Extension of efficiency-curves to low and high energies

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energy range of common radionuclide standards

Now we restrict our study to calibration with physical standards, no computational calibration.

certificates of a MIX calibration standards

1.

MIX 2018-014	A (kBq)
^{241}Am	396,1
^{152}Eu	502,4
^{133}Ba	484,5
^{60}Co	980,8
^{137}Cs	696,0
ref. date:	2018-06-01

energy-range:

excluding X-ray lines: 53 keV – 1408 keV

including X-ray lines: 31 keV – to 1408 keV

considering gamma- and X-ray lines with branching ratio >1%

However efficiency-calibration is needed for lower and higher energies:

^{125}I: 27.4 keV

^{24}Na: 1368.6 keV, 2754.0 keV

2.

Nuclide	Energy [keV]	Yield [%] IAEA TECDOC 619	Expanded Uncert.[%]
Cs-137	32.1	5.540	1.60
Am-241	59.54	35.680	1.50
Cd-109	88.03	3.626	5.80
Co-57	122.1	85.510	1.40
Co-57	136.47	10.710	1.40
Ce-139	165.9	79.900	1.40
Sn-113	255.00	2.110	4.00
Cr-51	320.1	9.870	1.90
Sn-113	391.7	64.940	4.00
Sr-85	514.0	98.500	1.60
Cs-137	661.7	84.990	1.60
Y-88	898.0	93.900	1.70
Co-60	1173	99.850	1.50
Co-60	1333	99.983	1.50
Y-88	1836	99.380	1.50
		Össz.:	

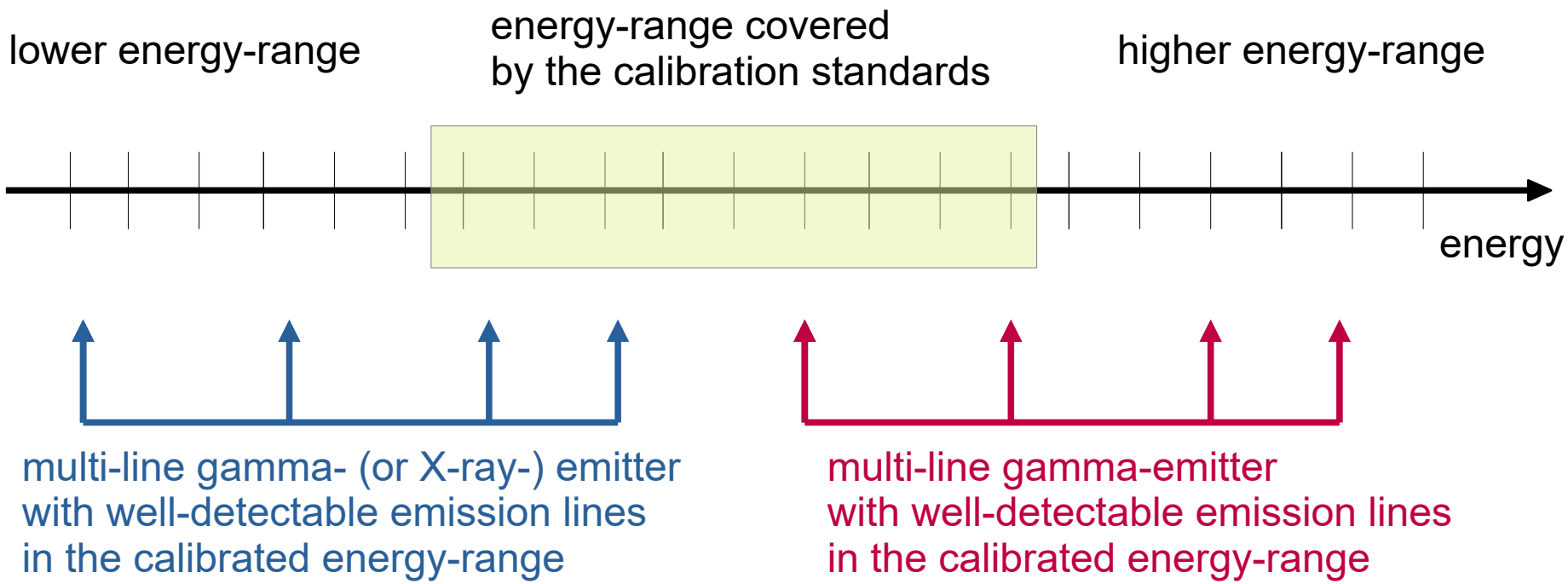
energy-range: 32 keV – 1836 keV

disadvantage:

several short-lived ($T_{½}$ < 1 year) radionuclides

→ the effective lifetime of of the standard is limited

extension of the energy-range



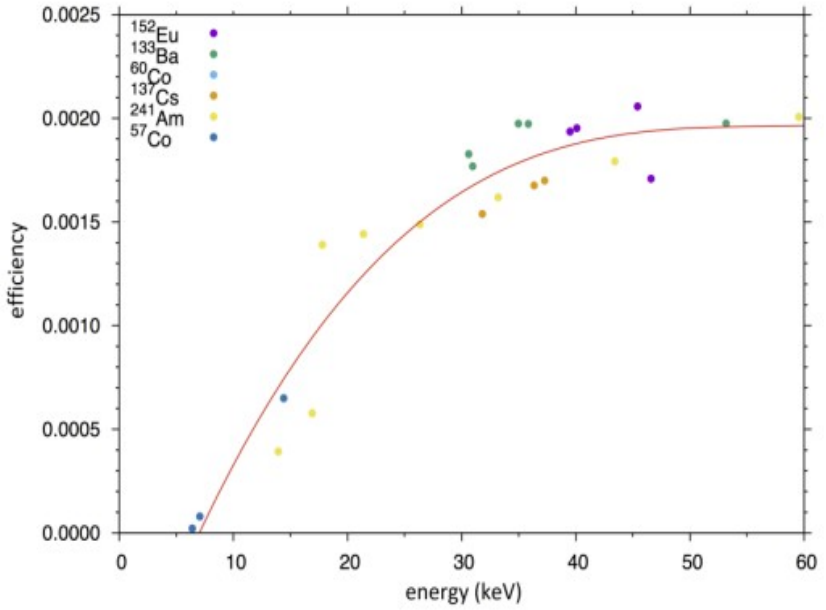
The sources used to extend energy-range should not be calibrated, only the indentical sample geometry is needed.

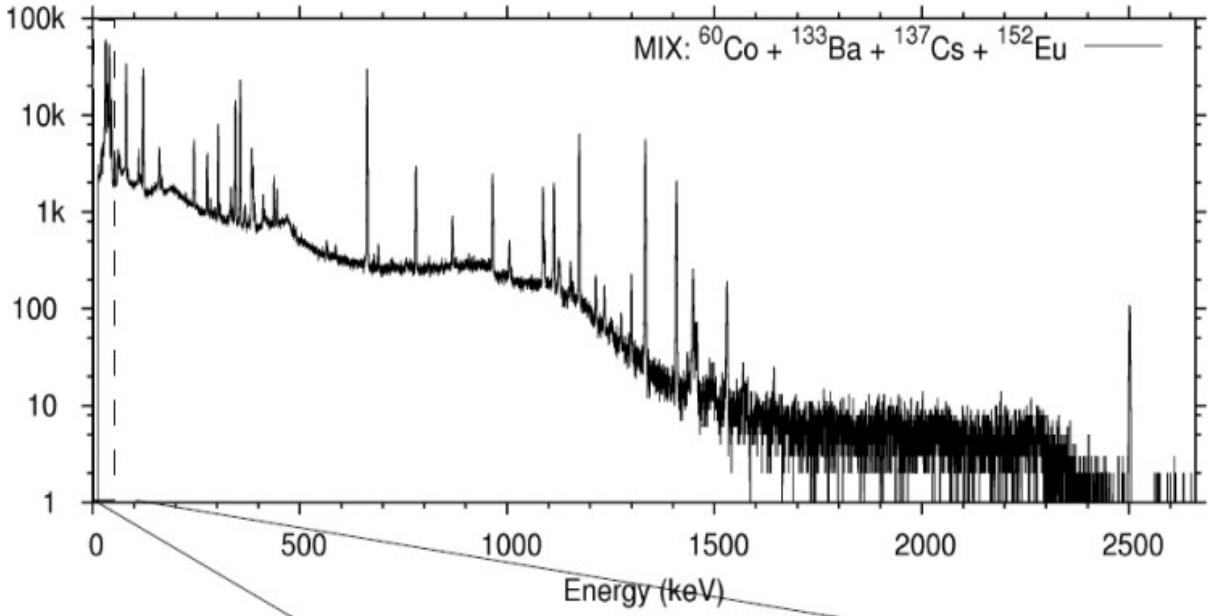
Their activity is measured based on their gamma-emission lines in the calibrated energy-range.

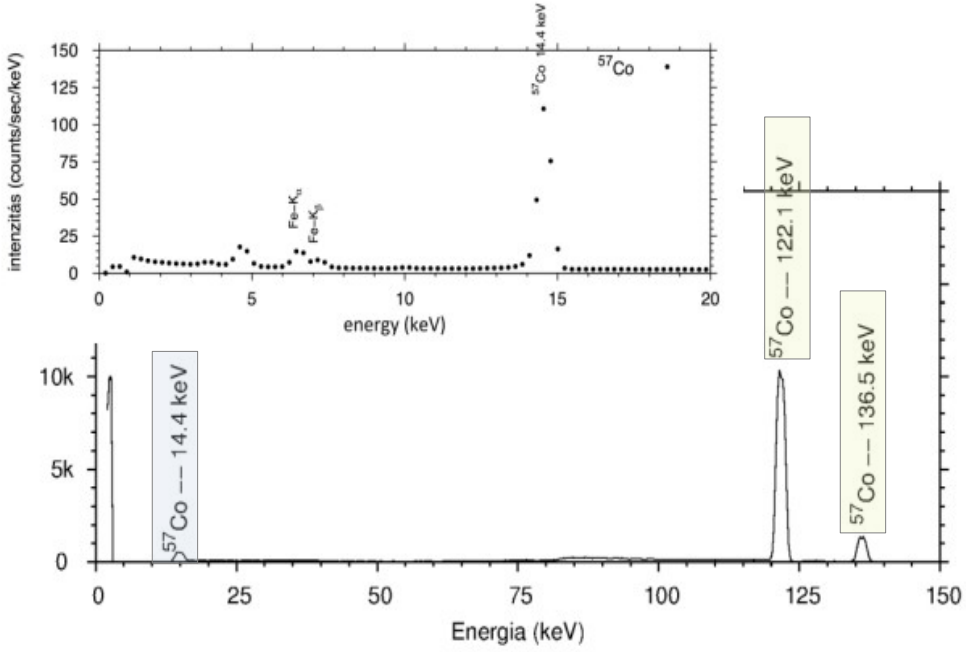
Emission intensities in the low and high energy-range are calculated based on activity and braching ratio.

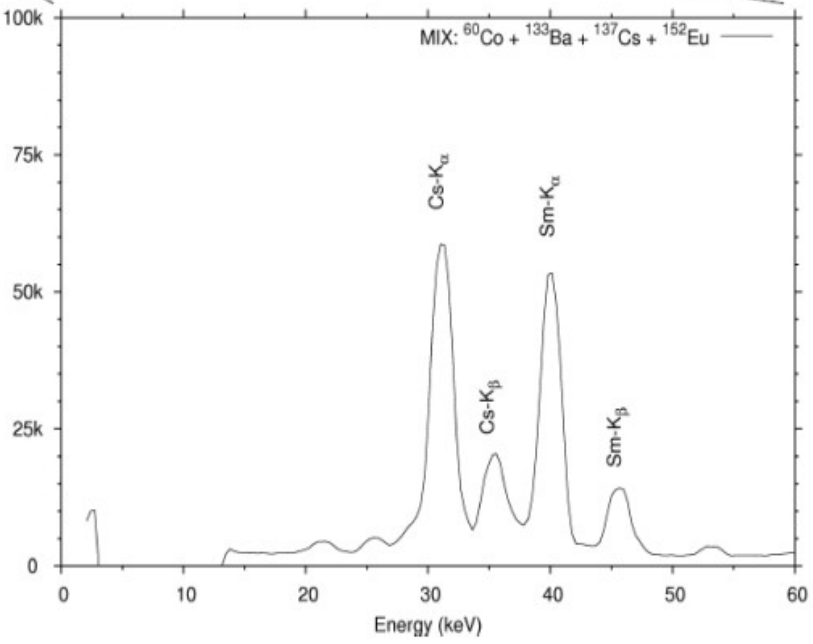
$$\text{detection efficiency: } \varepsilon = \frac{\text{detected count rate}}{\text{emitted count rate}} = \frac{\text{net peak area}}{A \times I_\gamma \times LT}$$

Extension of efficiency curve to low energies

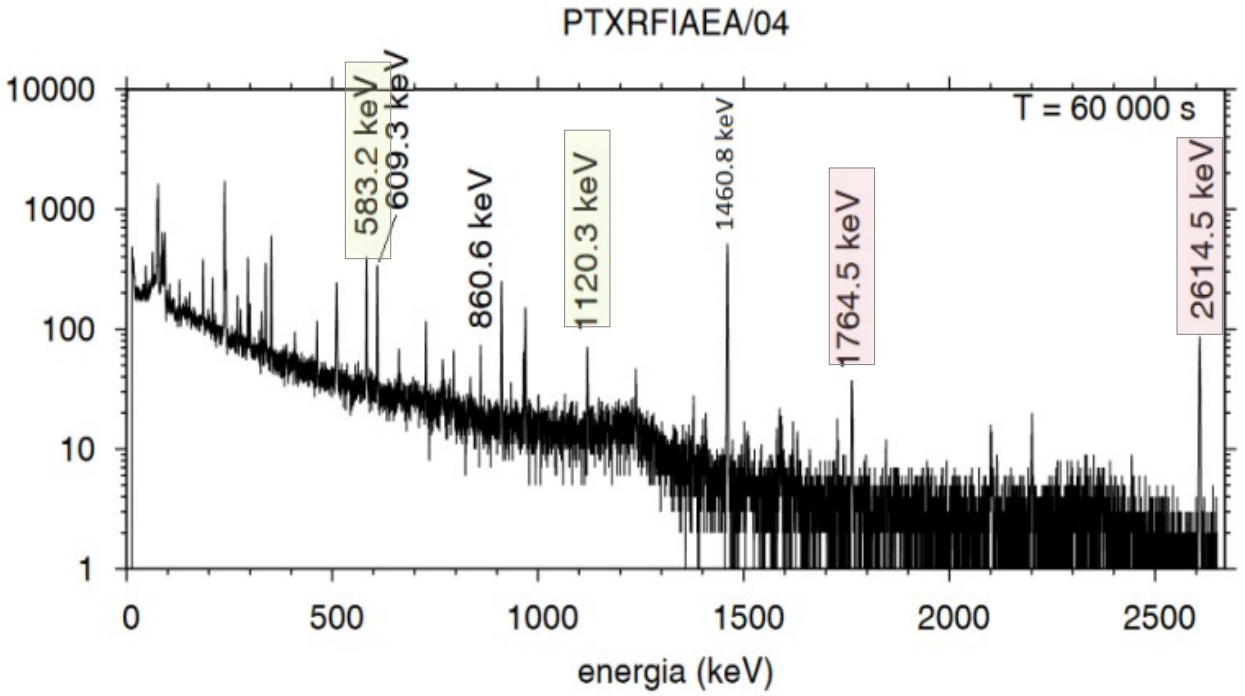








Extension of efficiency curve to high energies



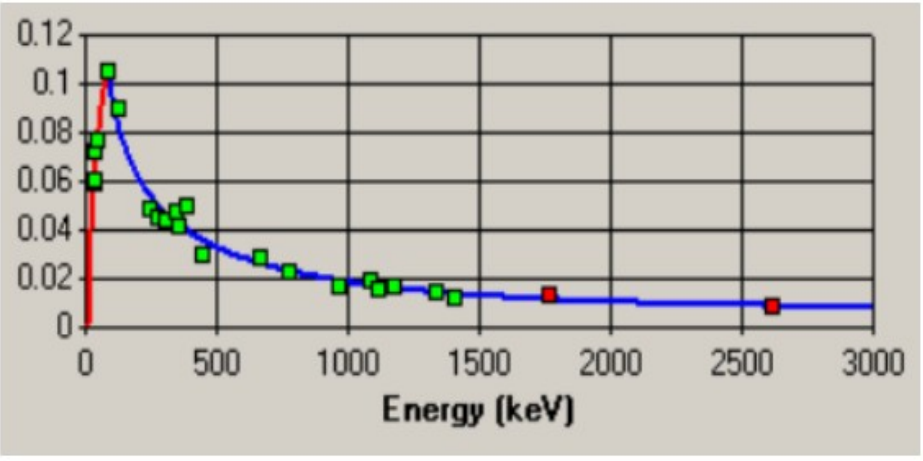
- most intense gamma-lines of the used radionuclides

(a) ^{208}Tl

	E(keV)	gyakoriság (%)
	277.4	6.3 %
	510.8	22.6%
*	583.2	84.5%
*	860.6	12.4%
→	2614.5	99%

(b) ^{214}Bi

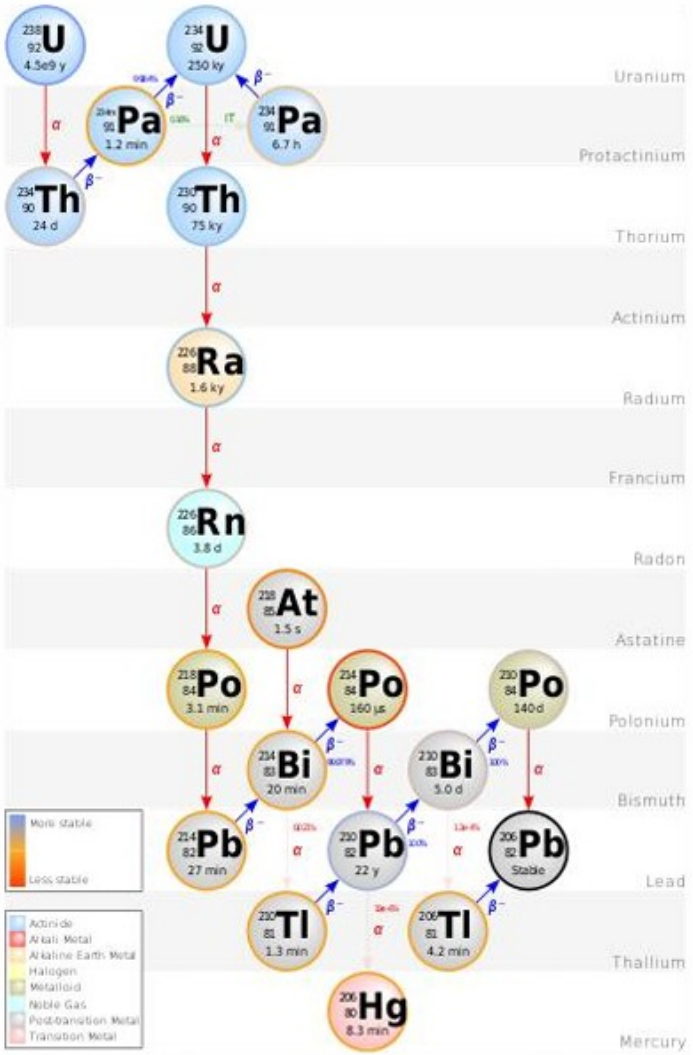
	E(keV)	gyakoriság (%)
*	609.3	46.1%
*	1120.3	15.1%
	1238.1	5.8%
→	1764.5	15.4%

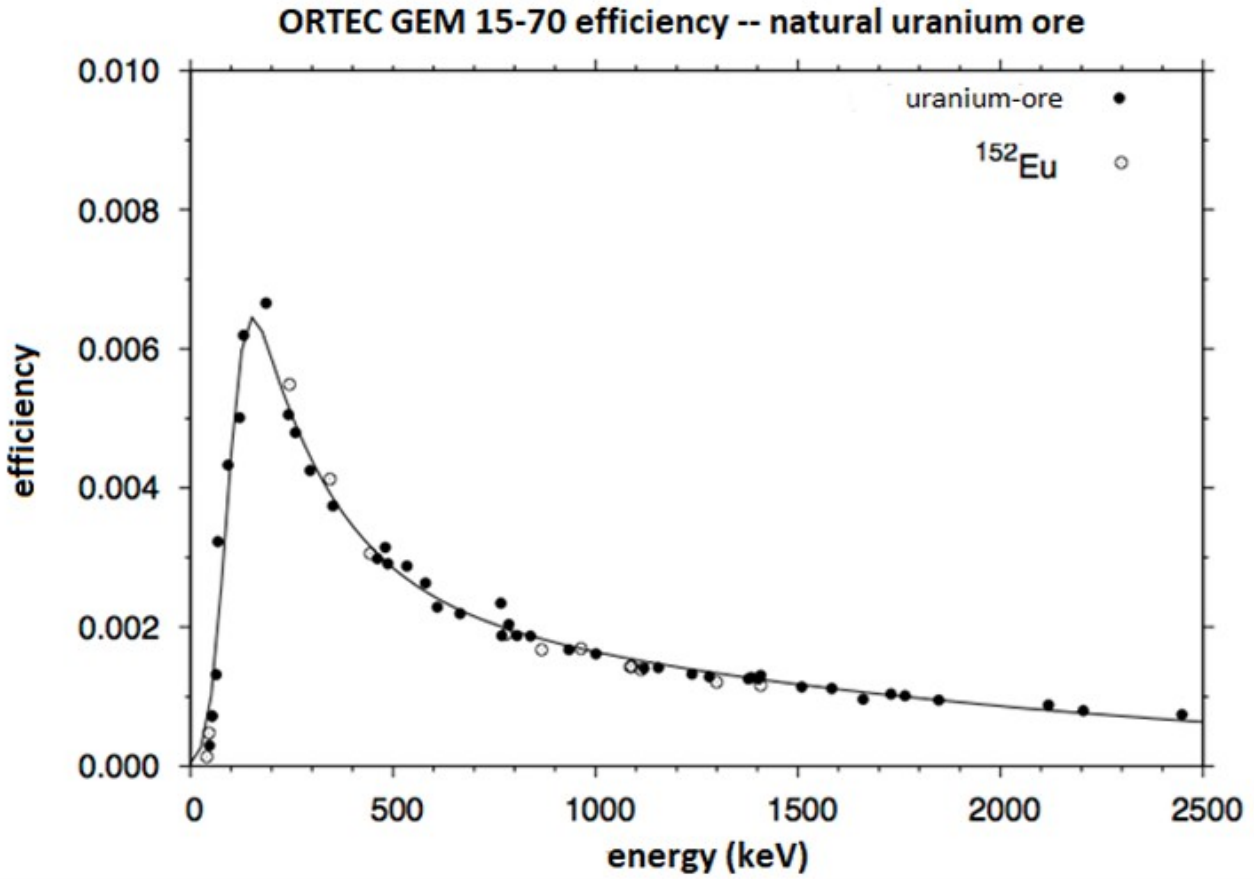


an example on wide energy-range calibration

Efficiency calibration with natural Uranium-ore: the whole ^{238}U decay chain in secular equilibrium

+^{235}U in natural abundance (0.71%)



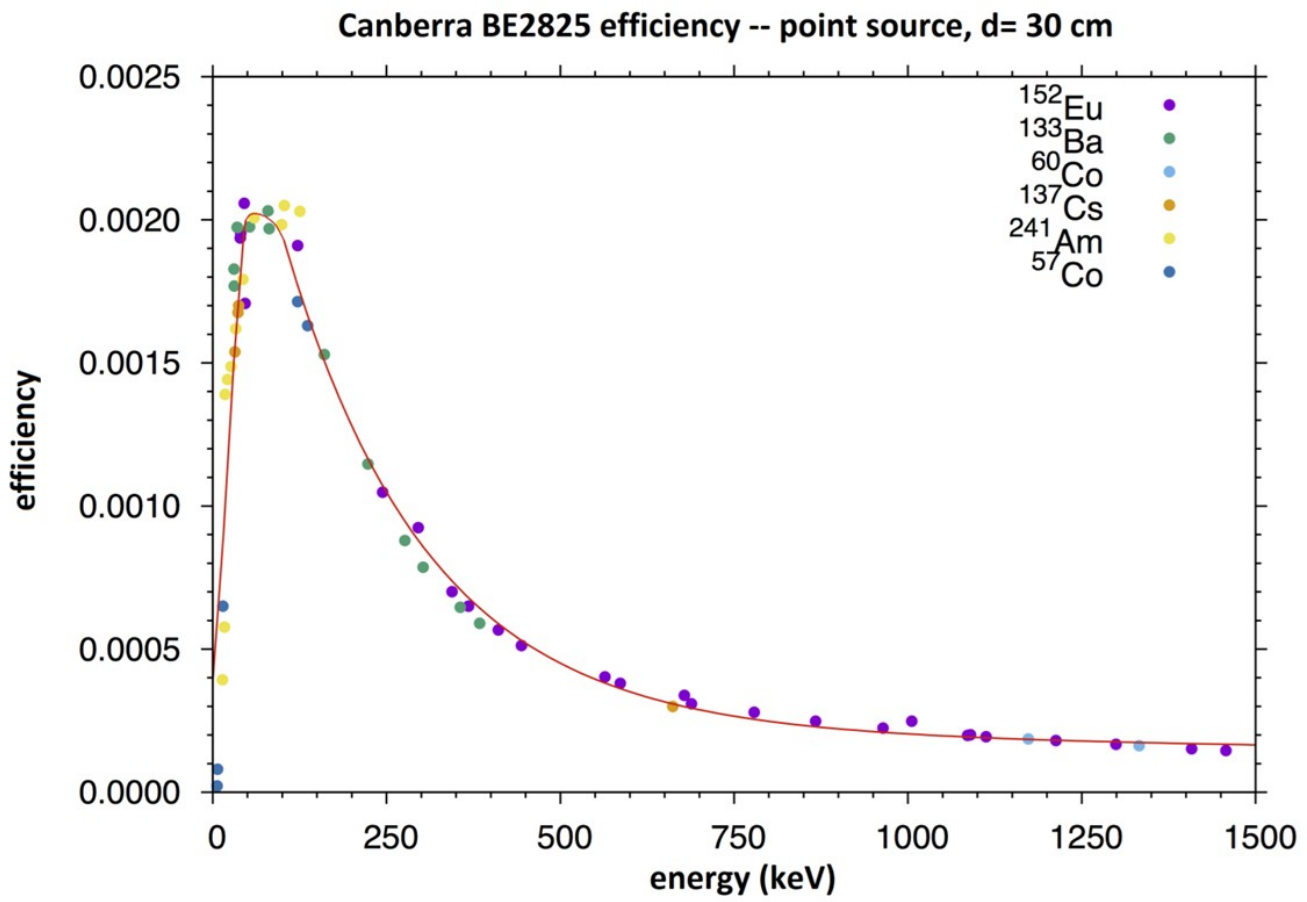


42 data points: ^{234}Th: 3, ^{234m}Pa: 2: ^{234}U:2, ^{230}Th: 1, ^{226}Ra: 1, ^{214}Pb: 5, ^{214}Bi: 14
efficiency-curve can be extended toward higher energies, up to 2447.9 keV (^{214}Bi)

without exact uranium-mass: relative effieciency curve:
extended to absolute by an additional standard (^{152}Eu)

known line overlap: ^{226}Ra 186.2 keV <-> ^{235}U 185.7 keV

Thank you for your attention!



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