Appendix B. Reported Uncertainties

The following tables include the uncertainties on the individual measurement results, as reported by the participants in the CCRI(II)-K2.Ge-68 comparison. Unless otherwise noted, uncertainties are relative standard uncertainties in percent.

Table 1. Uncertainty budget for ANSTO 4π(LS)β-γ coincidence (4P-LS-PO-NA-GR-CO).

QUANTITY *Q*	Relative uncert. of *Q*	Relative uncert. of act. conc.	Type (A/B)	Comment
counting statistics	0.06	0.03	A	Statistical analysis of 4 values
weighing	0.1	0.1	B	Weighing and solution handling
background	2.3	0.05	A	Statistical variation in background, mostly for the gamma channel
dead/live time	0.05	0.05	B	Variation of applied dead time and resolving time
extra-/inter-polation of efficiency curve	0.2	0.2	B	Extrapolation to efficiency = 1; variation of points included
decay correction	0.096	0.075	B	Uncertainty in half-life
adsorption	10	0.017	B	To ampoule
β+ / EC branching ratio	0.42	0.42	B	Mostly due to uncertainty in evaluated positron branching ratio
Correction for detection of 1077 keV γ-rays in gamma channel	0.1	0.1	B	Uncertainty in detection efficiency and decay scheme parameters
Correction for detection of 1077 keV γ-rays in LS channel	0.2	0.2	B	Uncertainty in detection efficiency and introduced non-linearity
Combined uncertainty		0.54		

Table 2. Uncertainty budget for ANSTO Triple-to-Double Coincidence Ratio efficiency calculation (4P-LS-MX-00-00-TD).

QUANTITY *Q*	Relative uncert. of *Q*	Relative uncert. of act. conc.	Type (A/B)	Comment
counting statistics	0.05	0.05	A	Statistical analysis of 25 values
weighing	0.1	0.1	B	Balance calibration, weighing and preparation of dilution
background	2.3	0.03	A	Background square root statistics
dead/live time	20	0.1	B	τ_D = 50 ± 10 µs
resolving time	17	0.15	B	τ_R = 60 ± 10 ns
decay data	0.47	0.38	B	Variation of decay scheme parameters according to evaluated decay data
decay correction	0.096	0.055	B	uncertainty in half-life
impurities				none detected
adsorption	10	0.017	B	to ampoule
efficiency dependence	0.4	0.4	B	efficiency dependence on activity concentration
adsorption	50	0.12	B	to scintillation vial
Combined uncertainty		0.61		

Table 3. Uncertainty budget for LNMRI/IRD 4πβ(LS)-γ Anticoincidence counting (4P-LS-PO-NA-GR-AC).

QUANTITY *Q*	Relative uncert. of *Q*	Relative uncert. of act. conc.	Type (A/B)	Comment
counting statistics	21	0.21	A	Standard deviation
weighing	5	0.05	B	The uncertainty was estimated based on the calibration of our Mettler XP56 balance, taken from the Certificate, in weighing range. For 10 mg mass the uncertainty was estimated in 0.10 %.
background	5.8	0.06	B	
dead/live time	1	0.01	B	Estimated standard uncertainty of live time
decay data	13	0.13	B	Estimated by using branching ratio from LNHB Table of Radionuclides
extra-/inter-polation of efficiency curve	45	0.45	A	Estimation of standard uncertainty of 15 extrapolated values
decay correction	2.5	0.025	B	Estimated by using the propagation of the uncertainty of half-life of (Ge+Ga)-68 over the measurement decay interval
Detection of 1077 keV gamma-ray	10	0.1	B	Estimated by using a Co-60 source
Combined uncertainty		0.53		

Table 4. Uncertainty budget for LNMRI/IRD 4πβ(LS)-γ coincidence counting (4P-LS-PO-NA-GR-CO).

QUANTITY *Q*	Relative uncert. of *Q*	Relative uncert. of act. conc.	Type (A/B)	Comment
counting statistics	25	0.25	A	Included in the fit procedure
weighing	10	0.1	B	The uncertainty was estimated based on the calibration of our Mettler XP56 balance, taken from the Certificate, in weighing range. For 10 mg mass the uncertainty was estimated in 0.10 %
background	5	0.05	B	
dead/live time	1.6	0.016	B	Estimated standard uncertainty of experimentally determination of dead time by two oscillator method
resolving time	9	0.09	B	Estimated standard uncertainty of experimentally determination of resolving time by accidental coincidence method
Gandy effect	5	0.05	B	Estimated by obtaining a beta-gamma time spectrum using a time-to- amplitude converter. The FWHM of the spectrum is used for the calculation of Gandy effect.
decay data	13	0.13	B	Estimated by using branching ratio from LNHB Table of Radionuclides
extra-/inter-polation of efficiency curve	32	0.32	A	Estimation of standard uncertainty of 7 extrapolated values
decay correction	0.49	0.0049	B	Estimated by using the propagation of the uncertainty of half-life of (Ge+Ga)-68 over the measurement decay interval
Detection of 1077 keV gamma-ray	10	0.1	B	Estimated by using a Co-60 source
Combined uncertainty		0.59		

Table 5. Uncertainty budget for NIM CIEMAT/NIST method using H-3 as a tracer (4P-LS-MX-00-00-CN).

QUANTITY *Q*	Relative uncert. of *Q*	Relative uncert. of act. conc.	Type (A/B)	Comment
counting statistics		0.04	B	
weighing		0.05	B	
background		0.003	B	
dead/live time		0.06	B	
decay data		0.57	B	Estimated uncertainty by CN2003 calculations
quenching		0.09	B	Estimated uncertainty of tSIE
tracer		0.27	B	Estimated uncertainty due to 0.70 % uncertainty in H-3 standard activity
extra-/inter-polation of efficiency curve		0.2	B	
decay correction		0.06	B	
Combined uncertainty		0.68		

Table 6. Uncertainty budget for NIM TDCR method (4P-LS-MX-00-00-TD).

QUANTITY *Q*	Relative uncert. of *Q*	Relative uncert. of act. conc.	Type (A/B)	Comment
counting statistics		0.08	A	
weighing		0.15	B	weighing repeatability and source dispersion
background		0.04	A	arising from the variation
dead/live time		0.01	B	
decay data		0.35	B	Effect from input of atomic and nuclear data and model
decay correction		0.15	B	
dilution factor		0.1	B	
defocusing		0.04	B	PMT efficiencies variation arising from defocusing
kB		0.05	B	
Combined uncertainty		0.43		

Table 7. Uncertainty budget for LNE-LNHB 4π(SL)β-γ coincidence counting (4P-LS-BP-NA-GR-AC).

QUANTITY *Q*	Relative uncert. of *Q*	Relative uncert. of act. conc.	Type (A/B)	Comment
counting statistics		0.15	A	6 liquid sources (UG)
Weighing		0.1	B	
Background		0.05	B	
dead/live time		0.01	B	Live time technique
decay data		0.46	B	Due to the threshold in the beta-channel
extra-/inter-polation of efficiency curve		0.08	A	Variation of the beta-efficiency performed by defocusing the photomultipliers
decay correction		0.02	B	
Combined uncertainty		0.5		

Table 8. Uncertainty budget for LNE-LNHB TDCR method (4P-LS-BP-00-00-TD).

QUANTITY *Q*	Relative uncert. of *Q*	Relative uncert. of act. conc.	Type (A/B)	Comment
counting statistics	0.02	0.02	A	experimental std deviation
weighing	0.1	0.1	B	
background	3	1.00E-04	A	
dead/live time	0.05	0.05	B	
resolving time	0.1	0.1	B	
pile-up	0.01	0.01	B	
decay data	0.4	0.4	B	
quenching	0.1	0.1	B	
decay correction	0.07	0.07	B	
Combined uncertainty		0.5		

Table 9. Uncertainty budget for LNE-LNHB 4π(Cherenkov)β-γ coincidence counting (4P-CD-BP-NA-GR-AC).

QUANTITY *Q*	Relative uncert. of *Q*	Relative uncert. of act. conc.	Type (A/B)	Comment
counting statistics		0.12	A	12 liquid sources filled with aqueous solutions
weighing		0.1	B	
background		0.05	B	
dead/live time		0.01	B	Live time technique
decay data		0.46	B	Due to the Cherenkov threshold in the beta-channel
extra-/inter-polation of efficiency curve		0.1	A	Variation of the beta-efficiency performed by defocusing the photomultipliers
decay correction		0.02	B	
Combined uncertainty		0.5		

Table 10. Uncertainty budget for PTB 4π(Cherenkov)β-γ Coincidence Counting (4P-CD-BP-NA-GR-CO) with double coincidences in the beta channel, stated as standard uncertainties.

QUANTITY *Q*	Relative uncert. of *Q*	Relative uncert. of act. conc.	Type (A/B)	Comment
counting statistics	0.0016	0.00026	A	correlations were taken into account
weighing	0.000082	0.000083	B	
background	0.19	0.000105	A	correlations were taken into account
dead/live time	0.002	0.00208	B	
resolving time	0.002	0.00208	B	
extra-/inter-polation of efficiency curve	0.0053	0.0053	B	
decay correction	0.00065	0.00065	B	
impurities				no impurities
adsorption				not tested
branching ratio	0.0047	0.0047	B	
dilution factor	0.000074	0.000074	B	
sample geometry	0.002	0.00208	B	
Combined uncertainty		0.0080		

Table 11. Uncertainty budget for PTB 4π(Cherenkov)β-γ Coincidence Counting (4P-CD-BP-NA-GR-CO) with triple coincidences in the beta channel, stated as standard uncertainties. Adopted as uncertainty on single value.

QUANTITY *Q*	Relative uncert. of *Q*	Relative uncert. of act. conc.	Type (A/B)	Comment
counting statistics	0.0018	0.00013	A	correlations were taken into account
weighing	0.000082	0.000083	B	
background	0.23	0.000105	A	correlations were taken into account
dead/live time	0.002	0.00208	B	
resolving time	0.002	0.00208	B	
extra-/inter-polation of efficiency curve	0.0043	0.0043	B	
decay correction	0.00065	0.00065	B	
impurities				no impurities
adsorption				not tested
branching ratio	0.0047	0.0047	B	
dilution factor	0.000074	0.000074	B	
sample geometry	0.0044	0.0044	B	
Combined uncertainty		0.0083		

Table 12. Uncertainty budget for BARC 4π(LS)β-γ coincidence (Efficiency Extrapolation Technique) (4P-LS-BP-NA-GR-CO), Window1 = 415 keV - 640 keV.

QUANTITY *Q*	Relative uncert. of *Q*	Relative uncert. of act. conc.	Type (A/B)	Comment
counting statistics		0.41	Type A	
weighing		0.02	Type B	Uncertainty due to Repeatability, Readability and Linearity was used and uncertainty was calculated for lowest weight of source
background		0.04	Type A	
dead/live time	5	0.11	Type B	
resolving time	10	0.08	Type B	
half life	0.01	0.003	Type B	
Combined uncertainty		0.43		

Table 13. Uncertainty budget for BARC 4π(LS)β-γ coincidence (Efficiency Extrapolation Technique) (4P-LS-BP-NA-GR-CO), Window2 = 415 keV onwards, i.e. All the pulses above 415 keV are accepted which also include 1077 keV gamma.

QUANTITY *Q*	Relative uncert. of *Q*	Relative uncert. of act. conc.	Type (A/B)	Comment
counting statistics		0.41	Type A	
weighing		0.02	Type B	Uncertainty due to Repeatability, Readability and Linearity was used and uncertainty was calculated for lowest weight of source
background		0.04	Type A	
dead/live time	5	0.11	Type B	
resolving time	10	0.08	Type B	
half life	0.1	0.003	Type B	
Combined uncertainty		0.43		

Table 14. Uncertainty budget for BARC Automated 4π(LS)β-γ coincidence (Efficiency Extrapolation Technique) (4P-LS-PO-NA-GR-CO).

QUANTITY *Q*	Relative uncert. of *Q*	Relative uncert. of act. conc.	Type (A/B)	Comment
counting statistics		0.4	Type A	
weighing		0.02	Type B	Uncertainty due to Repeatability, Readability and Linearity were used and uncertainty was calculated for lowest weight of source
background		0.02	Type A	
dead/live time	5	0.14	Type B	
resolving time	10	0.16	Type B	
half life	0.01	0.002	Type B	
Combined uncertainty		0.46		

Table 15. Uncertainty budget for BARC CIEMAT NIST efficiency tracing technique (4P-LS-PO-00-00-CN).

QUANTITY *Q*	Relative uncert. of *Q*	Relative uncert. of act. conc.	Type (A/B)	Comment
counting statistics		0.36	Type A	With background
weighing		0.05	Type B	Uncertainty due to Repeatability, Readability and Linearity was used and uncertainty was calculated for lowest weight of source
quenching		0.01		
tracer	0.6	0.67		
half life	0.1	0.003	Type B	
Combined uncertainty		0.76		

Table 16. Uncertainty budget for NMIJ CIEMAT NIST efficiency tracing technique (4P-LS-MX-00-00-CN).

QUANTITY *Q*	Relative uncert. of *Q*	Relative uncert. of act. conc.	Type (A/B)	Comment
counting statistics		0.02	A	
weighing		0.1	B	
background		0.001	B	
tracer		0.1	B	
decay correction		0.04	B	
dilution factor		0.04	B	
Ge efficiency		0.6	B	
discrimination		0.1	B	
sample repeatability		0.1	B	
Combined uncertainty		0.7		

Table 17. Uncertainty budget for KRISS 4πβ(LS)-γ coincidence counting (4P-LS-PO-NA-GR-CO).

QUANTITY *Q*	Relative uncert. of *Q*	Relative uncert. of act. conc.	Type (A/B)	Comment
counting statistics		0.15	A	S.D. of the mean activity from measurement of 10 sources and 2 backgrounds
weighing		0.1	B	
resolving time		0.12	B	Variation in activity values from different beta-beta resolving time
decay data		0.46	B	Uncertainty of positron decay from the DDEP
extra-/inter-polation of efficiency curve		0.31	B	Variation of extrapolated values obtained from different efficiency ranges
impurities		0.02	B	Gama-ray spectroscopic measurements in a long measurement interval
Compton 1077 keV		0.23	B	Uncertainty due to Compton scattering of gamma 1077 keV detected in the 511 keV gamma window
Combined uncertainty		0.64		

Table 18. Uncertainty budget for POLATOM 4π(LS)-γ coincidence counting (4P-LS-BP-NA-GR-CO).

QUANTITY *Q*	Relative uncert. of *Q*	Relative uncert. of act. conc.	Type (A/B)	Comment
counting statistics		0.05	A	
weighing		0.27	B	
background		0.01	B	
dead/live time		0.01	B	
resolving time		0.01	B	
decay data		0.2	B	
extra-/inter-polation of efficiency curve		0.5	B	
calibration factor				
decay correction		0.02	B	
impurities		0.01	B	
adsorption		0.2	B	
Combined uncertainty		0.64		

Table 19. Uncertainty budget for IFIN-HH 4π(PC)-γ coincidence, with extrapolation (4P-PC-BP-NA-GR-CO).

QUANTITY *Q*	Relative uncert. of *Q*	Relative uncert. of act. conc.	Type (A/B)	Comment
counting statistics		0.69	A	standard deviation of the four sources mean
weighing		0.1	B	
background		0.01	B	on 1 % correction factor for gamma background
dead/live time		0.03	B	on 5 % correction factor
resolving time		0.01	B	on 1 % correction factor
decay data		0.3	B	on correction factor of 0.8916
decay correction		0.04	B	
sublimation		0.5	B	Difference in recovery yield from different sources
approximation in formulae		0.2	B	Neglection of some terms
Combined uncertainty		0.94		

Table 20. Uncertainty budget for IFIN-HH LSC-TDCR (4P-LS-MX-00-00-TD).

QUANTITY *Q*	Relative uncert. of *Q*	Relative uncert. of act. conc.	Type (A/B)	Comment
counting statistics		0.65	A	standard deviation of the six sources mean
weighing		0.1	B	
background		0.1	B	On a 1 % correction for double coincidence background
dead/live time		0.6	B	
decay data		0.5	B	
decay correction		0.04	B	
Combined uncertainty		1.14		

Table 21. Uncertainty budget for IFIN-HH HPGe - gamma spectrometry method (SA-GH-GR-00-00-00).

QUANTITY *Q*	Relative uncert. of *Q*	Relative uncert. of act. conc.	Type (A/B)	Comment
counting statistics		1.3	A	standard deviation of the five different sources activity mean
calibration factor		1.7	B	
decay correction		0.04	B	
GESPECOR code		1	B	
Combined uncertainty		2.4		

Table 22. Uncertainty budget for IFIN-HH Ionization chamber (4P-IC-GR-00-00-00).

QUANTITY *Q*	Relative uncert. of *Q*	Relative uncert. of act. conc.	Type (A/B)	Comment
counting statistics		0.07	A	standard deviation of the mean
background		0.01	B	
calibration factor		0.6	B	Sahagia et al., 2012
decay correction		0.04	B	
geometry difference		0.35	B	Comparison with NIST ampoule
difference from theoretical value of efficiency		0.79	B	see Sahagia et al., 2012
Combined uncertainty		1.06		

Table 23. Uncertainty budget for SMU LSC TDCR (4P-LS-BP-00-00-TD).

QUANTITY *Q*	Relative uncert. of *Q*	Relative uncert. of act. conc.	Type (A/B)	Comment
counting statistics		0.14	A	
weighing		0.02	B	
background		0.037	A	
dead/live time		0.2	B	
resolving time		0.1	B	
decay data		0.22	B	
quenching		0.1	A	
decay correction		0.1	B	
impurities		0.1	B	
PMT asymmetry		0.01	B	
kB		0.1	B	
Combined uncertainty		0.40		

Table 24. Uncertainty budget for CIEMAT LS counting using the TDCR method (4P-LS-MX-00-00-TD).

QUANTITY *Q*	Relative uncert. of *Q*	Relative uncert. of act. conc.	Type (A/B)	Comment
counting statistics	0.1	1.50E-03	A	effect of statistics in TDCR determination
weighing	0.1	0.1	B	
background	2	1.0E-03	B	
dead/live time		0.1	B	determined with MAC3 and external clock
resolving time		0.05	B	
decay data		0.2	B	mainly from Ge data and β^+ ratio in Ga
decay correction	0.07	0.07	B	
model (incl. *kB*)		0.35		
PMT asymmetry		0.1		
Combined uncertainty		0.45		

Table 25. Uncertainty budget for CIEMAT 4πβ(LS)-γ coincidence counting (4P-LS-MX-NA-GR-CO).

QUANTITY *Q*	Relative uncert. of *Q*	Relative uncert. of act. conc.	Type (A/B)	Comment
counting statistics		0.3	A	counting and extrapolation
weighing		0.1	B	
background		0.2	B	
dead/live time		0.08	B	
resolving time		0.008	B	
decay data		0.4	B	Branching ratio in Ga
decay correction		0.06	B	
Combined uncertainty		0.55		

Table 26. Uncertainty budget for IRA 4πβ(PS)-γ coincidence counting (4P-PS-PO-NA-GR-CO).

QUANTITY Q	Relative uncert. of Q	Relative uncert. of act. conc.	Type (A/B)	Comment
counting statistics		0.1	A	Statistical standard deviation of the mean of $\rho_\beta \cdot \rho_\gamma/\rho_c$ observed during repeated counting of sources
weighing		0.225	B	Worst case uncertainty: $\Delta m/m$ for the lightest source of the 5 sources used
background		0.016	B	$\Delta B_\gamma/R_{\gamma min}$ where ΔB_γ the maximum dispersion of the γ-background rate during the campaign, while $R_{\gamma min}$ is the smallest γ-count rate measured at the two gamma settings
dead/live time	0.056	0.009	B	$\Delta\tau \times \rho\beta$ where $\Delta\tau$ is the uncertainty of the deadtime and $\rho\beta$ is a typical true beta count rate for the campaign
resolving time	0.145	0.002	B	$(\Delta\tau_R/\tau_R)\bullet(\rho_{acc}/\rho_{cmax})$ where $\Delta\tau_R/\tau_R$ is the relative standard uncertainty of the resolving time(τ_R) and ρ_{acc} is the accidental coincidence count rate, while ρ_{cmax} is the largest measured true coincidence countrate
decay data		0.46	B	Uncertainty of the decay-scheme correction (to the extrapolated intercepts)
extra-/inter-polation of efficiency curve		0.042	A	Typical relative standard deviation of an intercept obtained by Monte Carlo fits in which $(1-\varepsilon_\beta)/\varepsilon_\beta$ and $\rho_\beta\rho_\gamma/\rho_c$ are varied stochastically 10^4 times within their distributions assumed to be Gaussian
decay correction	0.096	0.031	B	Propagation of the half-life uncertainty to the decay correction factors
adsorption		0.001	B	
dilution factor		0.004	B	
timing		0.002	B	Worst case time base error
reproducibility		0.107	A	Relative standard deviation of 8 efficiency extrapolated activities obtained with 5 sources from 2 dilutions, two gamma settings, two dead times and two resolving times
Combined uncertainty		0.536		

Table 27. Uncertainty budget for IRA 4πβ(LS)-γ coincidence counting (4P-LS-PO-NA-GR-CO).

QUANTITY Q	Relative uncert. of Q	Relative uncert. of act. conc.	Type (A/B)	Comment
counting statistics		0.1	A	Statistical standard deviation of the mean of $\rho_\beta \cdot \rho_\gamma / \rho_c$ observed during repeated counting of sources
weighing		0.131	B	Worst case uncertainty: $\Delta m/m$ for the lightest source of the set used
background		0.05	B	$\Delta B_\gamma / R_{\gamma min}$ where ΔB_γ the maximum dispersion of the γ-background rate during the campaign, while $R_{\gamma min}$ is the smallest γ-count rate measured
dead/live time	0.056	0.01	B	$\Delta\tau \times \rho_\beta$ where $\Delta\tau$ is the uncertainty of the deadtime and ρ_β is a typical true beta count rate for the campaign
resolving time	0.145	0.002	B	$(\Delta\tau_R/\tau_R) \bullet (\rho_{acc}/\rho_{cmax})$ where $\Delta\tau_R/\tau_R$ is the relative standard uncertainty of the resolving time and ρ_{acc} is the accidental coincidence count rate, while ρ_{cmax} is the largest measured true coincidence count rate
decay data		0.461	B	Uncertainty of the decay-scheme correction to the extrapolated intercepts
extra-/inter-polation of efficiency curve		0.027	A	Typical relative standard deviation of an intercept obtained by Monte Carlo fits in which $(1-\varepsilon_\beta)/\varepsilon_\beta$ and $\rho_\beta \rho_\gamma / \rho_c$ are varied stochastically 10^4 times within their distributions assumed to be Gaussian
decay correction	0.096	0.028	B	Propagation of the half-life uncertainty to the decay correction factors
adsorption		0.001	B	
dilution factor		0.004	B	
timing		0.002	B	Worst case time base error
reproducibility		0.11	A	Relative standard deviation of 9 efficiency extrapolated activities obtained with 18 sources from 2 dilutions, one gamma setting, one dead time and one resolving time, and 3 ways of altering the beta detection efficiency
Combined uncertainty		0.506		

Table 28. Uncertainty budget for IRA CIEMAT/NIST (4P-LS-MX-00-00-CN).

QUANTITY *Q*	Relative uncert. of *Q*	Relative uncert. of act. conc.	Type (A/B)	Comment
counting statistics		0.1	A	Statistical standard deviation of the mean count rates observed during repeated counting of sources
weighing		0.188	B	$\Delta m/m$ for the lightest source of the sources used
background		0.001	B	$\Delta B/R_{min}$ where ΔB the maximum dispersion of the background rate, while R_{min} is the smallest Tricarb count rate measured
decay data		0.295	B	Propagation uncertainties on E_{max} & intensities on Ge and Ga efficiencies
quenching		0.306	B	Propagation of the tracer activity and tSIE uncertainties on total efficiency
tracer				Included in the line above
decay correction		0.054	B	Propagation of the half-life uncertainty on decay correction factor
adsorption		0.001	B	
kB and *Q(E)*		0.082	B	Relative standard deviation of activities obtained with *kB* = 0.0070, 0.0075, 0.0080 cm·MeV^{-1} and 3 prescriptions for *Q(E)* (KB, EFFY, and Grau Malonda models).
dilution factor		0.007	B	
timing		0.003	B	Time base error
sample repeatability		0.146	A	Relative standard deviation of activities of the 9 sources measured thrice on two Tricarb counters
Combined uncertainty		0.507		

Table 29. Uncertainty budget for IRA 4πγ integral counting and Monte Carlo computed efficiencies (4P-NA-GR-00-00-00).

QUANTITY Q	Relative uncert. of Q	Relative uncert. of act. conc.	Type (A/B)	Comment
counting statistics		0.1	A	Statistical standard deviation of the mean count rates observed during repeated counting of sources
weighing		0.145	B	$\Delta m/m$ for the lightest source of the sources used
background		0.005	B	$\Delta B_\gamma/R_{\gamma min}$ where ΔB_γ the maximum dispersion of the γ-background rate during the campaign, while $R_{\gamma min}$ is the smallest γ-count rate measured
dead/live time	0.054	0.035	B	$\Delta\tau \times \rho_\gamma$ where $\Delta\tau$ is the uncertainty of the deadtime and ρ_γ is a typical true gamma count rate
decay data		0.235	B	Propagation of the decay scheme parameter uncertainties on the MC efficiency
quenching				
decay correction		0.053	B	Propagation of the half-life uncertainty on decay correction factor
adsorption		0.001	B	
timing		0.002	B	Worst case time base error
energy threshold		0.101	B	Propagation of the energy threshold uncertainty (+/- 2 keV) on the Monte Carlo efficiency
source geometry		0.022	B	Propagation of the volume uncertainty of glass scintillation vials/plastic scintillation vials sources on the MC efficiency
efficiency calculation		0.039	A	Statistical uncertainty in the Monte Carlo computation of the efficiency
sample variability		0.133	A	Relative standard deviation of the activities obtained for the 46 sources used.
Combined uncertainty		0.347		

Table 30. Uncertainty budget for IRA HPGe gamma spectrometry (UA-GH-GR-00-00-00).

QUANTITY *Q*	Relative uncert. of *Q*	Relative uncert. of act. conc.	Type (A/B)	Comment
weighing		0.006	B	
adsorption		0.001	B	
efficiency calibration curve and counting statistics		0.7	A nd B	The commercial code we use which outputs the activity and its uncertainty does not list the various contributions to the uncertainty separately
Combined uncertainty		0.70		

Table 31. Uncertainty budget for INER CIEMAT/NIST (4P-LS-MX-00-00-CN).

QUANTITY *Q*	Relative uncert. of *Q*	Relative uncert. of act. conc.	Type (A/B)	Comment
counting statistics		0.06	A	
weighing		0.05	B	
background		0.01	A	
decay data		0.27	B	
quenching		0.07	A	
extra-/inter-polation of efficiency curve		0.1	A	
decay correction		0.03	B	
dilute		0.01	B	
Combined uncertainty		0.31		

Table 32. Uncertainty budget for TAEK 4πγ counting (4P-NA-GR-00-00-00).

QUANTITY *Q*	Relative uncert. of *Q*	Relative uncert. of act. conc.	Type (A/B)	Comment
counting statistics	0.10	0.10	A	
weighing	0.10	0.10	B	
background	2	0.02	B	
dead/live time	0.10	0.15	B	
decay data	0.50	0.10	B	Monte Carlo simulation efficiencies with upper and lower limits of the decay branching ratios were calculated.
decay correction	0.05	0.05	B	
impurities	0.05	0.05	B	
adsorption	0.05	0.05	B	
efficiency calculation with Monte Carlo simulation	0.55	0.55	B	
repeatability	0.20	0.20	B	
Combined uncertainty		0.6		

Table 33. Uncertainty budget for TAEK Ionisation Chamber (4P-IC-GR-00-00-00).

QUANTITY *Q*	Relative uncert. of *Q*	Relative uncert. of act. conc.	Type (A/B)	Comment
counting statistics	0.23	0.23	A	includes Ge-68 and reference source current measurement uncertainties.
weighing	0.01	0.01	B	
background	22	0.03	B	
decay data	0.50	0.03	B	
calibration factor	1.45	1.45	A	includes current measurement stability, electrometer linearity and chamber efficiency curve fitting procedure.
decay correction	0.05	0.05	B	
impurities	0.02	0.02	B	
adsorption	0.05	0.05	B	
ref. Source activity unc.		1.03	B	
Combined uncertainty		1.8		

Table 34. Uncertainty budget for NPL 4π(LS)-γ DCC (4P-LS-MX-GH-GR-CO).

QUANTITY *Q*	Relative uncert. of *Q*	Relative uncert. of act. conc.	Type (A/B)	Comment
counting statistics		0.3	A	Repeat measurements of 8 samples
weighing		0.03	B	Historical data
background	8	0.01	A	Derived from repeat measurements
dead/live time		0.3	B	Historical data
resolving time		0.01	B	estimated
Gandy effect		0.02	B	estimated
pile-up		0.01	B	estimated from count rates
decay data		0.2	B	Half-lives from DDEP
decay correction		0.05	B	
impurities		0.01	B	No impurities detected
range of extrap +		0.4	B	
polynomial order +		0.2	B	
choice of g-gates		0.2	B	difference between fit with single gate
Combined uncertainty		0.68		

Table 35. Uncertainty budget for NPL CIEMAT/NIST efficiency tracing (4P-LS-MX-00-00-CN).

QUANTITY *Q*	Relative uncert. of *Q*	Relative uncert. of act. conc.	Type (A/B)	Comment
counting statistics	0.18	0.18	A	Derived from repeat measurements
weighing	0.022	0.022	B	Historical data
background	35	0.01	A	Derived from repeat measurements
dead/live time	0.5	0.5	B	Historical data
resolving time		0.01	B	estimated
decay data	various	0.2	B	Predominantly EC/beta+ ratio ^{68}Ga
quenching	20	0.1	B	Change in *kB*
tracer	1.25	0.47	B	from calibration certificate
extra-/inter-polation of efficiency curve	0.067	0.067	A	Curve fit statistics
decay correction	0.05	0.05	B	
impurities	0.01	0.01	B	No impurities detected
EC model	0.6	0.6	B	examining effect on final results
scintillant volume		0.01	B	estimated
wall effect		0.01	B	estimated
Combined uncertainty		0.96		

Table 36. Uncertainty budget for NIST live-timed 4-pi beta-gamma anti-coincidence counting (4P-LS-BP-NA-GR-AC).

QUANTITY *Q*	Relative uncert. of *Q*	Relative uncert. of act. conc.	Type (A/B)	Comment
weighing	0.05	0.05	A	Uncertainty on gravimetric dilution factor, which was checked by radiometric measurements, and uncertainty on mean source mass, determined from previous experience and from performance of balance.
background		<0.01	A	Partially embodied in source-to-source variability component.
dead/live time	0.1	0.1	B	From limits of previous tests.
decay data	0.46	0.46	B	from DDEP data. Positron branching ratio of 0.8888 +/- 0.0041.
extra-/inter-polation of efficiency curve	0.13	0.13	A	Combination of the least-squares fit uncertainty (0.03 %) and extrapolation variability from using 4 different reasonable fits (0.13 %)
decay correction	0.096	0.003		Ge-68 half-life from DDEP 2014
impurities	0.03	0.03	B	No impurities found. Uncertainty based on limit from HPGe measurements.
source-to-source variability	0.13	0.13	A	Standard deviation of the distribution for the means from 4 sources. Each source mean was based on 2 to 3 measurements made over 17 days. (Two cocktails were used, with 2 sources per cocktail.)
correction factor for EC branch gamma ray interaction in LS	0.36	0.36	B	Uncertainty estimated using Geant4 simulation for various gamma-ray gates and efficiency ranges.
Combined uncertainty		0.62		

Table 37. Uncertainty budget for NIST TDCR (4P-LS-MX-00-00-TD).

QUANTITY *Q*	Relative uncert. of *Q*	Relative uncert. of act. conc.	Type (A/B)	Comment
counting statistics	N/A			
weighing	0.05	0.05	B	Standard uncertainty on the determination of C_A from standard uncertainty on determination of any single LS source mass.
background	0.6 % (triples) 0.02 % (doubles)	0.003	A	Standard uncertainty on the determination of C_A from the standard uncertainties on the triples (0.6 %) and doubles (0.02 %) background counting rates. Uncertainty was evaluated using a Monte Carlo method in which C_A was calculated for a single count on a single source at one efficiency value using random values of the triple and double background counting rates that were calculated from a normal distribution based on the respective average rates and their standard deviations.
dead/live time	0.01	0.01	B	Standard uncertainty on the determination of C_A from standard uncertainty on live time clock.
decay data		0.54	B	Standard uncertainty on the determination of C_A from the standard uncertainties on the nuclear and atomic input data. Uncertainty was estimated by a Monte Carlo approach that ran MICELLE2 500 times using 500 data sets constructed from random numbers drawn from the distributions for each input variable defined by their mean and standard uncertainty, as given in DDEP).
decay correction	0.096	0.004	B	Standard uncertainty on the determination of C_A from the standard uncertainty on the Ge-68 half-life (0.096 %).
measurement repeatability	0.09	0.09	A	Standard deviation on the determination of C_A from three measurements on a single sample. Average of 6 sources measured at least once with each of two gray filters (n = 10)
Measurement reproducibility	0.18	0.18	A	Standard deviation on the determination of C_A from 6 prepared sources
scintillator dependence	0.2	0.2	A	Standard uncertainty on the determination of C_A from LS counting sources prepared with two different scintillants, with 3 sources for each.

dilution factor	0.09	0.09	B	Standard uncertainty on the determination of C_A from standard uncertainty on dilution factor to master solution.
Combined uncertainty		0.62		

Table 38. Uncertainty budget for NIST CIEMAT/NIST efficiency tracing (4P-LS-MX-00-00-CN).

QUANTITY *Q*	Relative uncert. of *Q*	Relative uncert. of act. conc.	Type (A/B)	Comment
weighing	0.05	0.05	B	Gravimetric (mass) measurements for LS sources and for ^{3}H standard dilution
background	-	-	B	Completely embodied in LS measurement variability (below)
dead/live time	0.08	0.08	B	Live time determinations for LS counting time intervals, includes uncorrected dead time effects; assumed from specified tolerance limits of counters' gated oscillators
decay data	See DDEP tables	0.3	B	Standard uncertainty on the determination of C_A from the standard uncertainties on the nuclear and atomic input data. Uncertainty was estimated by a Monte Carlo approach that ran MICELLE2 500 times using 500 data sets constructed from random numbers drawn from the distributions for each input variable defined by their mean and standard uncertainty, as given in DDEP).
decay correction	0.096	0.02	B	For Ge-68 only
impurities				
adsorption				
LS measurement variability	0.62	0.62	A	LS measurement precision; reproducibility in massic activity for 2 cocktail compositions, each with 5 different quenched sources, measured in 2 counters on 3 measurement occasions; standard deviation of the mean for n = 12 data sets normally distributed including between and typical within standard deviation of the mean. The LS within-measurement precision for a given data set, in terms of the standard deviation of the mean for 5 samples measured for 5 cycles on three measurement occasions, ranged from 0.30 % to 0.49 %
dilution factor		0.09	B	Standard uncertainty on the determination of C_A from standard uncertainty on dilution factor to master solution.
cocktail composition dependence	-	-	B	Completely embodied in LS measurement variability (below)
decay correction, H-3	0.16	0.0026	B	For H-3 only

uncertainty in H-3 tracing standard	0.36	0.2	B
Combined uncertainty		0.73	