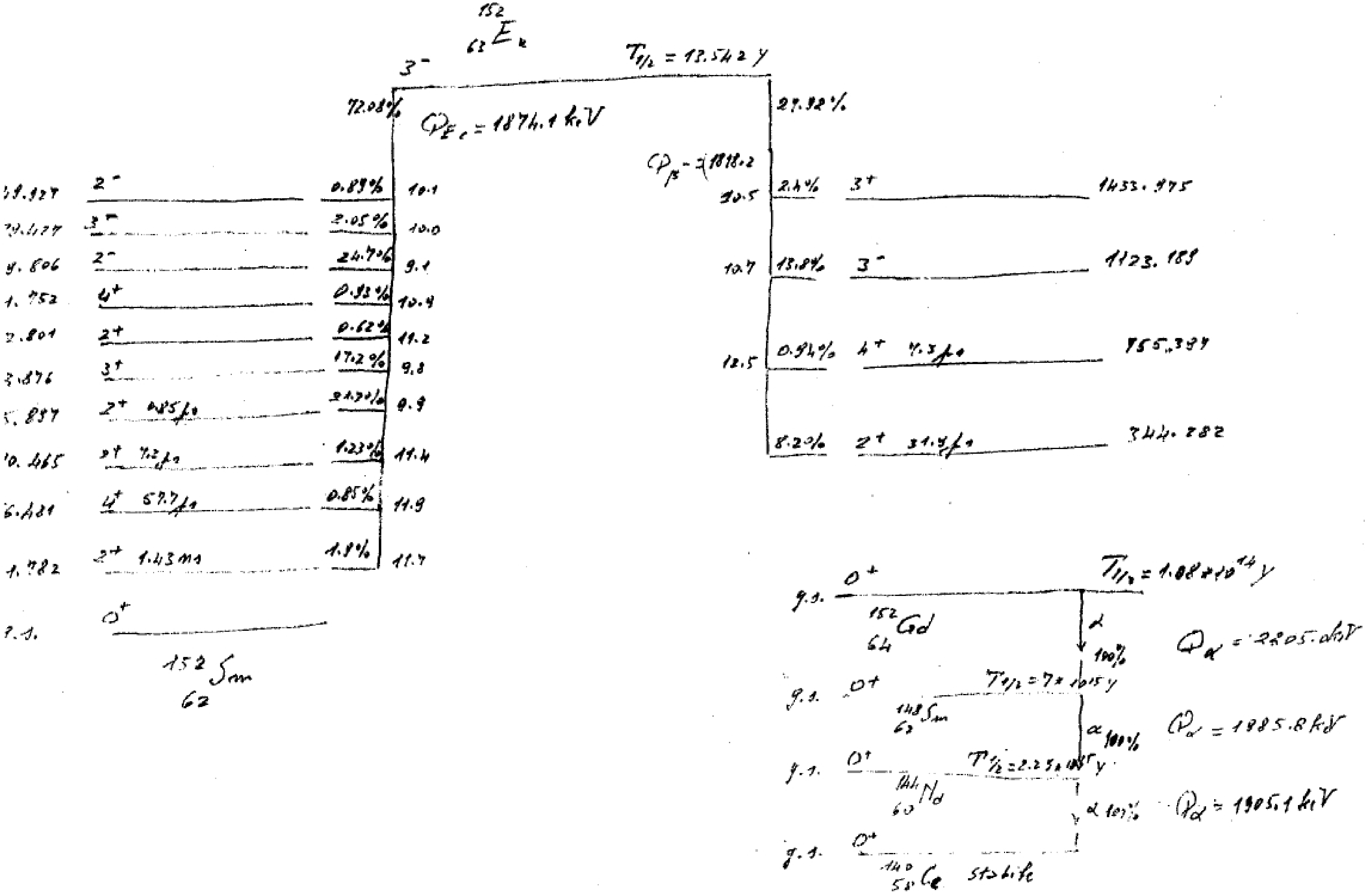

152 63 Eu
3⁻
T1/2 = 13.542 y
72.08%
QEC = 1874.1 keV
27.92%
Qβ⁻ = 1818.2
2⁻ 0.89% 10.1
3⁻ 2.05% 10.0
2⁻ 24.7% 9.1
4⁺ 0.93% 10.4
2⁺ 0.62% 11.2
3⁺ 17.2% 9.8
2⁺ 21.7% 9.9
4⁺ 0.85% 11.9
2⁺ 1.43 ns 1.9% 11.7
0⁺
152 62 Sm
3⁺ 2.4% 10.5 1433.975
3⁻ 13.8% 10.7 1123.183
4⁺ 0.94% 12.5 755.397
2⁺ 8.2% 344.282
g.s. 0⁺
152 64 Gd
α 100%
Qα = 2205 keV
148 62 Sm
Qα = 1985.8 keV
α 100%
144 60 Nd
Qα = 1905.1 keV
α 100%
140 58 Ce stable

Marinelli beaker has been specified[38] that closely fits over the endcap of the detector cryostat. Several standard sizes of Marinelli beaker are specified to accommodate samples of various volumes. With a standard geometry, the self-absorption in samples of similar composition and volume will be comparable. Some calibrated standard sources are available in Marinelli beaker form to simplify the efficiency determination for such bulk samples.

Recording of separate spectra for each source provides results that are simple to interpret, but the calibration process is then time consuming and tedious. The substitution of a single source that emits many different gamma-ray energies is a tempting alternative because only a single calibration spectrum need be recorded and analyzed. The problems of interference between multiple responses become much more severe, however, and, if precise results are to be obtained, more sophisticated methods of determining peak area must be used which take into account these interference effects. Several authors[41,64,65] suggest the use of ^{226}Ra in equilibrium with its decay products and provide tables of gamma-ray intensities per disintegration (see Table 12-3). These cover the energy range from 188 to 2446 keV and are particularly useful because a source of ^{226}Ra is often available in radioisotope laboratories. References 39 and 66 provide similar lists of gamma-ray intensities per disintegration for a number of other isotopes proposed for detector efficiency calibration. Of these, ^{152}Eu has gained recent popularity because of its convenient half-life (13 y) and the wide range of gamma-ray energies produced in its decay (see Table 12-4).

TABLE 12-4 Multiple Gamma Rays Emitted in the Decay of ^{152}Eu

Energy (keV)	Relative Intensity
121.8	141. ± 4.[a]
244.7	36.6 ± 1.1
344.3	127.2 ± 1.3
367.8	4.19 ± 0.04
411.1	10.71 ± 0.11
444.0	15.00 ± 0.15
488.7	1.984 ± 0.023
586.3	2.24 ± 0.05
678.6	2.296 ± 0.028
688.7	4.12 ± 0.04
778.9	62.6 ± 0.6
867.4	20.54 ± 0.21
964.0	70.4 ± 0.7
1005.1	3.57 ± 0.07
1085.8	48.7 ± 0.5
1089.7	8.26 ± 0.09[b]
1112.1	65.0 ± 0.7
1212.9	6.67 ± 0.07
1299.1	7.76 ± 0.08
1408.0	100.0 ± 1.0
1457.6	2.52 ± 0.09

[a] In order to use this line, no ^{154}Eu should be present.

[b] Not intended for use in calibrations because of the proximity to the more intense nearby energy.

Source: Data taken from Gehrke et al.[66]

Sorgente a emissione $^{241}Am - ^{244}Cm$

4. Alpha spectrometry source

energie

4.1 General Information

KK 864

Traceability

The sources are traceable to standards held by national laboratories such as the Physikalisch-Technische Bundesanstalt (Germany), the National Physical Laboratory (UK), the National Institute of Standards and Technology (USA) the Laboratoire Primaire des Rayonnements Ionisants (France), and many other national laboratories world-wide. Further details are given in section 9.1.

Recommendations on source handling

To maintain the accuracy of measurements, these sources must be handled with care. Sources should be handled with tweezers to avoid leaving grease on the surface of the source, which would degrade the spectrum. The sources must not be cleaned with abrasive compounds such as metal polish, as this would remove the active deposit. The sources should be kept in their storage boxes when not in use.

Tolerances

The maximum deviation of the measured activity at the reference time from the nominal value is +/-30%.

Quality assurance

The sources are calibrated at AEA Technology QSA's DKD accredited measurement laboratory in Germany. The manufacturing facility operates a quality management system which has been independently audited and approved to ISO9001:1994.

Availability

The sources are normally delivered within 4-6 weeks from receipt of order.

4785.509

Reference date 08/12/05

Half life Intensity(Bq)

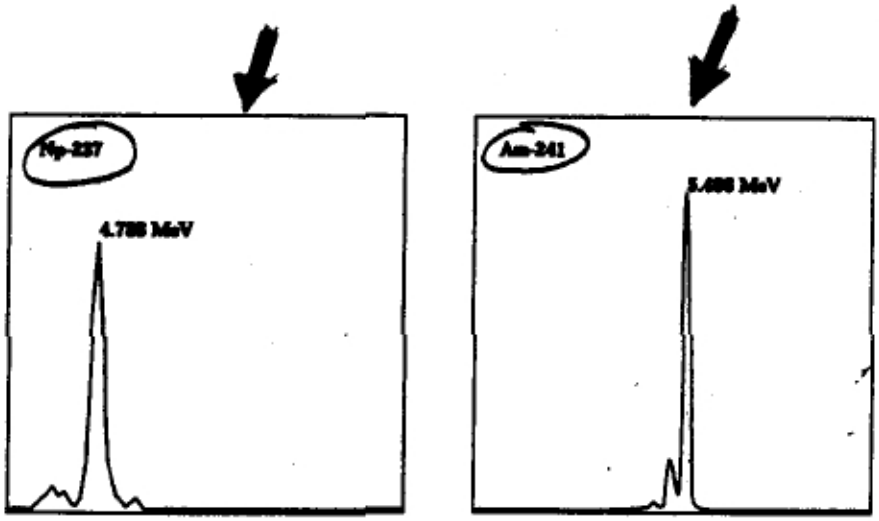
Selection chart

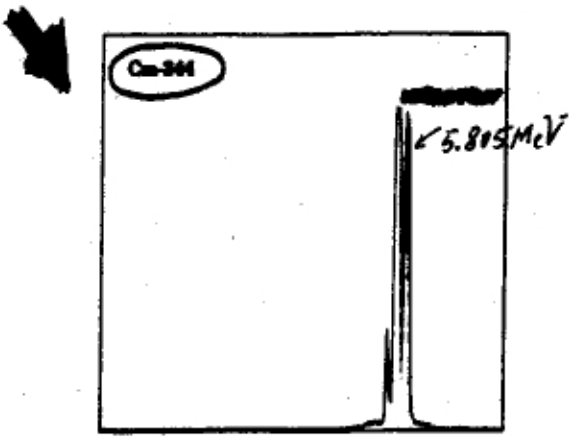
Radionuclide	Alpha particle energy [MeV]	Intensity [%]
2.14×10⁶ y 150 ⇒ Np-237	~~4.660~~ 4644	~~6.2~~ 5.9
	~~4.765~~ 4769.3	~~8.6~~ 14.3
	~~4.772~~ 4774.2	~~25.0~~ 38.1
	~~4.788~~ 4789.85	~~47.0~~ 47.6
	4824.1	0.9
~~Pu-238~~	~~5.456~~	~~11.5~~
	~~5.499~~	~~28.9~~
	~~5.545~~	~~71.1~~
432.2 y 100 ⇒ Am-241	5.388 6442.8	1.4 13.2
	5.445 5485.56	12.8 85.1
	~~5.486~~	~~85.2~~
Pu-238	5.456	28.3
	5.499	71.6
18.10 y 100 ⇒ Cm-244	5.763 5762.16	~~23.5~~ 23.6
	~~5.800~~ 5804.77	~~76.7~~ 76.4

0.3089

To help select the source needed, the energies and intensities of the most intense alpha particles emitted by the different nuclides are shown in the table.

4.2 Reference sources





Ordering information

Radionuclide	Nominal activity	Energy of most intense alpha particle [MeV]	Product code uncalibrated [1]	Product code calibrated [2]
Am-241	50 Bq	5.486	AMR11	AMR21
Am-241	500 Bq	5.486	AMR12	AMR22
Am-241	5000 Bq	5.486	AMR13	AMR23
Am-241	40000 Bq	5.486	AMR14	not available
Pu-238	1000 Bq	5.499	PPRB2505	PPRB2497
Pu-239	1000 Bq	5.155	PIRB2506	PIRB2498
Cm-244	1000 Bq	5.805	CLRB2507	CLRB2499
mixed nuclide				
Pu-239	1000 Bq	5.155	QCRB2508	QCRB2500 [3]
Am-241	1000 Bq	5.486		
Cm-244	1000 Bq	5.805		
mixed nuclide				
Np-237	150 Bq	4.788	QCRB4020	QCRB4021 [3]
Am-241	100 Bq	5.486		
Cm-244	100 Bq	5.805		

1) For energy calibration only - no certificate of calibration is included
2) For energy and efficiency calibration - certificate of calibration included
3) The certificate of calibration states the total α emission rate and the nominal activities of individual radionuclides

size, the accuracy of [redacted] One major difficulty is that the dimensions of these detectors are not standardized to any degree, and it is very difficult to determine precisely their active volume. Furthermore, long-term changes in charge collection efficiency and/or window thickness can lead to drifts in the detector efficiency over periods of time.

For these reasons, users will normally carry out their own periodic efficiency calibrations of their germanium detectors using sources calibrated by some other means. Any error in assumed detector dimensions will then apply both to the calibration and actual measurements and will not affect the accuracy of activity measurements. The source–detector distance still must be accurately measured and reproduced to avoid errors in the relative solid angle. The calibration is normally carried out for an assortment of gamma-ray energies covering the range of interest to allow construction of an empirical efficiency versus energy curve.

Many of the national standards laboratories will provide isotopes whose gamma ray emission rates have been calibrated to a precision ranging from 0.5 to 2%. Single isotope sources provide a few well-separated gamma-ray peaks whose area can be determined by simple methods to calibrate the detector efficiency. If the energy scale must extend over a relatively wide range, multiple sources must be used, either sequentially or in combination. Table 12-2 lists radionuclides used for efficiency calibrations, together with decay data necessary to compute gamma-ray yields from absolute activity.

Standard calibration sources are available as small deposits on thin backing material, so that they may closely approximate nonabsorbing point sources. However, radioactive samples to be measured often have non-negligible volume and mass, and gamma rays can be attenuated by self-absorption within the sample material itself. In such cases, correction must be made for this attenuation if an accurate determination of the gamma ray emission rate from the entire sample is needed. To aid in the calibration of large-volume samples, typically of water solutions or soil, a standard sample container called a

TABLE 12-3 Gamma Rays Emitted by ^{226}Ra in Equilibrium with its Daughters[a]

Isotope	Gamma-Ray Energy (keV)	Relative Intensity
^{226}Ra	186.211 ± 0.010	9.00 ± 0.10
^{214}Pb	241.981 ± 0.008	16.06 ± 0.19
^{214}Pb	295.213 ± 0.008	42.01 ± 0.53
^{214}Pb	351.921 ± 0.008	80.42 ± 0.81
^{214}Bi	609.312 ± 0.007	100 ± 0.92
^{214}Bi	768.356 ± 0.010	10.90 ± 0.15
^{214}Bi	934.061 ± 0.012	6.93 ± 0.10
^{214}Bi	1120.287 ± 0.010	32.72 ± 0.39
^{214}Bi	1238.110 ± 0.012	12.94 ± 0.17
^{214}Bi	1377.669 ± 0.012	8.87 ± 0.15
^{214}Bi	1509.228 ± 0.015	4.78 ± 0.09
^{214}Bi	1729.595 ± 0.015	6.29 ± 0.10
^{214}Bi	1764.494 ± 0.014	34.23 ± 0.44
^{214}Bi	1847.420 ± 0.025	4.52 ± 0.09
^{214}Bi	2118.551 ± 0.030	2.53 ± 0.05
^{214}Bi	2204.215 ± 0.040	10.77 ± 0.20
^{214}Bi	2447.860 ± 0.100	3.32 ± 0.08

[a]Only the strongest transitions are shown. Energies are measured relative to an assumed 411.794 keV gamma ray from ^{198}Au. Quoted errors do not include any error contribution from this reference standard.

Source: Zobel et al.[41]

Série naturelle 238 U

Sorgente ^{137}Cs elettroni di conversione

1) $37\ kBq$ al $17/11/2005 \Rightarrow 37\ kBq\ e^{-\frac{2.25}{30.07\ ln 2}} = 37\ kBq * 0.943$

2) β branch 0.944

3) elettroni conversione
dr pg. F-23 Table of Isotopes

$\alpha = \frac{I_e}{I_\gamma}\ (M_4, 660\ keV, Z_{Cs} = 55) \simeq 0.112$

$I_e + I_\gamma = I_e + \frac{I_e}{0.112} = 1\ ;\ 1.112\ I_e = 0.112\ ;\quad I_e = 0.1007$

4) Backscattering $- 0.85$

5) Angolo solido $\frac{S}{4\pi R^2} \simeq \frac{150\ mm^2}{4\pi * 3600\ mm^2} = 3.316 * 10^{-3}$

$I_e\ (c/s) = 37.000 * 0.944 * 0.944 * 0.1007 * 0.85 * 3.316 * 10^{-3} = 9.11\ c/s$

Sperimentale 7035 ± 173 in 732 s

$I_{e\ sper} = (9.61 \pm 0.24)\ c/s$

Sorgente ^{60}Co HV 734 — BaF_2 15×15

397 kBq 1 Gennaio 2006 $T_{1/2} = 5.27\,y$; $\tau = 7.60 \times 365 = 2.775 \times 10^3\,d$

$t - t_0 = 2.496\,d$

Attività (6 Marzo 2008) $= 397\,kBq \times e^{-\frac{736}{2775}} = 298\,kBq$

Geometria: $\frac{\pi}{4} d^2 \frac{1}{4\pi l^2} = \frac{1}{16}\left(\frac{d}{l}\right)^2 = \frac{1}{16}\left(\frac{15}{100}\right)^2 = 1.406 \times 10^{-3}$

$\eta_{\text{eff. fotopicco totale}}(1332\,keV)_{\text{a 10 cm}} = \frac{I/T \quad c/o}{2.98 \times 10^5\ c/o} = 2.54 \times 10^{-5}$

$\eta_{\text{eff. fotop. intrinseca}}(1332\,keV)_{\text{a 10 cm}} = \frac{I/T}{2.98 \times 10^5 \times 1.406 \times 10^{-3}} = \frac{I/T}{419\ c/o} = 1.8 \times 10^{-2}$ (8053/1062)

Sorgente ^{22}Na

370 kBq Febbraio 2003 $T_{1/2} = 2.6\,y$; $\tau = 3.75$

Attività (6 Marzo 2008) $= 370\,kBq \times e^{-\frac{5}{3.75}} = 97.5\,kBq$

Geometria $= 1.406 \times 10^{-3}$

$\eta_{\text{eff. fotopicco totale}}(1274\,keV)_{\text{a 10 cm}} = \frac{I(1274)/T}{9.175 \times 10^4\ c/o} = 3.78 \times 10^{-5}$ (4123/1117, 3.6 h)

$\eta_{\text{eff. fotop. intrinseca}}(1274\,keV) = \frac{I/T}{137.1} = 2.63 \times 10^{-2}$ (3.6 h)

Sorgente ^{137}Cs

421 kBq 1 Gennaio 2006 $T_{1/2} = 30.07\,y$; $\tau = 43.38\,y$

Attività (6 Marzo 2008) $= 421\,kBq\ e^{-\frac{2.17}{43.38}} = 400.5\,kBq$; Attività $\gamma = 321.4\,kBq$

Geometria $= 1.406 \times 10^{-3}$

$\eta_{\text{eff. fotop. totale}}(661.6) = \frac{I\,T}{3.214 \times 10^5\ c/o} = 1.3 \times 10^{-4}$ (45160/3580, 42.1 h) ; $\eta_{\text{eff. fotop. intrinseca}}(661.6) = \frac{I/T}{451.9\ c/o} = 9.3 \times 10^{-2}$ (42.1 h)