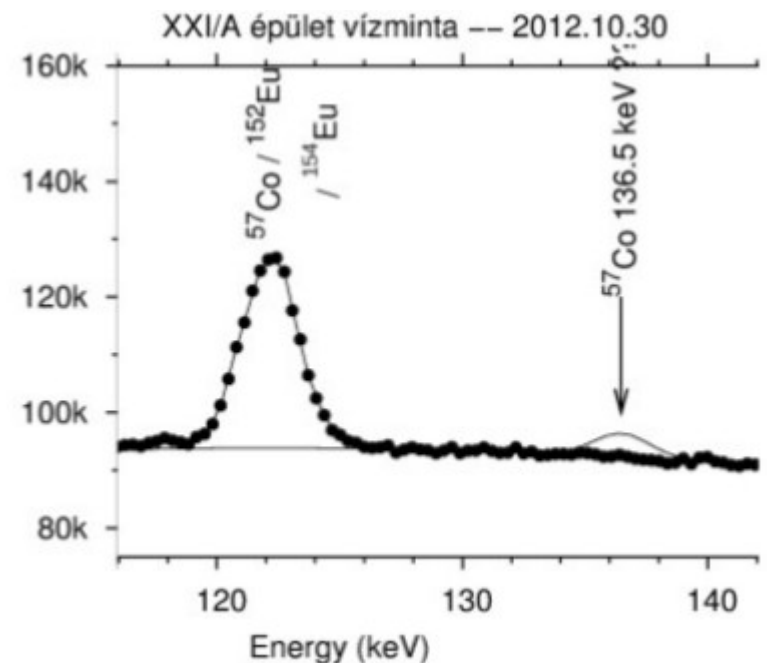
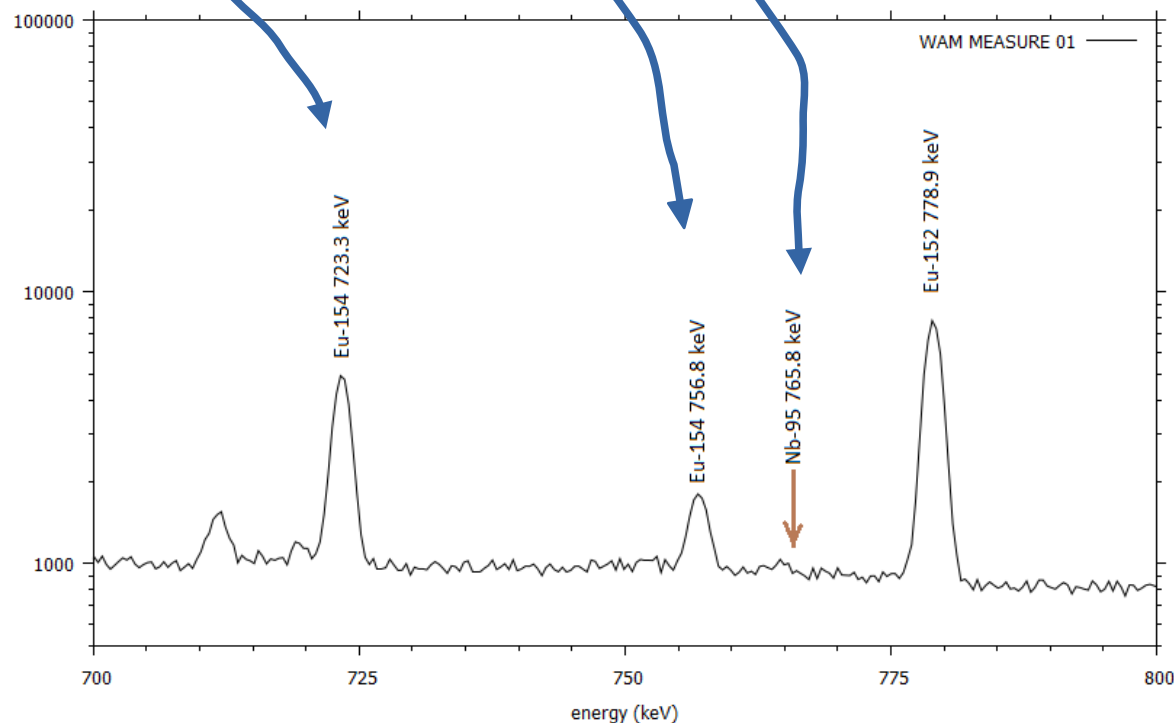
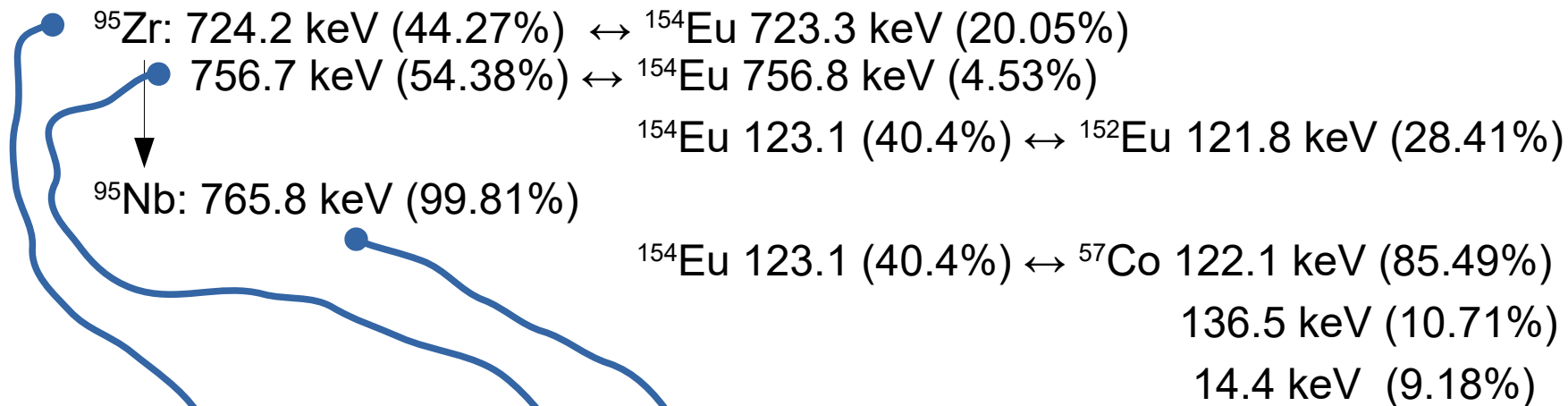


The production mechanism of annihilation radiation includes **Doppler broadening**. The annihilation peak produced in a photon spectrum by annihilation radiation therefore has a higher full width at half maximum (FWHM) than decay-generated gamma rays in spectrum.

$^{85}\text{Sr}$   $T_{1/2} = 64.85\text{ d}$  or  $^{85}\text{Kr}$   $T_{1/2} = 10.75\text{ y}$

If the spectrum evaluation code cannot handle properly the width of annihilation peak, sometimes improves the peak fit with adding an extra line of the above mentioned radionuclides.

# $^{57}\text{Co} \leftrightarrow ^{95}\text{Zr}, ^{95}\text{Nb}, ^{152}\text{Eu}, ^{154}\text{Eu}$ overlaps



# False identification of $^{109}\text{Cd}$

Decays by electron capture

→ emits the characteristic X-ray lines

of its daughter element Ag: Ag-K $\alpha$ : 22.1 keV,

Ag-K $\beta$ : 25.0 keV

+ gamma: 88.0 keV

However Ag characteristic X-rays can be induced in other way.

CATALYSTS FOR REMOVAL OF RADIOACTIVE IODINE

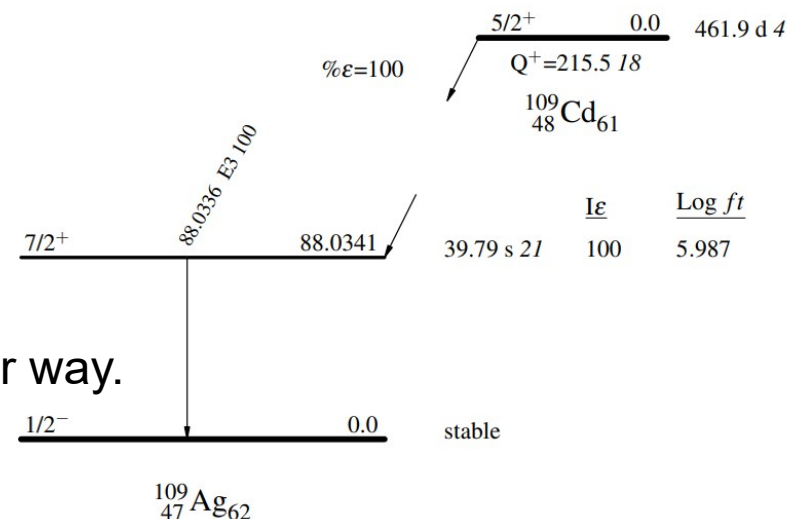
## AC 6120

used in air samplers  
for iodine sampling

contains 7% Ag



AC 6120 catalysts are designed for the removal of radioactive inorganic iodine as bound in organic compounds such as methyl iodine (iodomethane). The adsorbers are commonly used in nuclear power plants, nuclear waste reprocessing plants, and nuclear off-gas or air monitoring systems.



$^{125}\text{I}$  emission lines (X-ray + gamma)  
induce Ag characteristic X-ray.

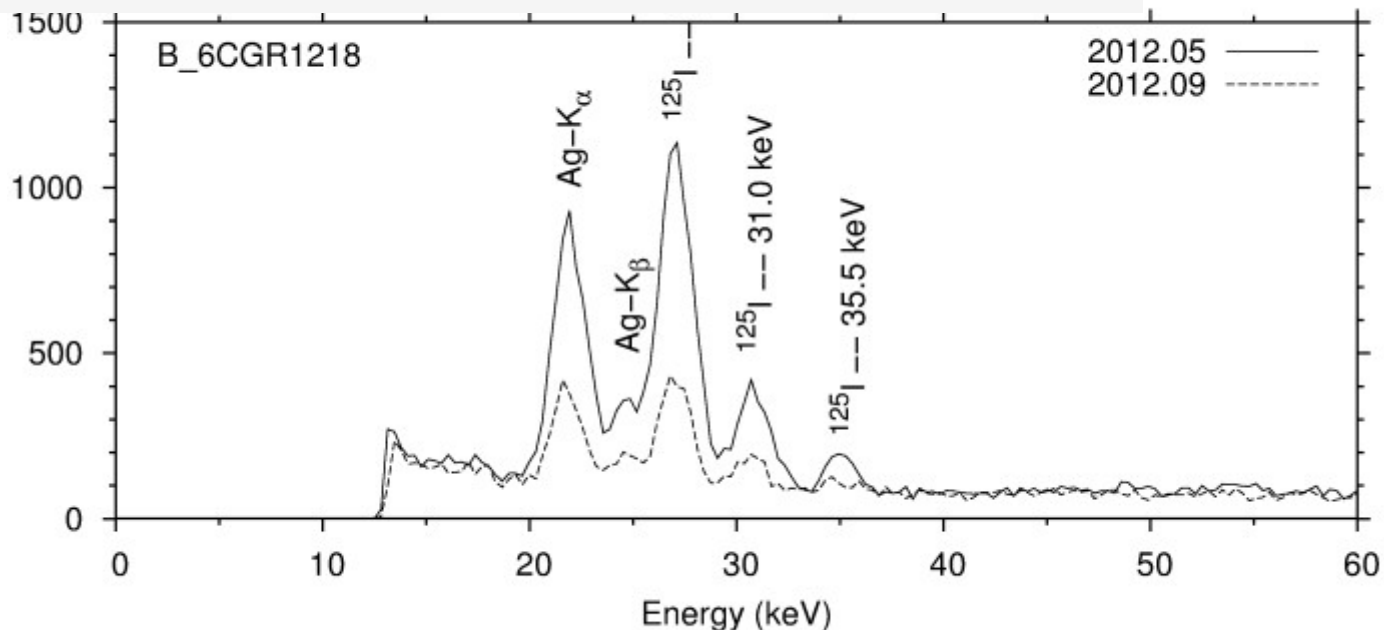


Figure 3.: Ag characteristic X-ray lines excited by  $^{125}\text{I}$

# failed nuclide identifications due to line-overlaps

$^{95m}\text{Nb}$  235.69 keV 24.9%  $\leftrightarrow$   $^{227}\text{Th}$  235.97 keV

THE  $^{95m}\text{Nb}$  has another gamma line at 204.12 keV (2.33%).

$^{95}\text{Nb}$  765.79 keV 100%  $\leftrightarrow$   $^{214}\text{Bi}$  768.36 keV 4.94% A<sub>95</sub>The other

gamma lines of Nb have a frequency of 0.01-0.03%.

$^{89}\text{Zr}$  908.96 keV 100.0%  $\leftrightarrow$   $^{228}\text{Ac}$  911.20 keV 25.8 % A<sub>89</sub>The other

gamma lines of Zr have a frequency of less than 1%.

$^{109}\text{Cd}$  88.04 keV 3.61%  $\leftrightarrow$   $^{212}\text{Pb}$  and  $^{214}\text{Pb}$  Bi characteristic X-ray lines: Bi-K<sub>B1</sub>87.35 keV

THE  $^{109}\text{Cd}$  The characteristic X-ray lines from the Cd decay product are more intense: Ag-K 22.1 keV 85.2% A<sub>109</sub>

The occurrence of Cd in AC6120 granules was previously clarified.

$^{56}\text{Co}$  846.88 keV 100.0%

$^{56}\text{Co}$  1238.28 keV 67.6%  $\leftrightarrow$   $^{214}\text{Bi}$  1238 keV

THE  $^{214}\text{Bi}$  has 3 stronger gamma lines: 609.3 keV, 1764.5 keV, 1120.3 keV

$^{57}\text{Co}$  122.06 keV 85.60%  $\leftrightarrow$   $^{152}\text{Eu}$  121.78 keV 28.58%  $\leftrightarrow$   $^{154}\text{Eu}$  123.07 keV 40.79 %  $\leftrightarrow$

$\leftrightarrow$   $^{75}\text{Se}$  121.12 keV 17.20%

This is the strongest gamma line of the first three radionuclides.<sup>57</sup>

Additional lines of Co: 136.47 keV 10.68%, 14.41 keV 9.16%

THE  $^{75}\text{Se}$  Additional lines of Se: 264.66 keV 58.9%, 136.0 keV 58.3%, 279.54 keV 24.99% The

two Eu isotopes have several additional lines.

$^{65}\text{Zn}$  1115.55 keV  $\leftrightarrow$   $^{89}\text{Kr}$  1116.6 keV  $T_{1/2}=3.15$  seconds

– this is its only significant gamma line.

$^{203}\text{Hg}$  279.20 keV 81.00%  $\leftrightarrow$   $^{75}\text{Se}$  279.54 keV 24.99%

$^{203}\text{Hg}$  This is the only gamma line of Hg. The  $^{75}\text{Se}$

You can see more of his lines above.

$^{141}\text{Ce}$  145.44 keV 48.20%  $\leftrightarrow$

THE  $^{141}\text{Ce}$  This is the only gamma line of Ce.

were identified:

964.8 keV, 969.0 keV:  $^{228}\text{Ac}$  911.2 keV is the strongest line

583.2 keV  $^{208}\text{Tl}$  (the 2614.5 keV line has a higher intensity than this, but the detector efficiency is lower there)

1238.1 keV  $^{214}\text{Bi}$  609.3 keV is the strongest line

That is, all the lines now identified belong to natural radionuclides.

$^{85}\text{Sr}$ : the strongest gamma line is at 514 keV.

Genie-2000 fits the 511 keV annihilation peak with a similar full width at half maximum as the other gamma lines.

Due to the increased width of the annihilation peak, the fit is incorrect here.

Genie 'corrects' this discrepancy by adding  $^{85}\text{Sr}$  and consequently its a gamma line what is actually not present in the sample, but mathematically the goodness of fit can be improved.

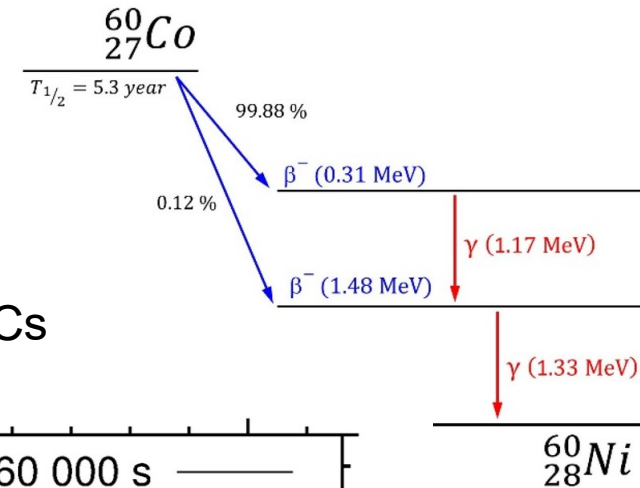
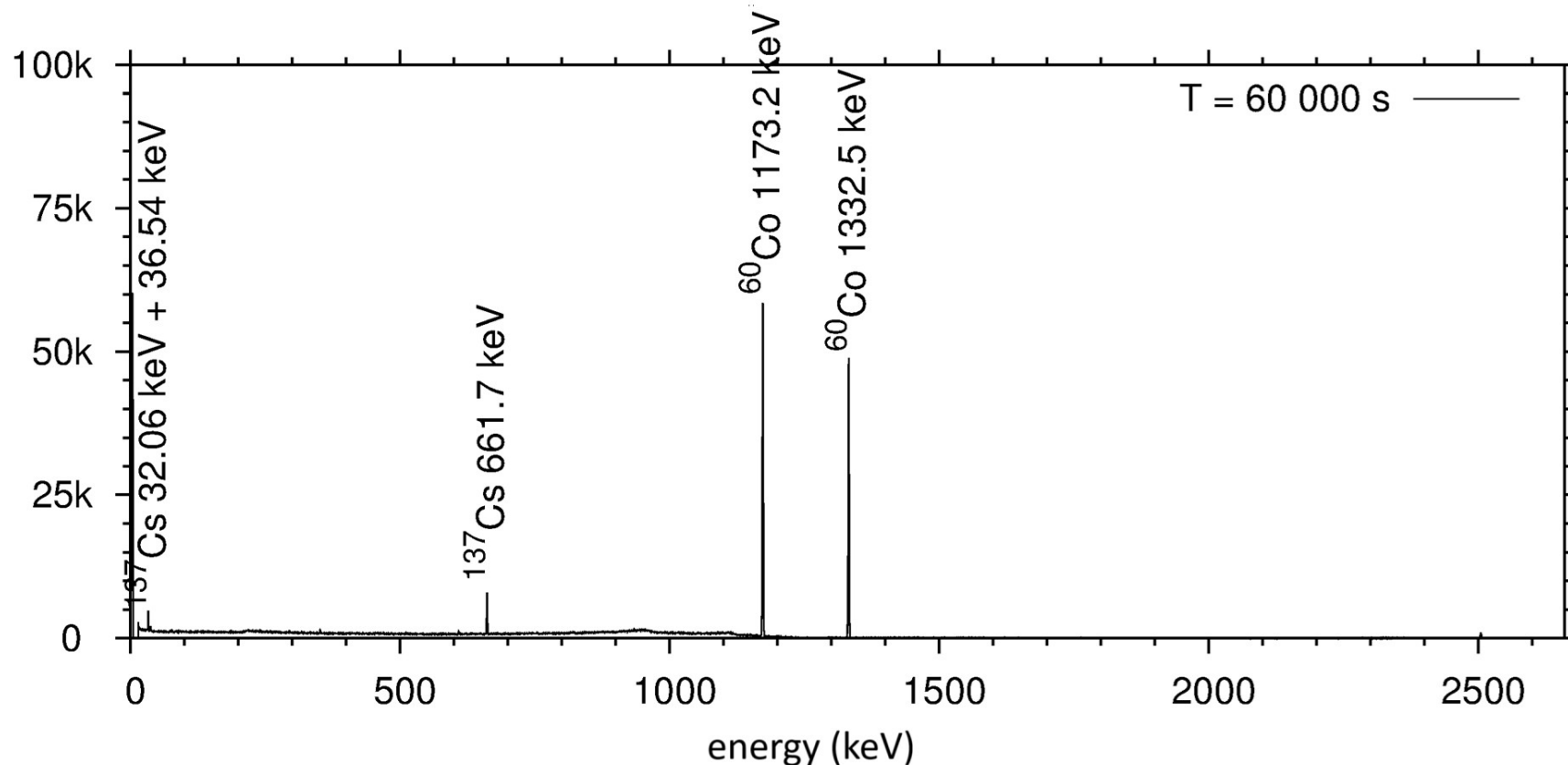


# Line overlaps from artefacts in gamma-spectrum

$^{60}\text{Co}$   $T_{1/2} = 5.27$  y: gammas: 1173.2 keV, 1332.5 keV

$>2 \times 511$  keV: pair production can occur  
and becomes more significant with increasing energy

**1173 keV – 511 keV = 662 keV** – just the only gamma-line of  $^{137}\text{Cs}$



Is this a real  $^{137}\text{Cs}$  peak or artefact (escape peak of  $^{60}\text{Co}$  1173.2 keV)?

If coming from  $^{60}\text{Co}$ , escape peak of  $^{60}\text{Co}$  1332.5 should also appear.

Or: apply an absorber between the sample and detector, which significantly reduces 662 keV.



# Attempt to evaluate a gamma-spectrum with artificial intelligence (ChatGPT)

Nice — I opened and analysed your uploaded `RHK_WAM_MEASURE_01.CNF`. I made a best-effort parse (details and limitations below) and produced a plotted spectrum plus a CSV of the channel/count data for you to download.

## What I did (assumptions)

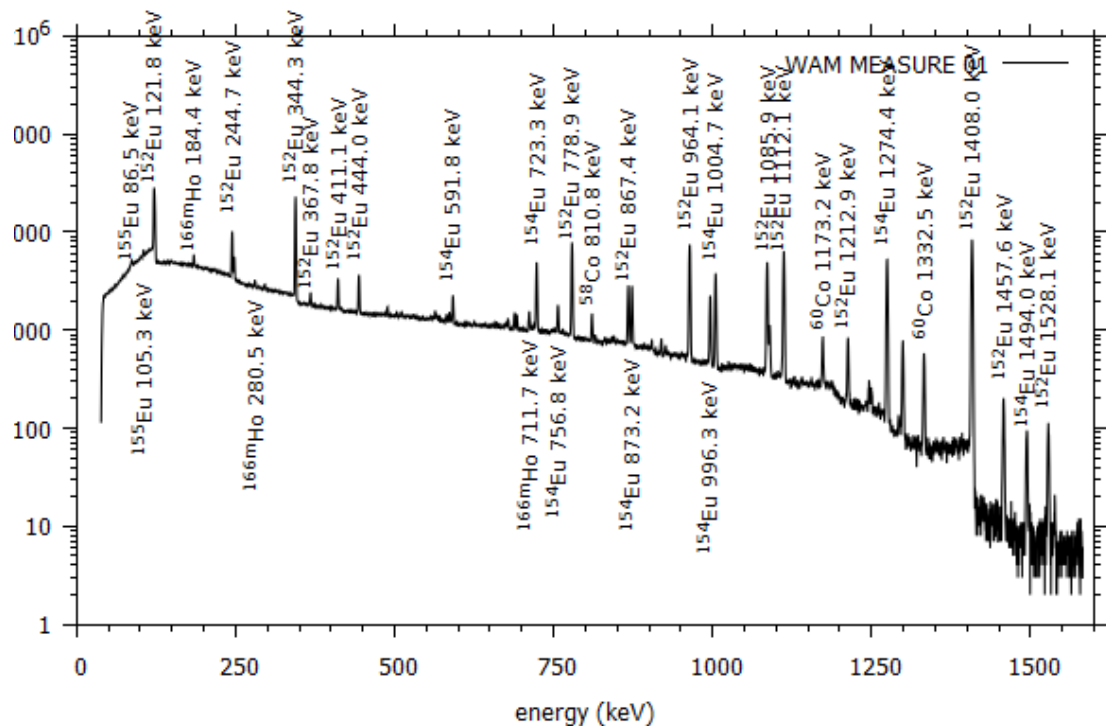
- I inspected the file and found it is a binary file of 67,072 bytes.
- I made a reasonable parse: the file has a 1536-byte header followed by 65,536 data bytes.
  - That means the spectrum portion is 65,536 channels, each stored as unsigned 8-bit integers (0–255).
  - This assumption explains the file size exactly ( $1536 + 65536 = 67072$ ). I could not find readable ASCII calibration text in the header.
- I converted the 65,536 data bytes into counts per channel and performed basic peak-finding and summary statistics.
- I plotted the raw counts vs channel and saved both a PNG plot and a CSV of the channel/count table.

## Quick summary (raw spectrum)

- Channels: 65,536
- Data type (assumed): uint8 (0–255)
- Total counts: 494,507
- Mean counts per channel: 7.5456
- Number of non-zero channels: 7,677
- Maximum count value observed: 255 (several channels are saturated at 255)

## Important caveats & limitations

1. **No energy calibration provided** — I analysed counts vs channel index. I cannot convert channels → keV (or identify isotopes) without an energy calibration (channel-to-energy mapping) or known reference peaks (e.g., Cs-137 661.7 keV, Co-60 lines, etc.).
2. **File contains XML-like header** — the XML header likely contains useful metadata (detector, acquisition time, calibration) but my first attempt only tried to parse numeric text and then raw data. If you want I can extract and show the XML header contents so we can read metadata.
3. **Peak detection is basic** — I used a local-maximum + threshold method and estimated FWHM by half-max interpolation. For robust peak energies, net areas and uncertainties, Gaussian/Voigt fits and background subtraction are recommended.
4. **Some detected “peaks” may be artefacts** — large plateaus or repeated patterns in the binary can produce strange FWHM or repeated comparable peaks (the output shows some very large FWHM values for a few entries). I can refine detection parameters (prominence, minimum distance, smoothing) if you want fewer/more conservative peaks.

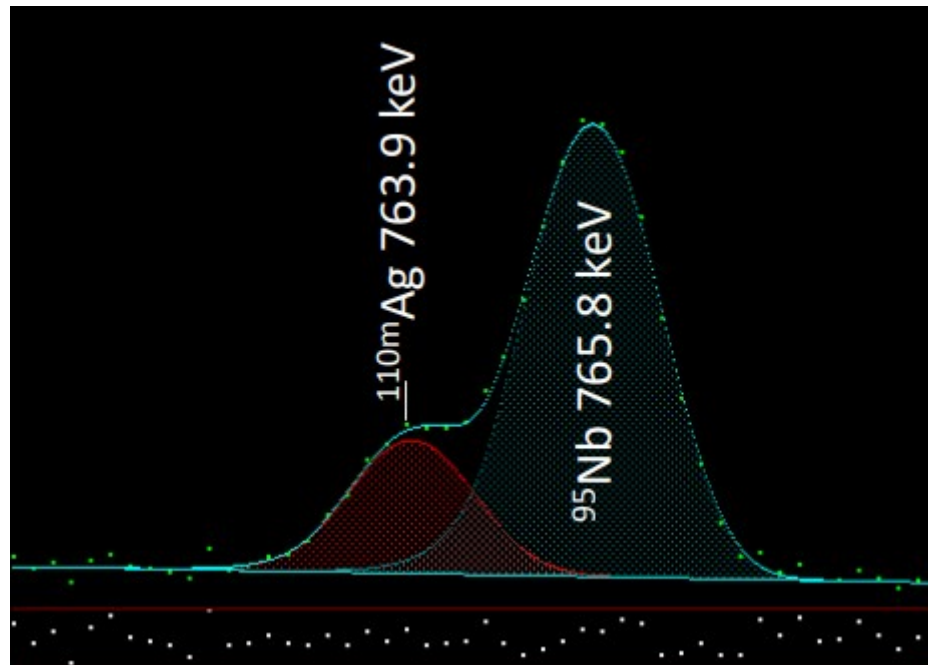


## Suggested next steps (pick any)

- I can extract and show the XML header so we can read instrument metadata (acquisition time, detector, existing calibration parameters). This often provides the channel → energy calibration and live time.
- If you can provide a small calibration file or tell me which known photopeaks are present (e.g., Cs-137, Co-60), I can compute an energy calibration and convert channels → keV and report peak energies (with uncertainties).
- I can perform Gaussian fits to the largest peaks to get peak centroids and net areas (and uncertainties), and do background subtraction.
- I can save the spectrum plot as PNG and provide it for download.
- I can try different peak detection parameters (more/less smoothing, higher prominence) and re-run automatically.

Tell me which of the above you want next (for example: “Show me the XML header” or “Please do Gaussian fits on the top 5 peaks and give energies — use Cs-137 at 661.7 keV as a calibration reference”), and I’ll run it and return results right away.

# Thank you for your attention!



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