Gamma

szerző: PGY

γ information

Construct a γ spectrum for Kr-87 based on the following information.

keV	%
402	100
850	19
2050	6
2570	42

Spectroscopy

α and β spectroscopy

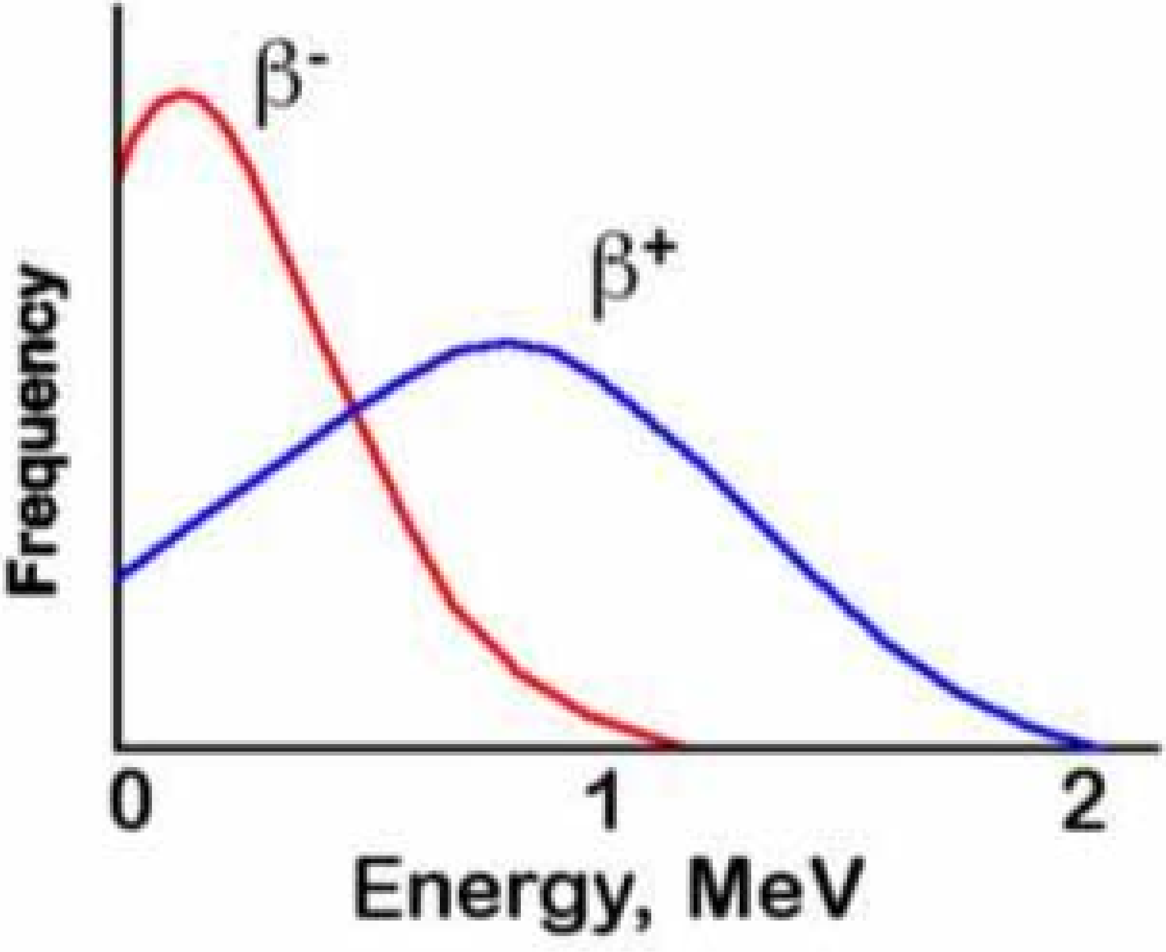
All that is commonly done is:

- Count total activity - quant analysis
- E_{MAX} determinations

Methods required to count α and β are not very discriminating if at all.

β are not monochromatic anyway.

Typical β spectra



Determination of E_{MAX}

This can be evaluated by finding the maximum thickness of a substance that the radiation can penetrate.

alpha - air, beta - aluminum

A plot of E vs. thickness can be produced.

Seldom used for analytical purposes. Liquid scintillation is the major method used for measuring β.

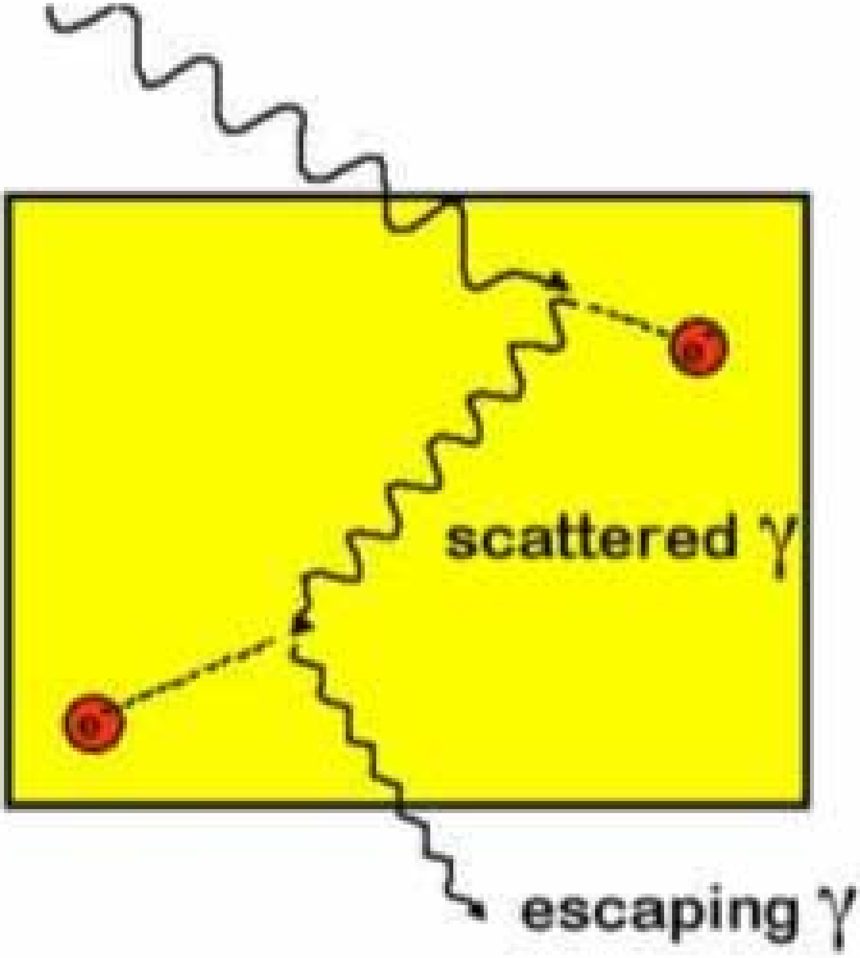
Compton effect

Due to the incident γ colliding with an electron and being scattered.

A portion of the energy is transferred to the electron and γ' is formed. If it escapes, that energy is lost - not detected.

The fact that any amount of energy can be lost in this manner results in a continuum of energy values where $E \leq \gamma$.

Compton effect



Compton effect

Some scattering angles are less favored than others.

This results in the
Compton edge
Compton valley

This effect is observed with all photo peaks.

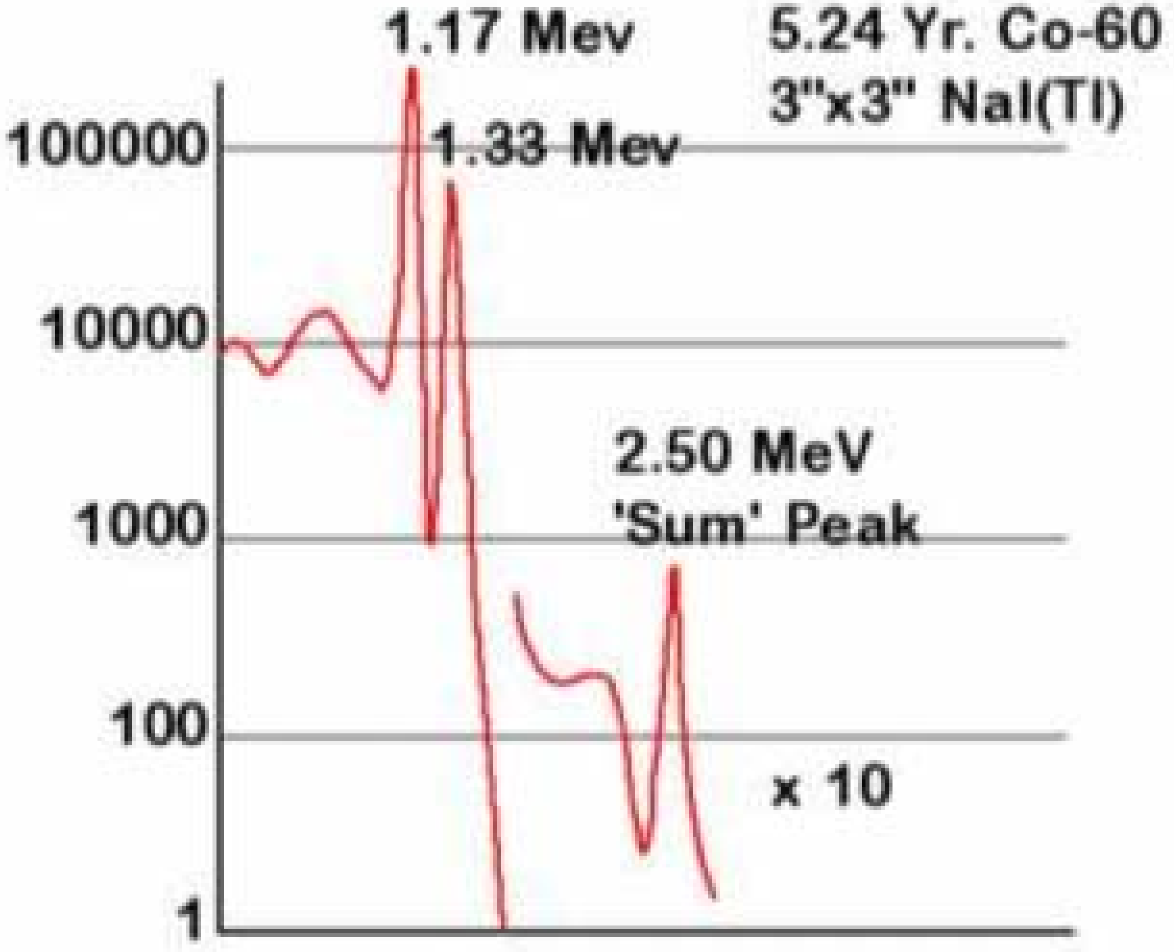
Sum peaks

A radioisotope will often have more than one mode of decay.

This can result in more than a single γ being observed.

If the isotope produces two or more intense gamma and the sample has a relatively high activity, a sum peak may be observed.

Sum peaks


1.17 Mev
5.24 Yr. Co-60
3"x3" NaI(TI)
100000
1.33 Mev
10000
2.50 MeV
'Sum' Peak
1000
100
x 10
1

Sum peaks

A sum peak is always of much lower intensity than any of the γ that produced it.

What happens:

- On occasion, the 1.17 an 1.33 MeV g both enter the NaI(Tl) detector at the same time.
- A single pulse of photons are produced and recorded as a single pulse.
- The analyzer has no way of telling knowing the source of the pulse.

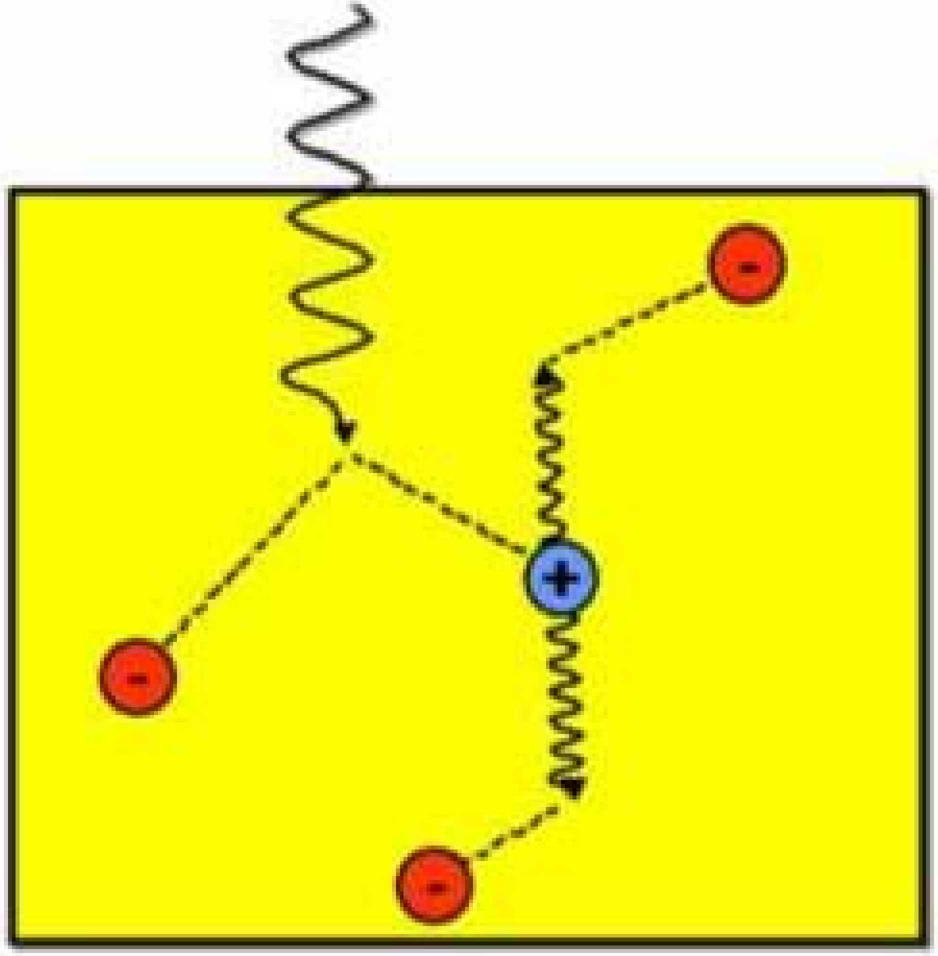
Pair production

When a γ interacts with the strong electrical field around a nucleus, it is possible to form a e^-, e^+ pair.

This may occur when ever $E_\gamma > 1.022$ MeV (Twice the rest mass of an electron)

The e^+ is quickly stopped by the crystal and annihilated resulting in the production of 2 - 0.511 MeV γ

Pair production



The two 0.511 MeV γ that are produced will travel in opposite directions to conserve momentum.

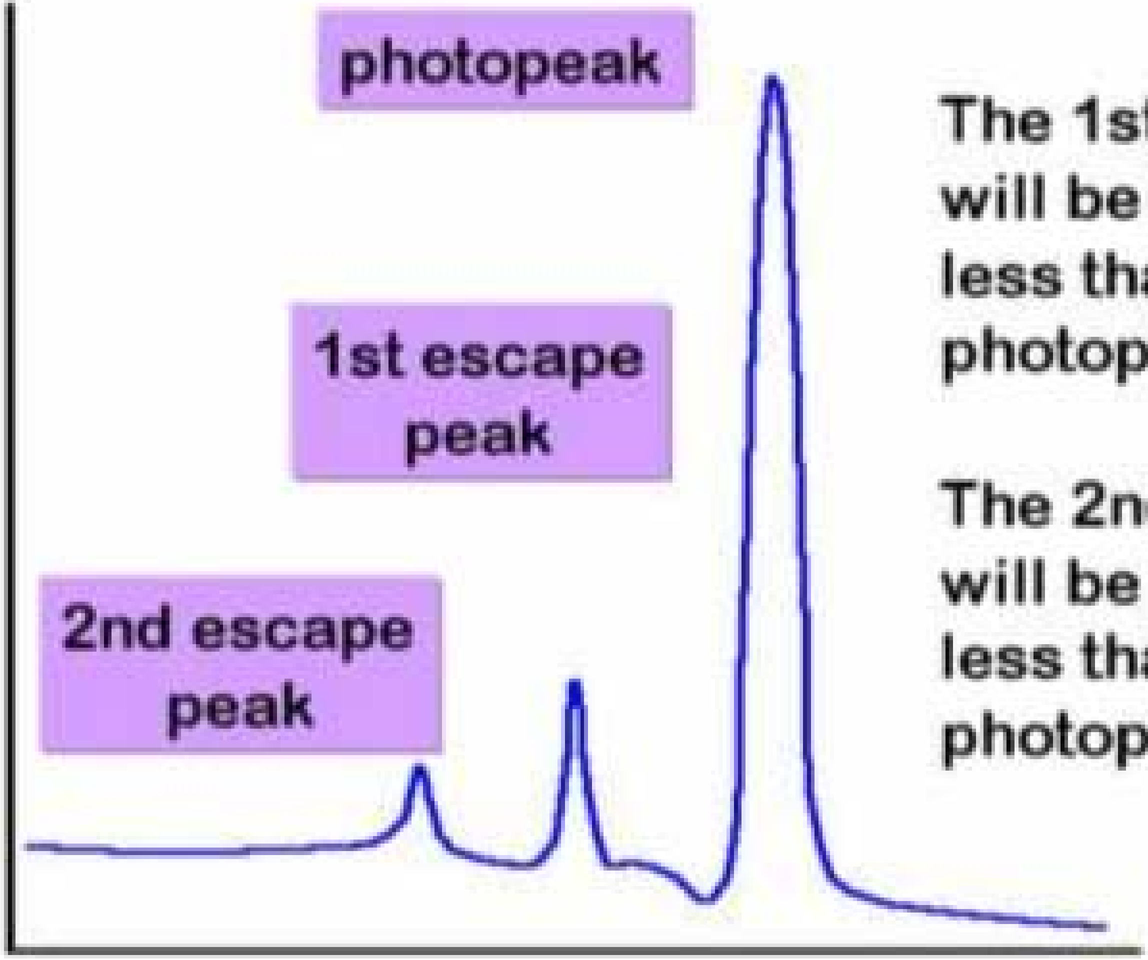
Pair production

As the energy of the incoming gamma increases, the probability of pair production will go up.

Pair production can cause an effect of the resulting γ spectrum.

Because the two 0.511 MeV γ are moving at new directions, they might escape the crystal - escape peaks.

Escape peaks

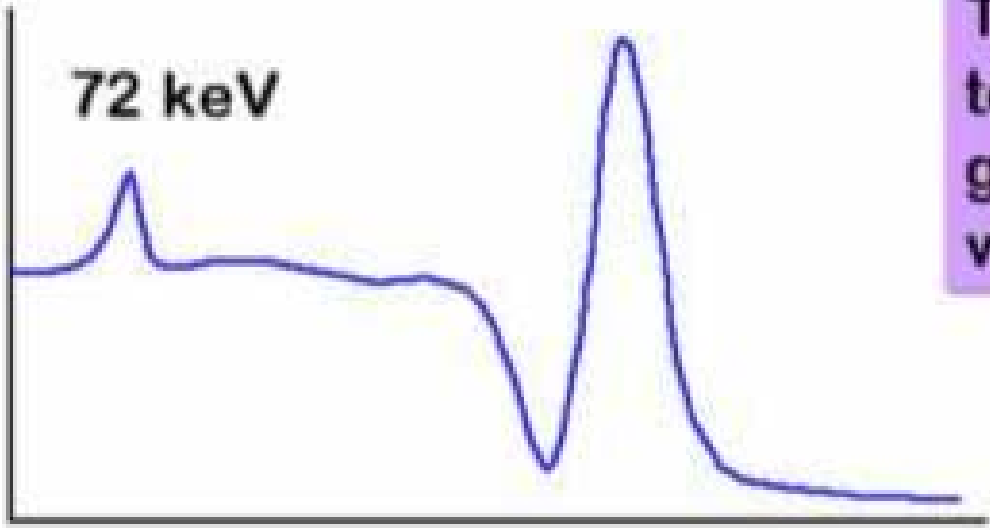


The 1st escape peak will be 0.511 MeV less than the photopeak.

The 2nd escape peak will be 1.022 MeV less than the photopeak.

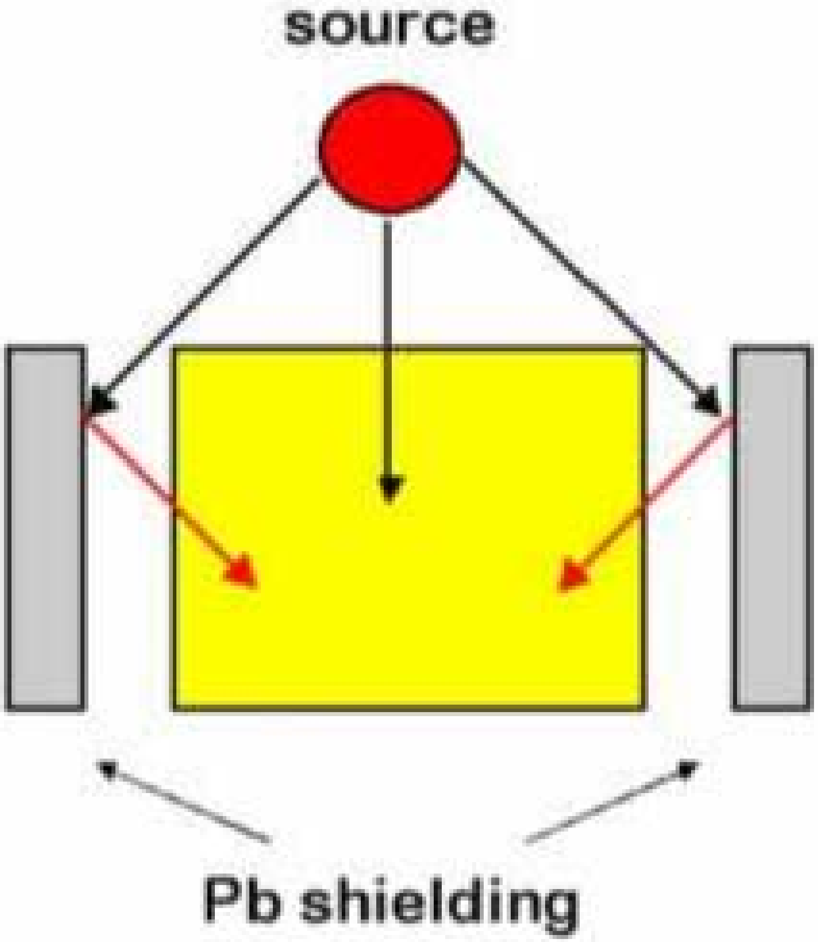
Lead X-rays

When your detector is shielded with lead, a peak a 72 keV may be observed.



This artifact is due to the interaction of g from your sample with the shielding.

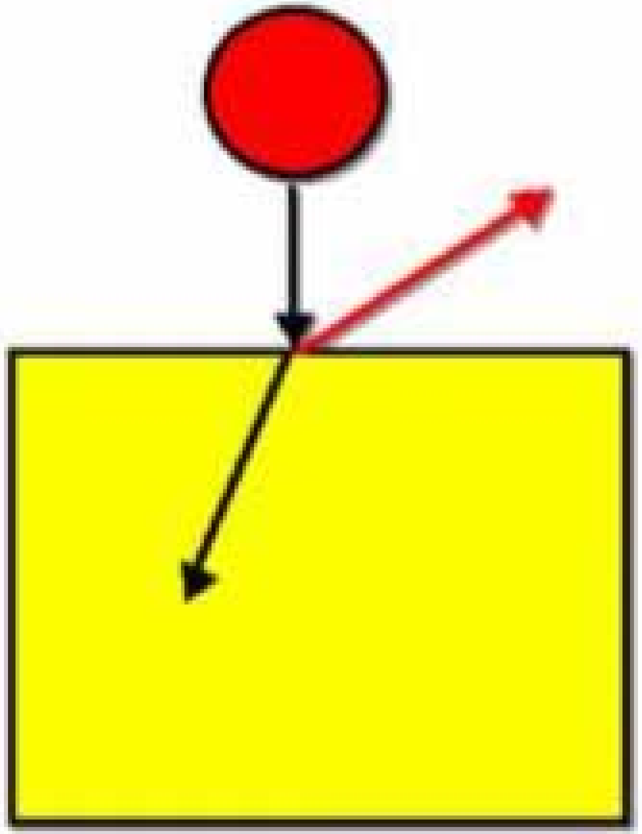
Lead X-rays



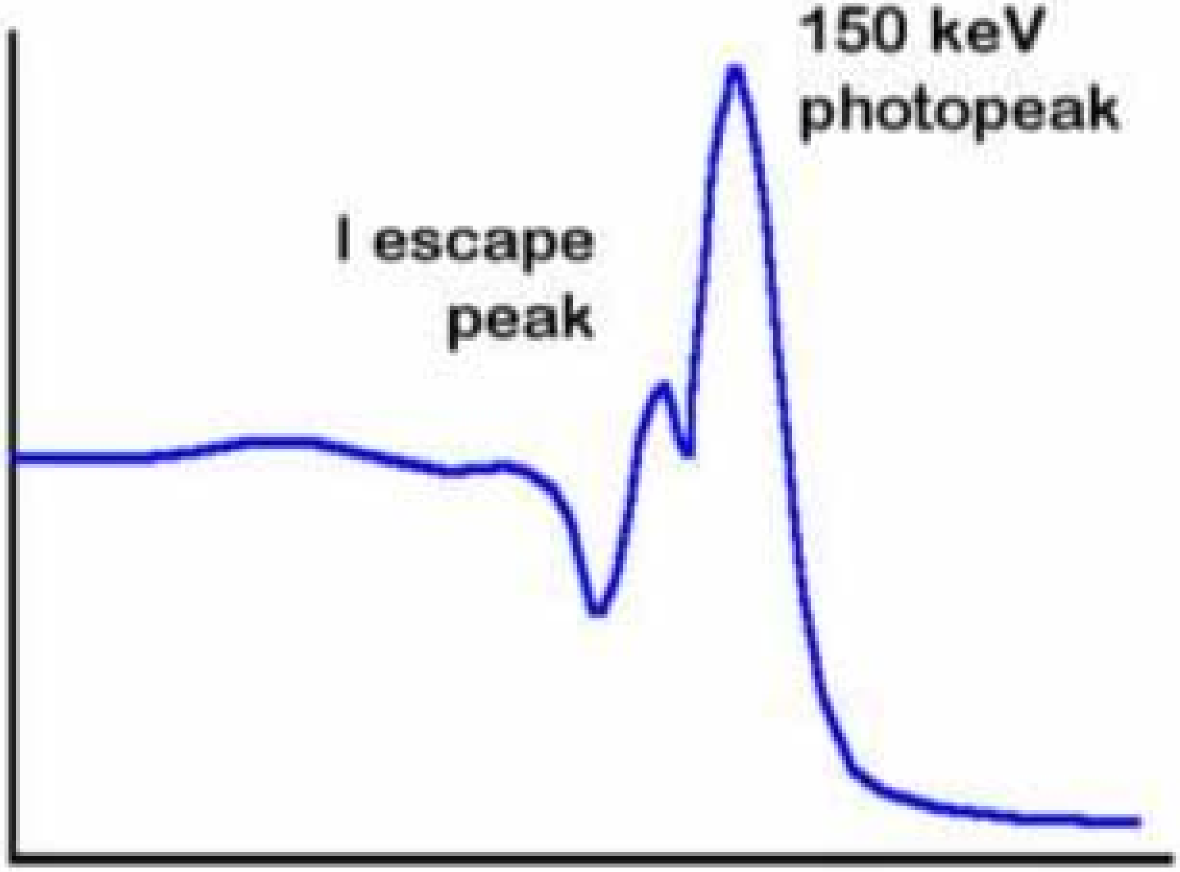
This effect can be reduced by moving the shielding farther away from the detector/source

Iodine X-ray escape

- If $E\gamma < 200$ keV, the γ can be totally absorbed by the top of the crystal.
- The nearness to the surface may allow an iodine X-ray to escape (28 keV)
- A peak at $E\gamma$ - 28 keV may then be observed.

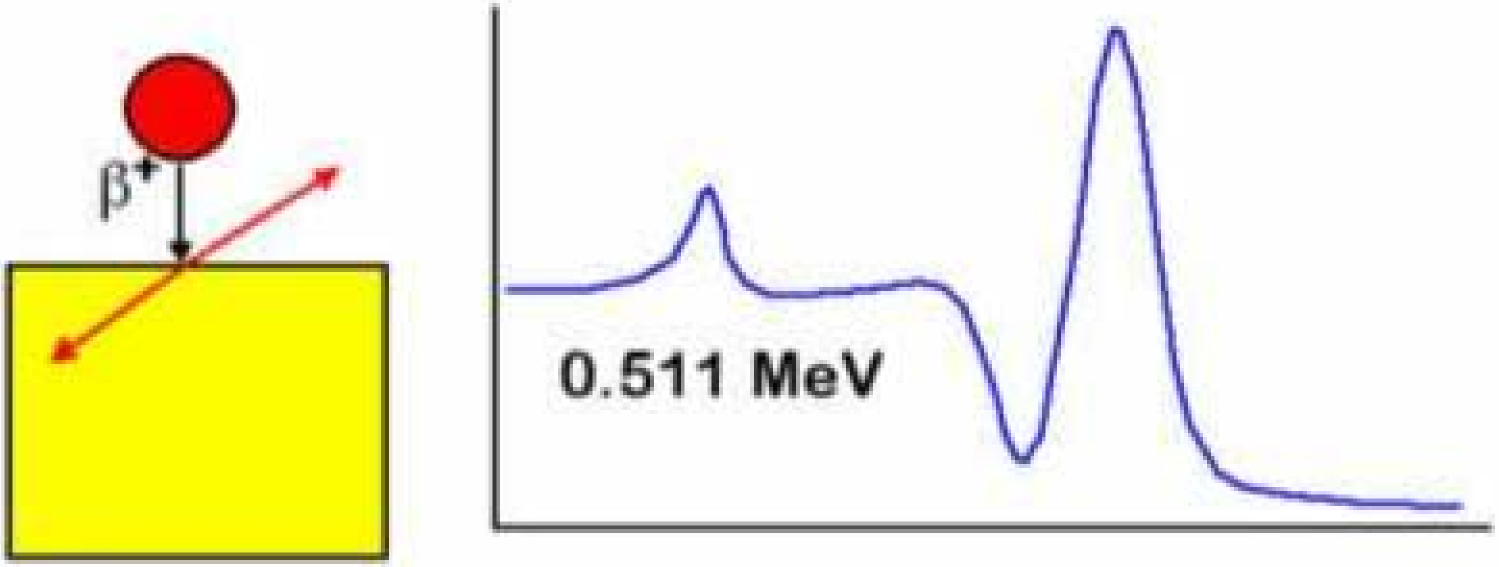


Iodine X-ray escape

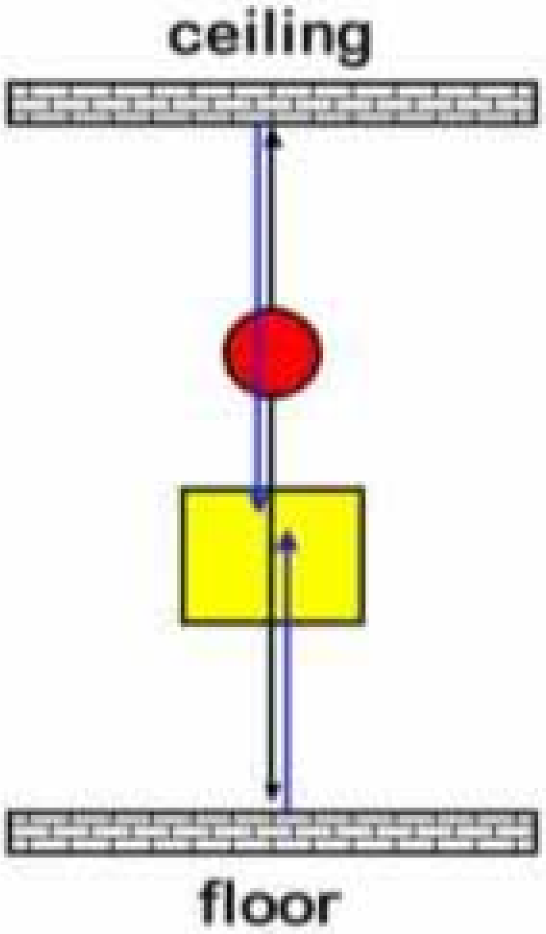


Annihilation Peak

A 0.511 MeV γ peak can occur for any β^+ emitters. Since the β^+ is typically annihilated at the crystal's surface, only a single γ is detected.



Backscatter

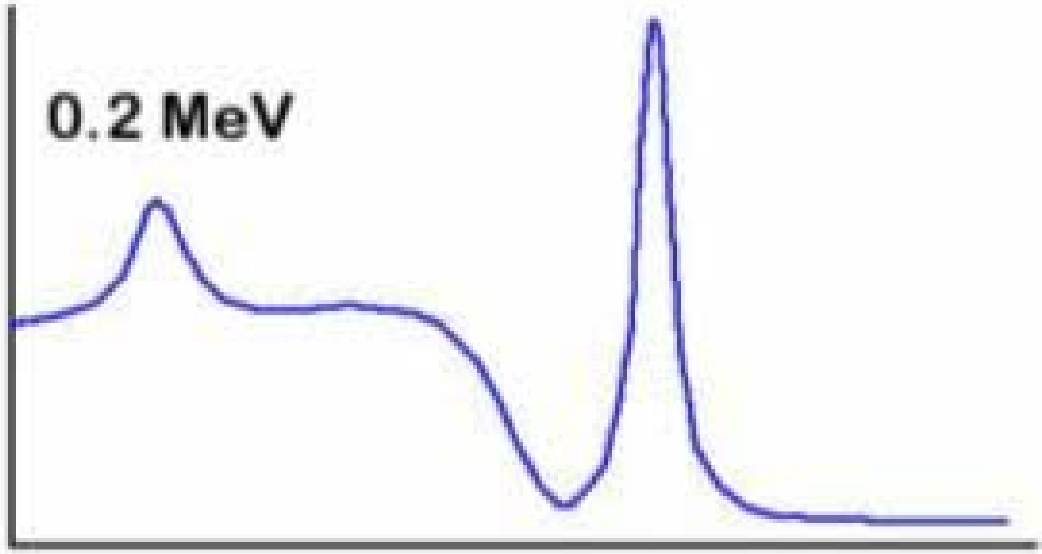


This artifact appears in most spectra.

It results from any γ that undergo a 180° backscatter.

Backscatter

The maximum energy for a 180° backscatter is $\leq$ 0.225 MeV. A peak near 0.2 MeV is common.



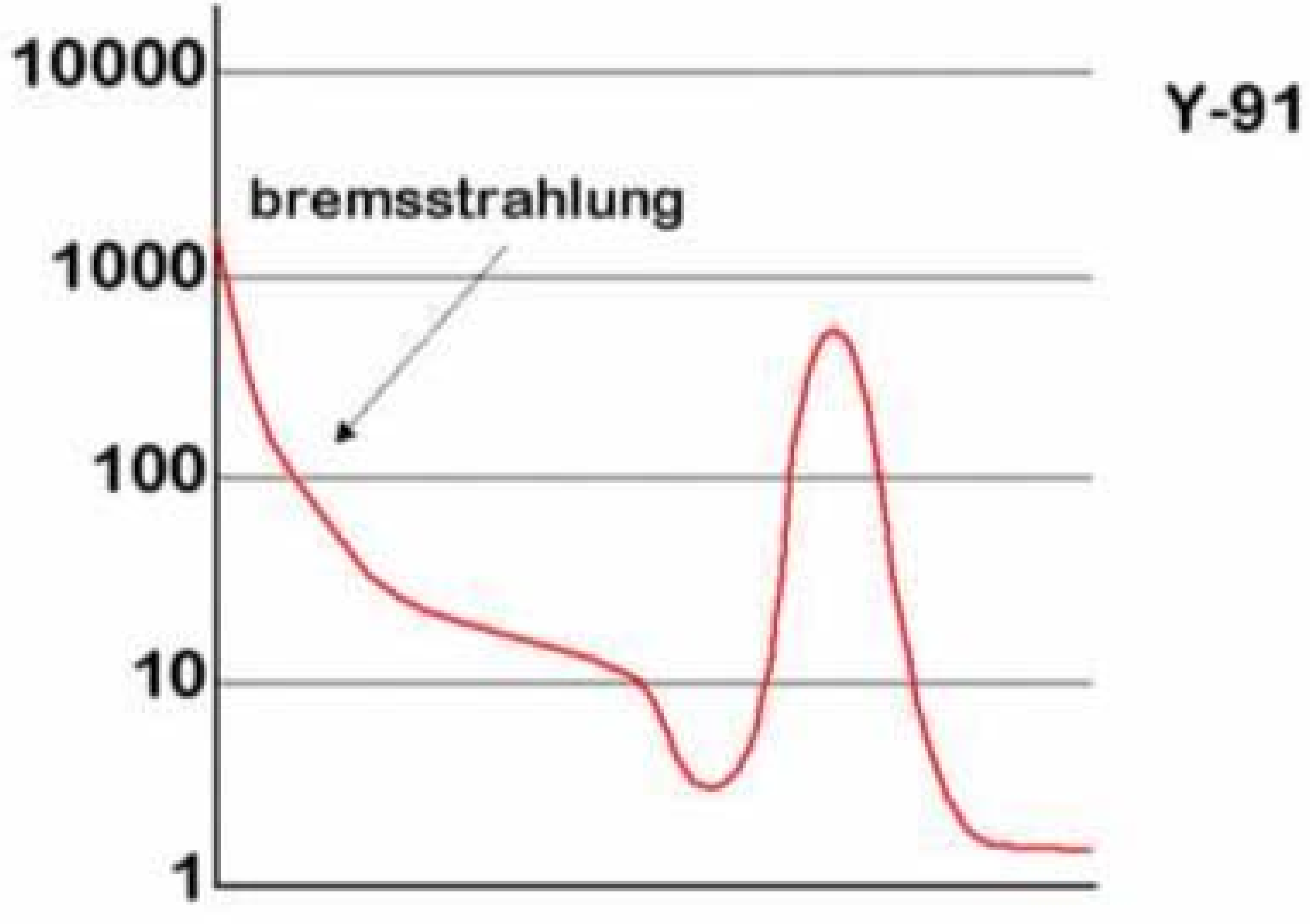
Bremsstrahlung

"Breaking energy"

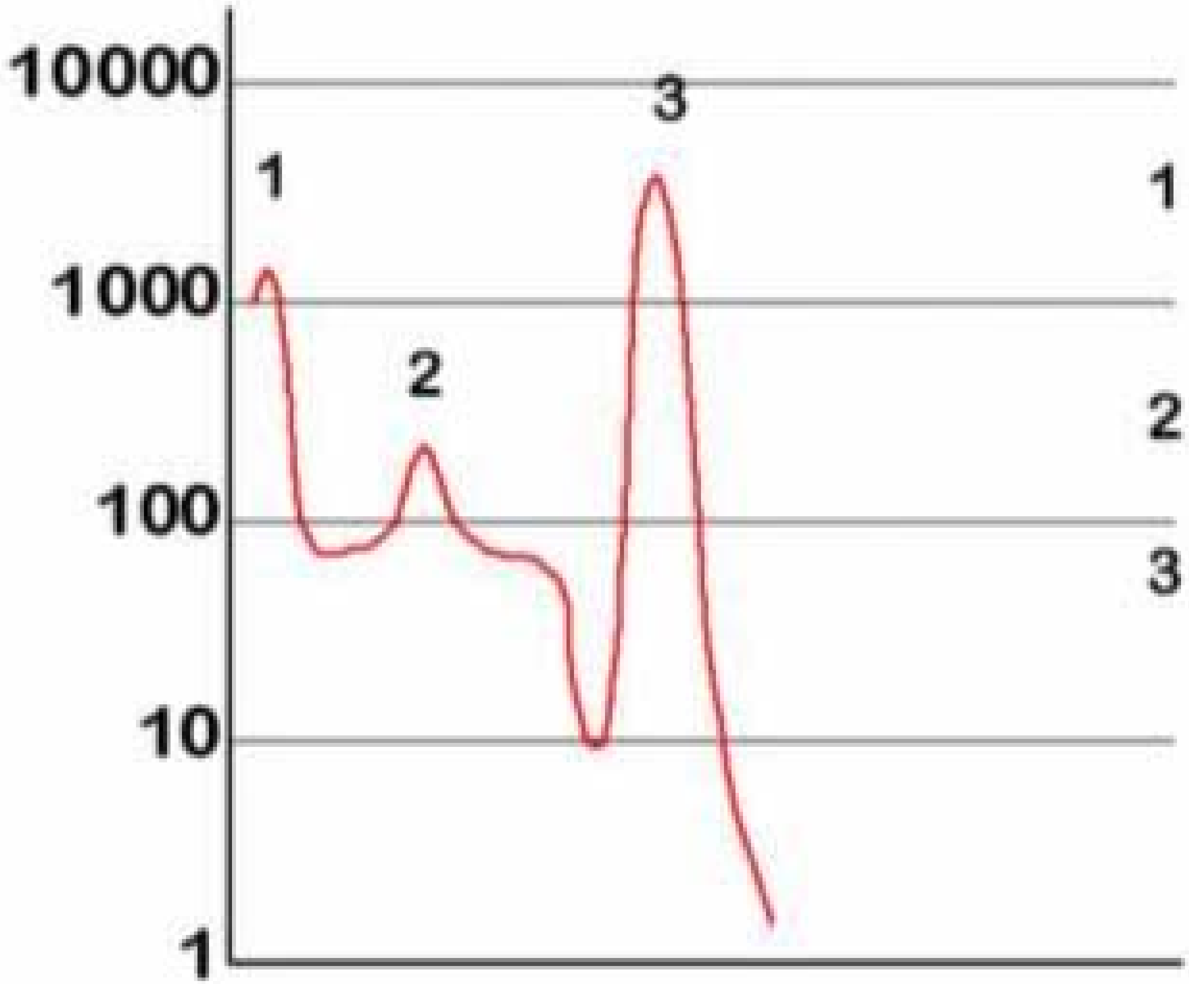
Many γ emitters are also β^- emitters.

These β^- can cause a continuous distribution of low energies being observed in your spectrum.

Bremsstrahlung



Sample spectrum, Cs-137

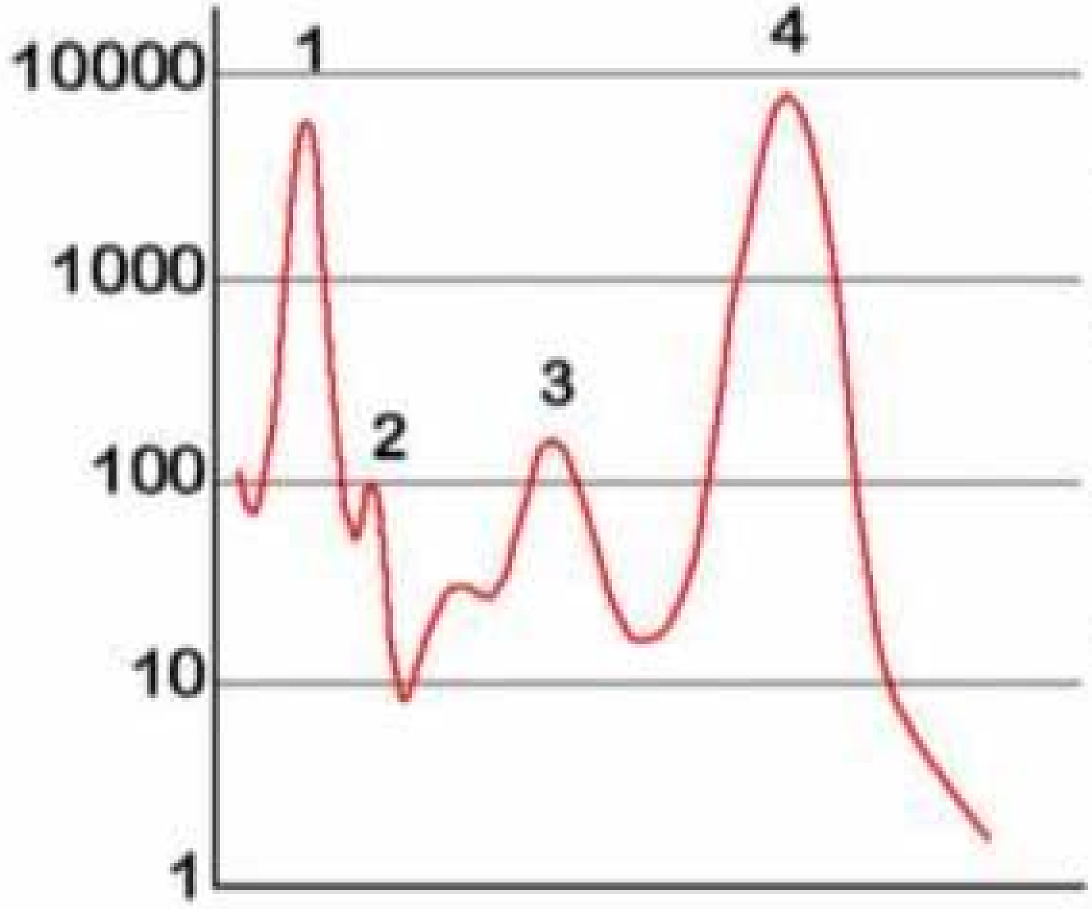


1 - 0.032 keV (Ba X-ray)

2 - backscatter

3 - 0.662 MeV photopeak

Sample spectrum, Te-132



1 - 0.028 I X-ray

2 - 0.055 MeV

3 - backscatter

4 - 0.23 MeV

Detector resolution

The resolution of your detector/counting system will determine how accurately you can qualify various isotopes.

Resolution is based on photopeak width.

We usually use the 0.662 MeV γ of Cs-137 as a reference.

Resolution = $W_{1/2}$ / P

$W_{1/2}$ = channel range at 1/2 height

P = channel of peak maximum

Detector resolution

For NaI(Tl), crystal size has a direct effect on resolution.

As crystal sizes increases,

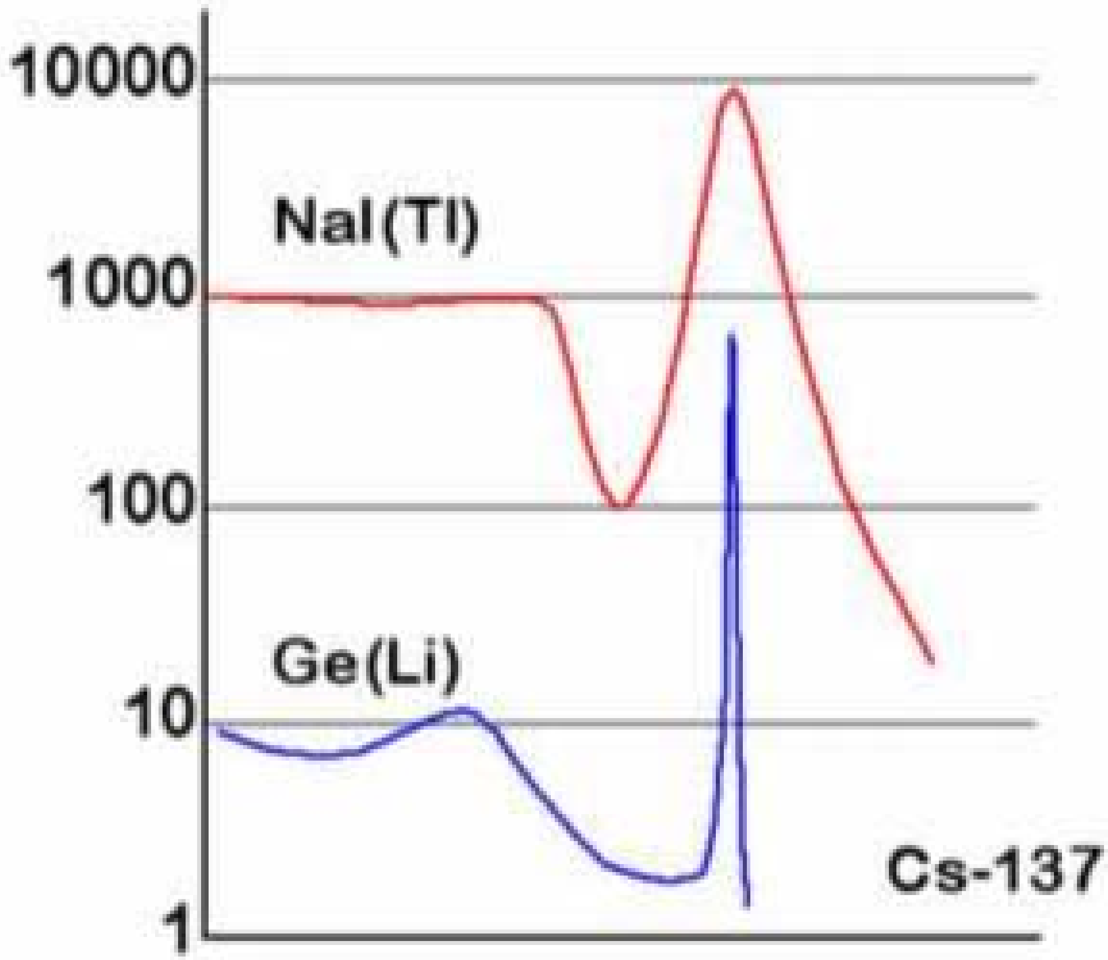
you get better absorption

the Compton is smaller

so resolution improves.

If high resolution is required, use a Ge(Li) or intrinsic Ge detector.

Ge(Li) vs NaI(Tl) resolution



Note the tradeoff.

Higher response with the NaI(Tl).

Higher resolution with a Ge(Li).

γ information

The Chart of the Nuclides only lists the most intense γ produced by an isotope.

Sources like the CRC Handbook of Chemistry give more complete γ tables.

This information can be used to estimate what a γ spectra should look like and identify potentially interfering peaks.

γ information

Construct a γ spectrum for Mg-28 based on the following information.

keV	%
32	96
350	70
391	31
950	29

γ information

Construct a γ spectrum for As-71 based on the following information.

keV	%	keV	%
ann. rad.		1051	3
630	10	1918	1
834	100	2202	4
893	2		