

NPL REPORT IR 43

**Environmental Radioactivity
Proficiency Test Exercise 2016**

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September 2017



Environmental Radioactivity Proficiency Test Exercise 2016

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ABSTRACT

The results of NPL's twenty-second Environmental Radioactivity Proficiency Test Exercise are reported. Six different sample types were offered: an aqueous mixture of two alpha emitters and two beta emitters (designated 'AB'), an aqueous mixture of three alpha emitters ('A1'), an aqueous mixture of three beta emitters ('B1'), an aqueous mixture of three gamma emitters ('GH'), a second aqueous mixture of three gamma emitters ('GL') and a dried ion-exchange resin sample containing a mixture of three gamma emitters ('R1'). In total, 399 results were submitted; 392 were analysed and, of these, 85% were found to be 'In Agreement' with the NPL Assigned Values.

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ISSN 1754-2952

Issued September 2017

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Approved on behalf of NPLML by Richard Brown,
Knowledge Leader, Chemical, Medical and Environmental Science Division

Assigned Values (reference time 2016-06-01 1200 UTC)

Nuclide (AB)	Assigned Value (Bq g⁻¹)
³ H	5.03 ± 0.13
⁹⁰ Sr	4.658 ± 0.042
²⁴¹ Am	2.574 ± 0.022
²⁴⁴ Cm	16.07 ± 0.11
Gross alpha	19.6 ± 1.2
Gross beta	10.7 ± 1.6
Nuclide (A1)	Assigned Value (Bq kg⁻¹)
²³² Th	3.305 ± 0.064
²³³ U	16.040 ± 0.098
²³⁶ U	11.748 ± 0.058
Gross alpha	37.4 ± 4.2
Nuclide (B1)	Assigned Value (Bq g⁻¹)
³ H	0.958 ± 0.024
¹⁴ C	0.4974 ± 0.0066
³⁶ Cl	0.2509 ± 0.0020
Nuclide (GH)	Assigned Value (Bq g⁻¹)
⁶⁰ Co	12.074 ± 0.094
¹³⁴ Cs	2.503 ± 0.036
¹⁵⁴ Eu	4.015 ± 0.064
Nuclide (GL)	Assigned Value (Bq kg⁻¹)
¹³⁷ Cs	9.53 ± 0.17
²¹⁰ Pb	19.39 ± 0.40
²⁴¹ Am	14.825 ± 0.064
Nuclide (R1)	Assigned Value (Bq g⁻¹)
⁶⁰ Co	1.543 ± 0.072
¹³⁷ Cs	1.904 ± 0.052
²⁴¹ Am	5.34 ± 0.13

UNCERTAINTIES

The reported expanded uncertainty is based on a standard uncertainty multiplied by a coverage factor $k = 2$, providing a coverage probability of approximately 95 %. The uncertainty evaluation has been carried out in accordance with UKAS requirements.

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1. SUMMARY

This environmental radioactivity Proficiency Test Exercise (PTE) was the twenty-second in a series of such exercises run by NPL over the last 28 years. The exercises help analysts to identify measurement problems and also support UKAS accreditations in this area; they are run on an annual basis. A range of sample types have been made available over the course of these exercises; these have been mostly aqueous in nature, although in recent years solid samples have been included.

Six sample types were made available for analysis in the 2016 PTE:

- (i) **AB:** a mixture of two α -emitting radionuclides and two β -emitting radionuclides
20 g of dilute nitric acid (1 – 20 Bq g⁻¹ per radionuclide)
- (ii) **A1:** a mixture of four α -emitting radionuclides
500 g of dilute nitric acid (1 – 20 Bq kg⁻¹ per radionuclide)
- (iii) **B1:** a mixture of three β -emitting radionuclides
500 g of very dilute NaOH solution (0.1 – 2 Bq g⁻¹ per radionuclide)
- (iv) **GH:** a 'high-level' mixture of three γ -emitting radionuclides
100 g of dilute nitric acid (1 – 20 Bq g⁻¹ per radionuclide)
- (v) **GL:** a 'low-level' mixture of three γ -emitting radionuclides
500 g of dilute nitric acid (1 – 20 Bq kg⁻¹ per radionuclide)
- (vi) **R1:** a dried ion-exchange resin sample containing a mixture of three γ -emitting radionuclides
100 g (1 – 20 Bq g⁻¹ per radionuclide)

As in previous years, the main objective was to assess the performance of the participating laboratories. This required the participants to identify (and/or measure) the activity per unit mass of the radionuclides present in the samples, whereas the tasks of NPL were to prepare and distribute the samples, to collect, analyse and interpret the results and to compile an exercise report.

Each participant was allocated by NPL a unique laboratory code number (if not already allocated in a previous PTE in this series). This was done in confidence so that no third parties could identify which participant had which code number. The participants were asked to add their code numbers to their Reporting Forms and the code numbers would be used by NPL to label the results in the final PTE report.

The activities per unit mass of the radionuclides in the aqueous sample types were traceable to national standards of radioactivity, and therefore to the international measurement system.

Each aqueous sample type was prepared (as a bulk sample) by combining weighed aliquots of standard solutions of the individual radionuclides with a weighed amount of carrier solution and then diluting the mixture further to achieve the target activity per unit mass. Dilution factors were measured gravimetrically and were verified by counting sources prepared at the various dilution levels using either liquid scintillation counting or gamma spectrometry. The Assigned Value for each nuclide was calculated by dividing the activity per unit mass of the original standard solution by the dilution factor(s). The bulk solution was subdivided into (typically) 40 bottles and homogeneity was checked by gamma spectrometry where applicable. Solution stability was checked by counting one or more bottles at NPL at regular intervals throughout the course of the PTE.

The Power-Moderated Weighted Mean (PMWM) (Pommé, 2012) of the participants' values for each nuclide (and for combined nuclides) in the aqueous sample types was also calculated. This provides a more robust estimate than the weighted mean in the event of discrepant data sets. For mutually consistent data, the method approaches the weighted mean, the weights being the reciprocals of the variances associated with the measured values. For data suspected of inconsistency, the weighting is moderated by augmenting laboratory variances by a common amount and/or by decreasing the power of weighting factors. For increasingly discrepant data sets, there is a smooth transition from the weighted mean to the arithmetic mean.

The ion-exchange resin sample was prepared by dispensing aliquots of a solution of the individual radionuclides dropwise to a bulk resin sample (as supplied by the manufacturer) before drying the resin on a hotplate, homogenising the dried material in a mixer and dividing into sub-samples in 100 ml plastic bottles. The homogeneity of the batch was determined by gamma spectrometry. For each radionuclide, the PMWM of the participants' submitted data was calculated and a decision taken as to whether or not to use the PMWM as an Assigned Value.

PMWM values of participants' results were also calculated for each of the following, and again a decision was made in each case as to whether or not to use the PMWM as an Assigned Value:

- Sample Type AB gross alpha
- Sample Type AB gross beta
- Sample Type A1 gross alpha
- Sample Type B1 gross beta

The NPL data analysis method is described in Section 2 and the Assigned Values and PMWM values are summarised in Section 3.

Note that, unless otherwise stated, all uncertainties quoted in this report are standard uncertainties multiplied by a coverage factor of $k = 1$, providing a level of confidence of approximately 68 %.

2. TREATMENT OF DATA

The data were analysed using the same methods as in the 2014 exercise (Dean et al., 2015). The deviation 'D' from the assigned value from each laboratory value was calculated from:

$$D = \frac{L - N}{N} = \left(\frac{L}{N} - 1 \right) \quad [1]$$

The standard uncertainty ($k=1$) ' u_D ' of the deviation was calculated from:

$$u_D = \frac{L}{N} \sqrt{\left(\frac{u_L}{L} \right)^2 + \left(\frac{u_N}{N} \right)^2} \quad [2]$$

The quantities zeta (ζ), the relative uncertainty of a laboratory's value (R_L) and the z-score were calculated from:

$$\zeta = \frac{L - N}{\sqrt{u_L^2 + u_N^2}} \quad [3]$$

$$R_L = \frac{u_L}{L} \quad [4]$$

$$z = \frac{L - N}{\sigma_p} = \frac{L - N}{0.05823 N} \quad [5]$$

where:

L is the participant's value;

N is the Assigned Value;

u_L is the standard uncertainty of the participants' value;

u_N is the standard uncertainty of the Assigned Value;

σ_p is the standard uncertainty for proficiency assessment.

Note the z-score presented is as defined in ISO 13528:2005 rather than the commonly understood z-score and is used to reject results on the basis of a maximum percentage deviation.

The zeta and z-scores were used to determine whether the difference between the participant's value and the Assigned Value was significantly different from zero. The Interquartile Range outlier test (Harms and Gilligan, 2011) was used to determine whether the relative uncertainty R_L was significantly larger than the other values in the data set. Note that this test is unable to identify outliers if the data set is smaller than 7.

Results for which the absolute values of the zeta score and the z-score are both ≤ 2.576 and for which R_L is not significantly larger than the other values in the data set are taken to mean that the participant's value is 'in agreement' with the Assigned Value. These results are plotted in white in this report.

If (i) R_L is significantly larger than the other values in the data set, or (ii) the result passes the zeta test but not the z-test (i.e., there is a large deviation from the Assigned Value combined with a large uncertainty), or (iii) the result passes the z-test but not the zeta test (where there is a small deviation from the Assigned Value and a small uncertainty), the participant's value is classified as 'questionable' (plotted in yellow).

If the absolute values of both the zeta score and the z-score are greater than 2.576, then the participant's value is classified as 'discrepant' from the Assigned Value (plotted in red), regardless of the value of R_L . The factor of 0.05823 used to calculate the z-score is the ratio of 0.15 (i.e. a deviation of 15%) to 2.576. In other words, a participant value with a deviation D having an absolute value of $\leq 15\%$ will pass the z-test.

Table 1 Summary of data classification criteria

zeta test	R_L test	z test	Classification
pass	pass	pass	in agreement
pass	fail	pass	questionable
fail	pass	pass	questionable
pass	-	fail	questionable
fail	-	fail	discrepant

3. SUMMARY OF PARTICIPANTS' RESULTS

The reference time is 2016-06-01 1200 UTC.

Table 2 AB summary

Nuclide (AB)	NPL Assigned Values (Bq g ⁻¹)	PMWM (Bq g ⁻¹)	Deviation %	Zeta	Critical Value
³ H	5.031 ± 0.064	5.028 ± 0.038	0.0	-0.03	2.58
⁹⁰ Sr	4.658 ± 0.021	4.558 ± 0.056	-2.1	-1.67	2.83
²⁴¹ Am	2.574 ± 0.011	2.574 ± 0.026	0.0	0.01	2.77
²⁴⁴ Cm	16.066 ± 0.054	15.04 ± 0.16	-6.4	-6.13	2.85

Table 3 A1 summary

Nuclide (A1)	NPL Assigned Values (Bq kg ⁻¹)	PMWM (Bq kg ⁻¹)	Deviation %	Zeta	Critical Value
²³² Th	3.305 ± 0.032	3.351 ± 0.063	1.4	0.66	2.85
²³³ U	16.040 ± 0.049	15.85 ± 0.25	-1.2	-0.75	2.92
²³⁶ U	11.748 ± 0.029	11.97 ± 0.19	1.9	1.14	2.90

Table 4 B1 summary

Nuclide (B1)	NPL Assigned Values (Bq g ⁻¹)	PMWM (Bq g ⁻¹)	Deviation %	Zeta	Critical Value
³ H	0.958 ± 0.012	0.9621 ± 0.0070	0.4	0.31	2.58
¹⁴ C	0.4974 ± 0.0033	0.4995 ± 0.0072	0.4	0.26	2.76
³⁶ Cl	0.2509 ± 0.0010	0.2506 ± 0.0053	-0.1	-0.07	3.25

Table 5 GH summary

Nuclide (GH)	NPL Assigned Values (Bq g ⁻¹)	PMWM (Bq g ⁻¹)	Deviation %	Zeta	Critical Value
⁶⁰ Co	12.074 ± 0.047	12.195 ± 0.073	1.0	1.39	2.66
¹³⁴ Cs	2.503 ± 0.018	2.464 ± 0.020	-1.5	-1.42	2.63
¹⁵⁴ Eu	4.015 ± 0.032	3.893 ± 0.030	-3.1	-2.79	2.58

Table 6 GL summary

Nuclide (GL)	NPL Assigned Values (Bq kg ⁻¹)	PMWM (Bq kg ⁻¹)	Deviation %	Zeta	Critical Value
¹³⁷ Cs	9.527 ± 0.086	9.506 ± 0.068	-0.2	-0.20	2.58
²¹⁰ Pb	19.39 ± 0.20	18.32 ± 0.58	-5.5	-1.74	2.74
²⁴¹ Am	14.825 ± 0.032	15.34 ± 0.15	3.5	3.43	2.72

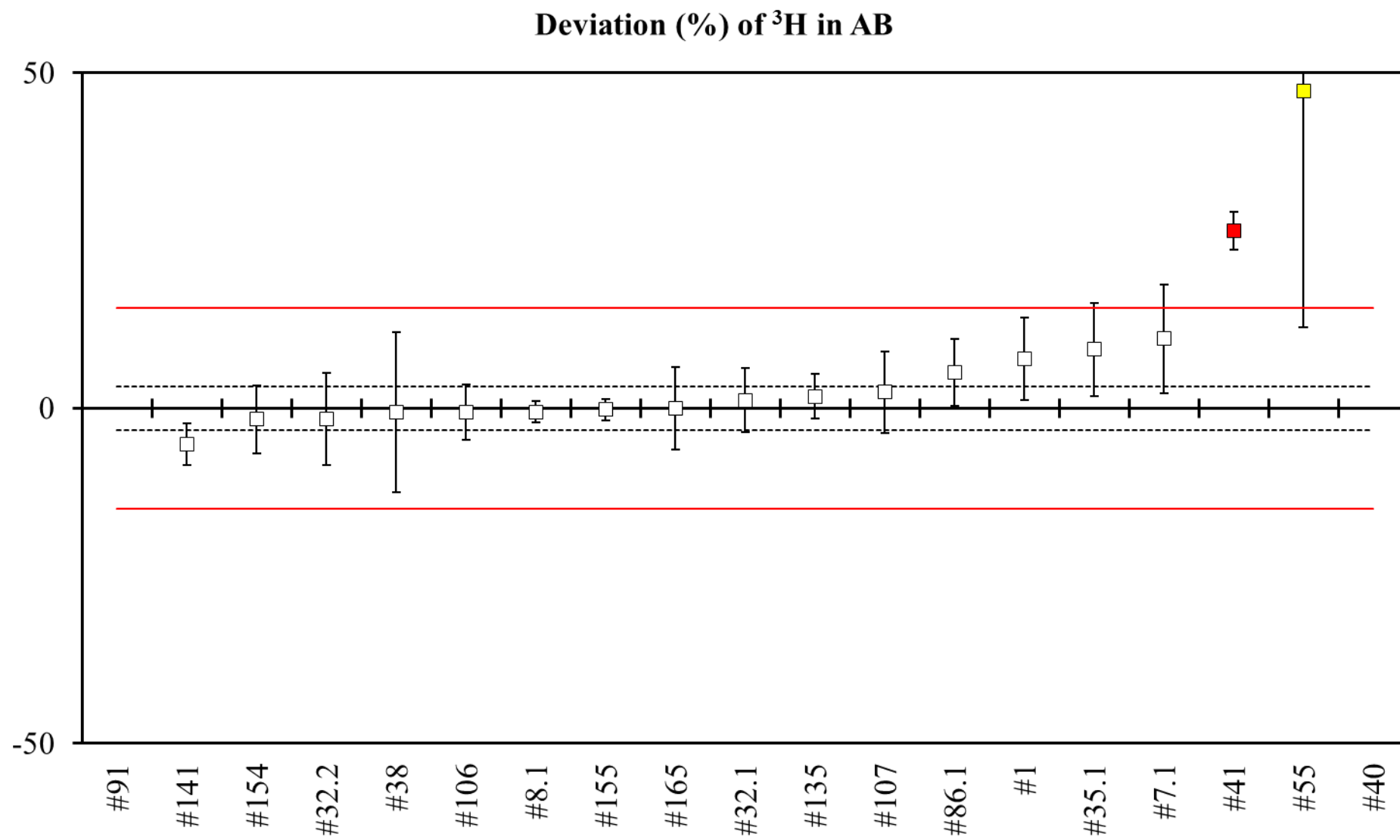
Table 7 R1 summary

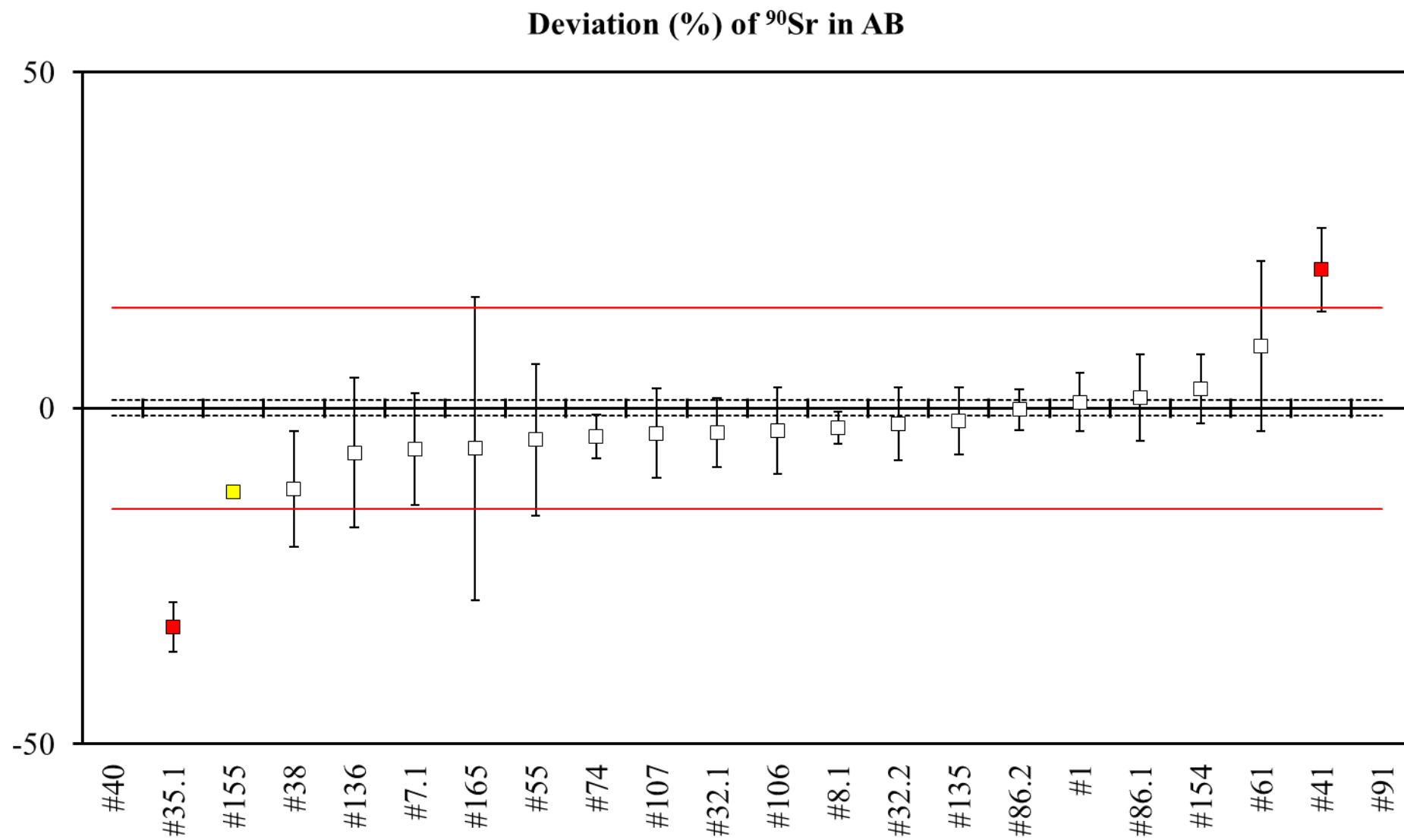
Nuclide (R1)	PMWM (Bq g ⁻¹)
⁶⁰ Co	1.543 ± 0.036
¹³⁷ Cs	1.904 ± 0.026
²⁴¹ Am	5.338 ± 0.067

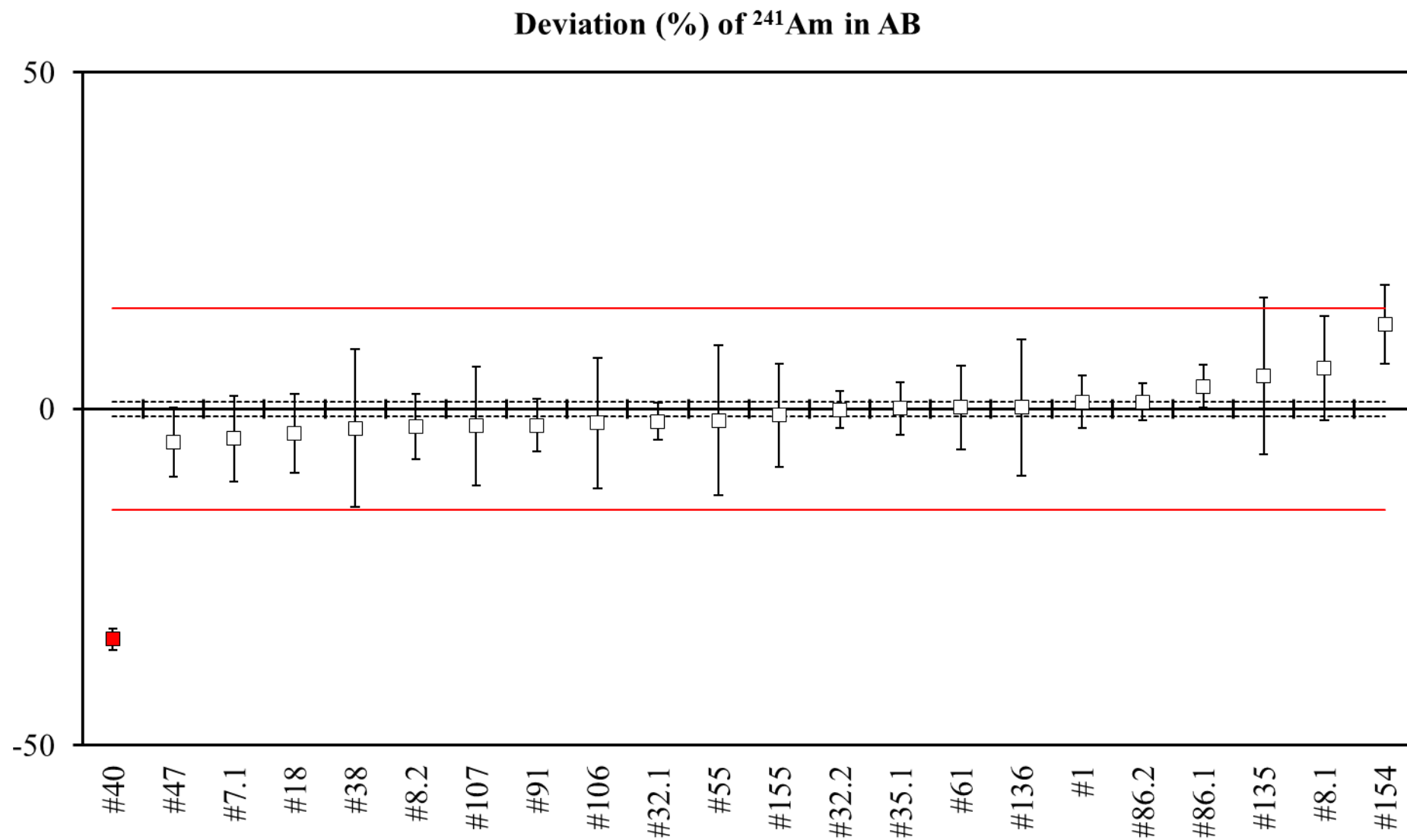
Table 8 Gross nuclide measurements summary (excluding R1)

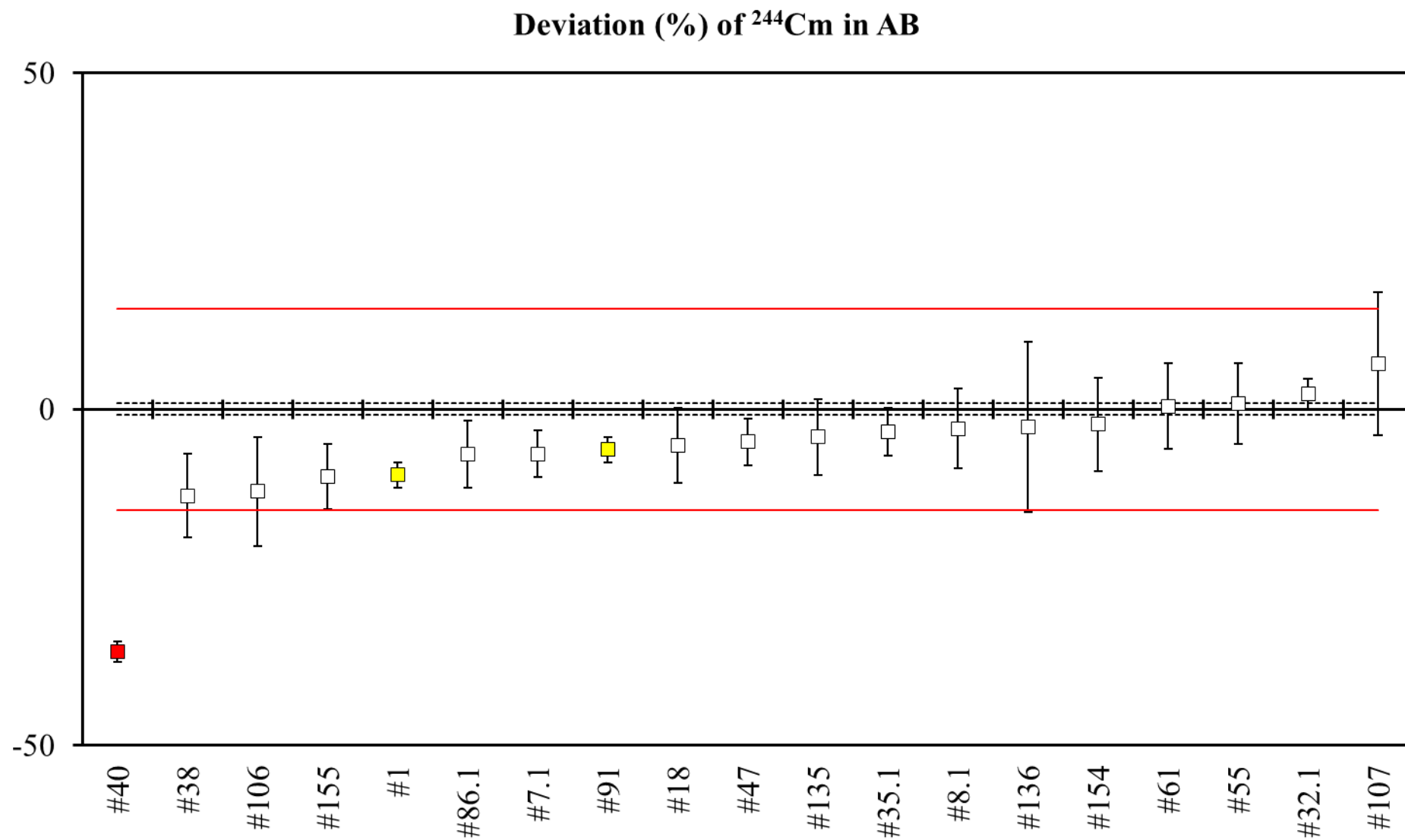
Nuclides	PMWM
Gross alpha (AB)	(19.62 ± 0.61) Bq g ⁻¹
Gross beta (AB)	(10.68 ± 0.81) Bq g ⁻¹
Gross alpha (A1)	(37.4 ± 2.1) Bq kg ⁻¹
Gross beta (B1)	Value not used (see Section 11)

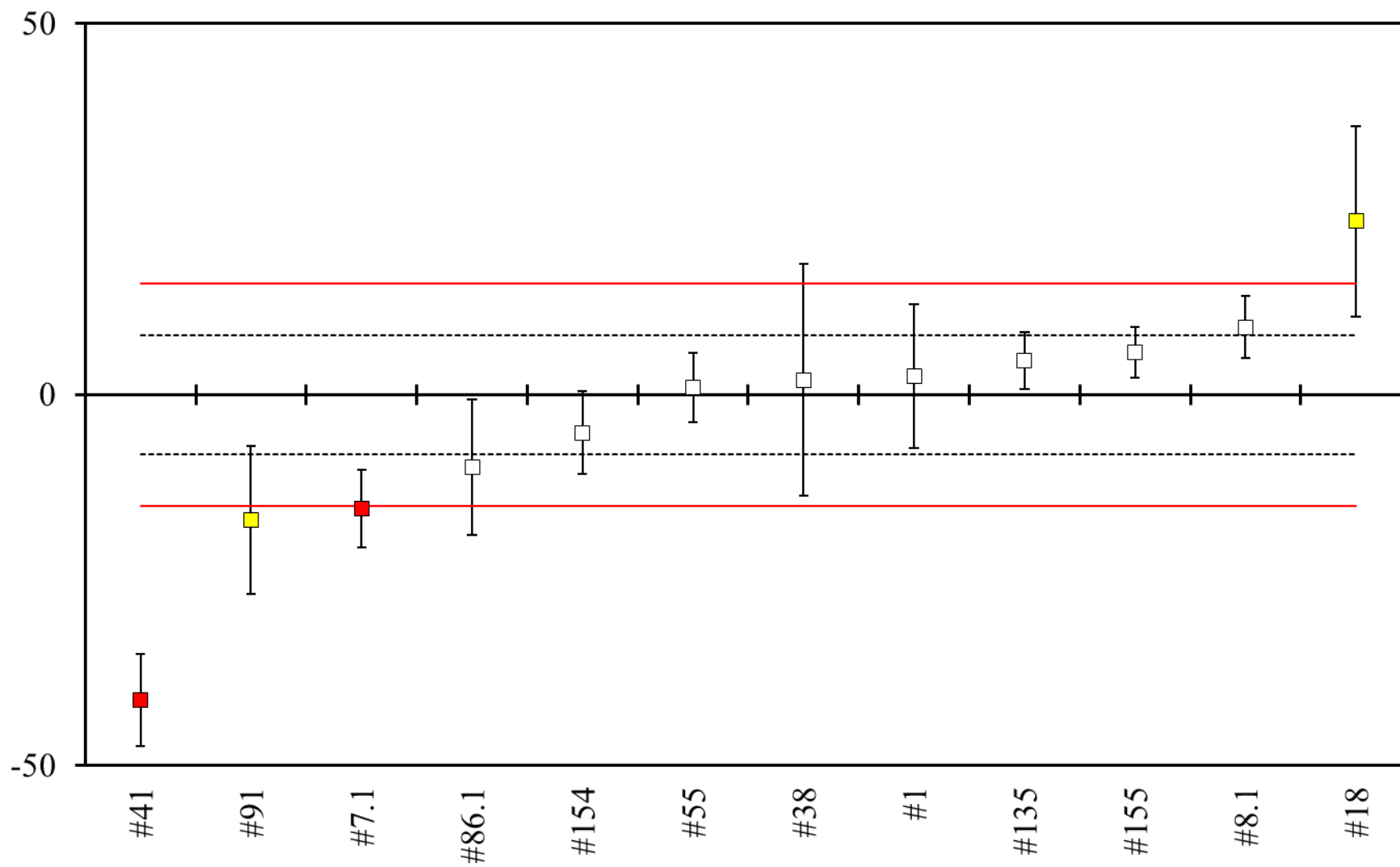
4. Alpha Beta (AB) Deviation Plots

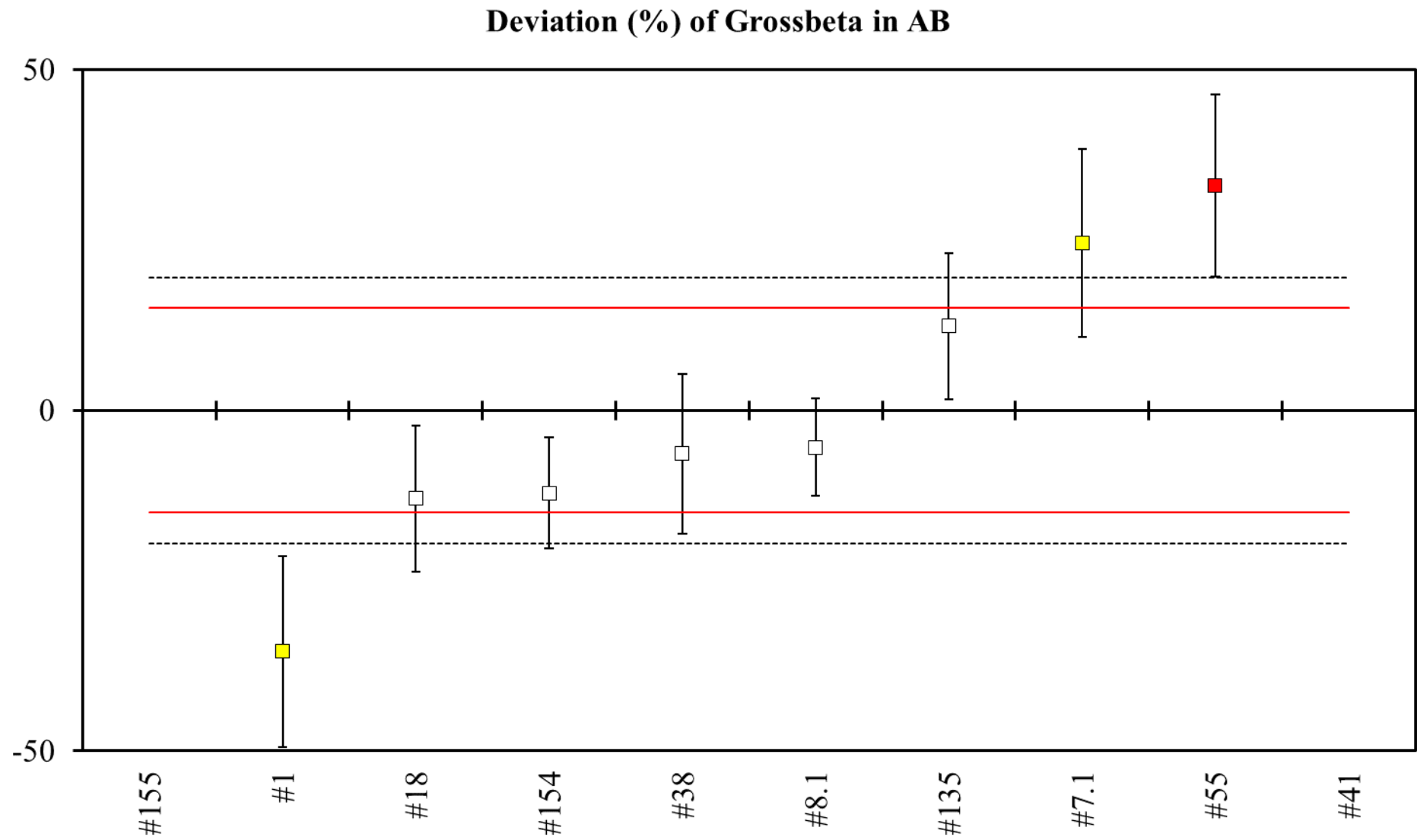




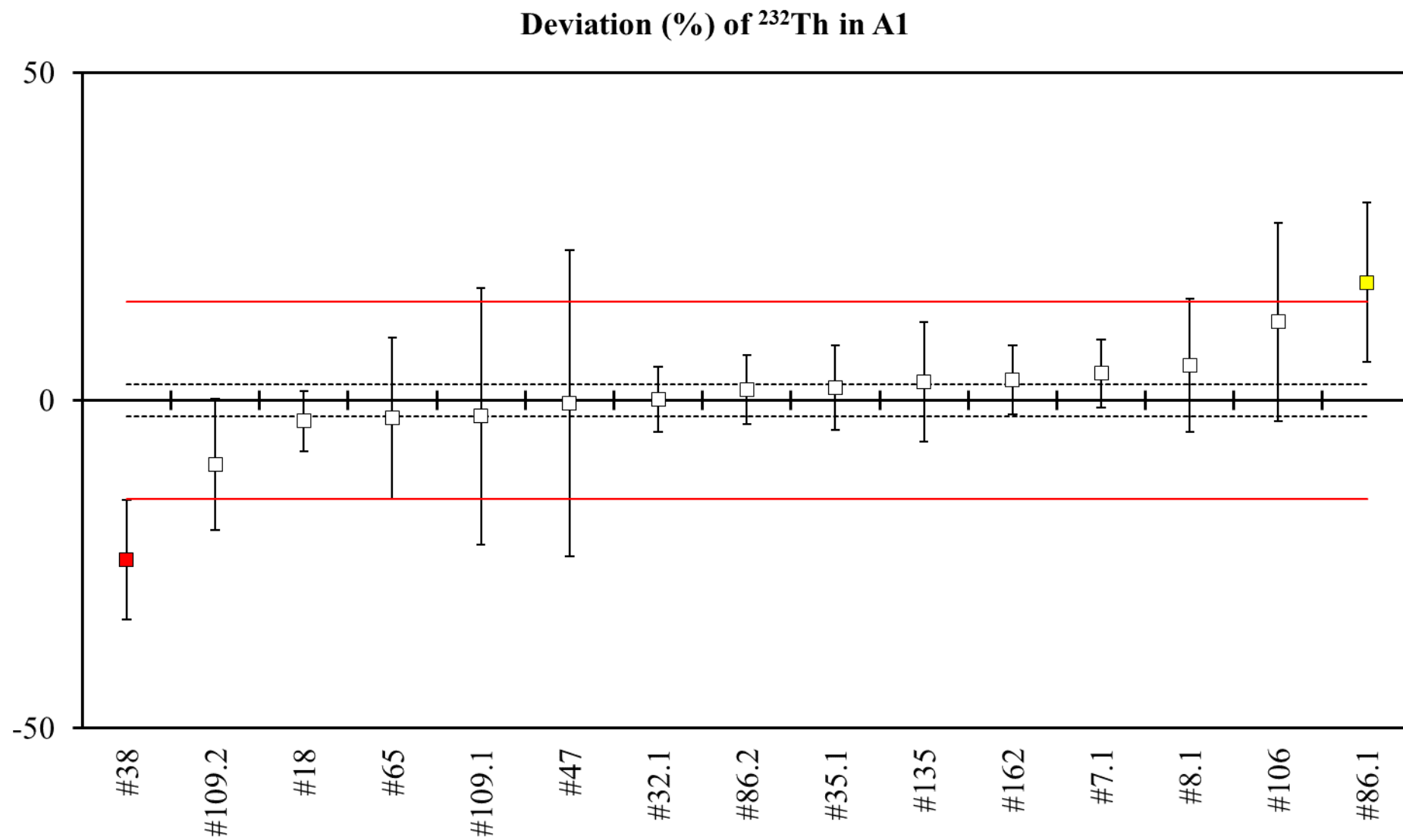


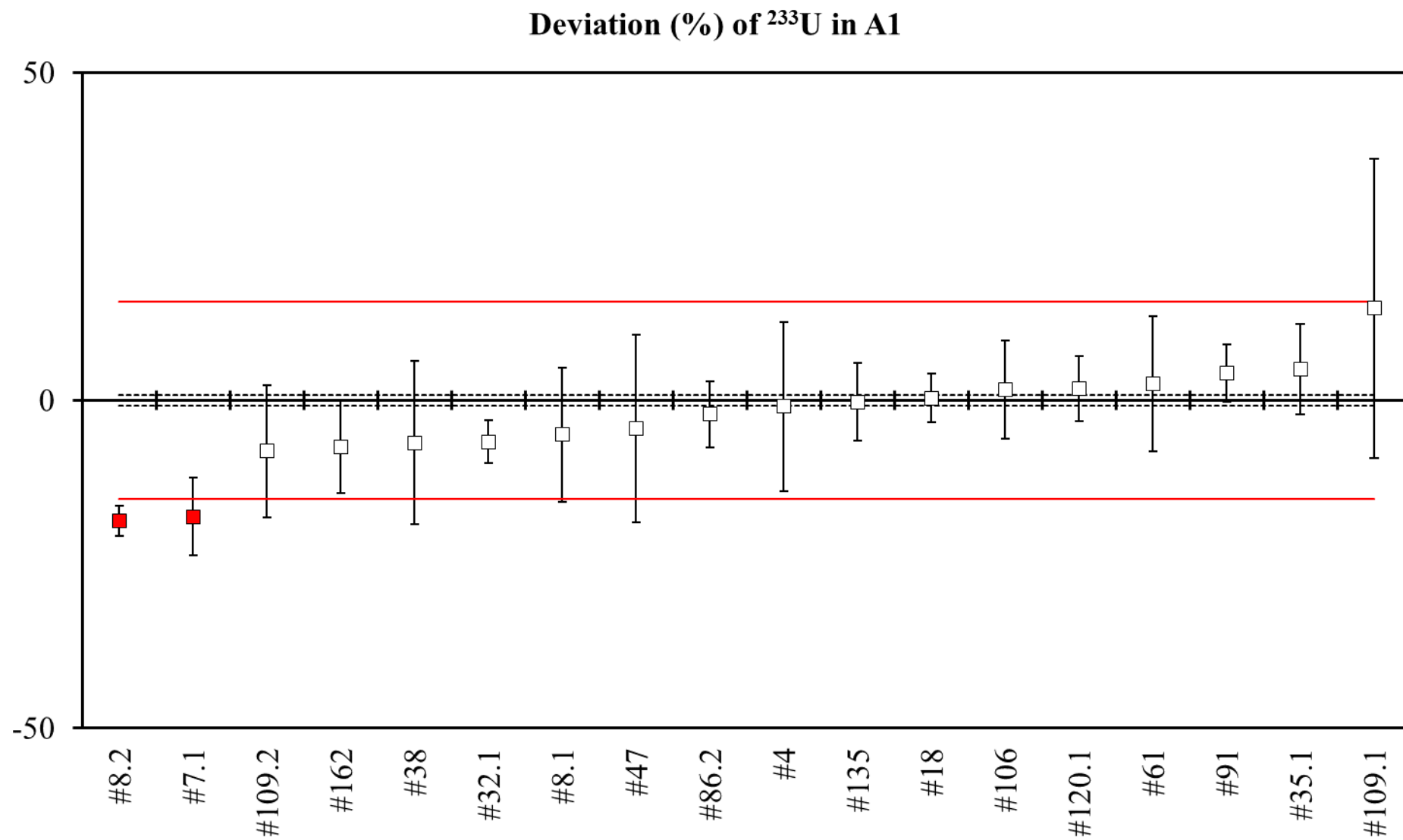


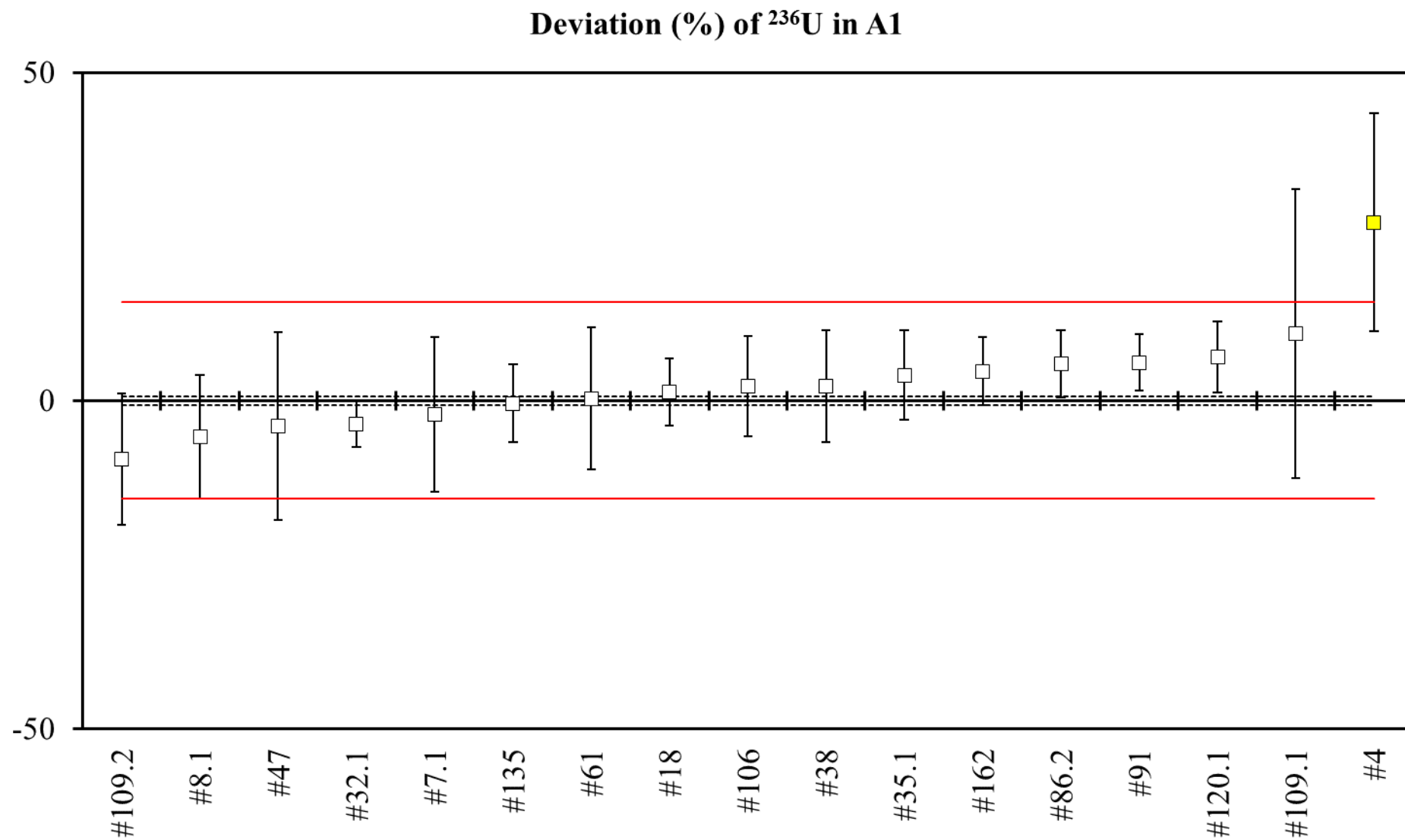
Deviation (%) of Grossalpha in AB

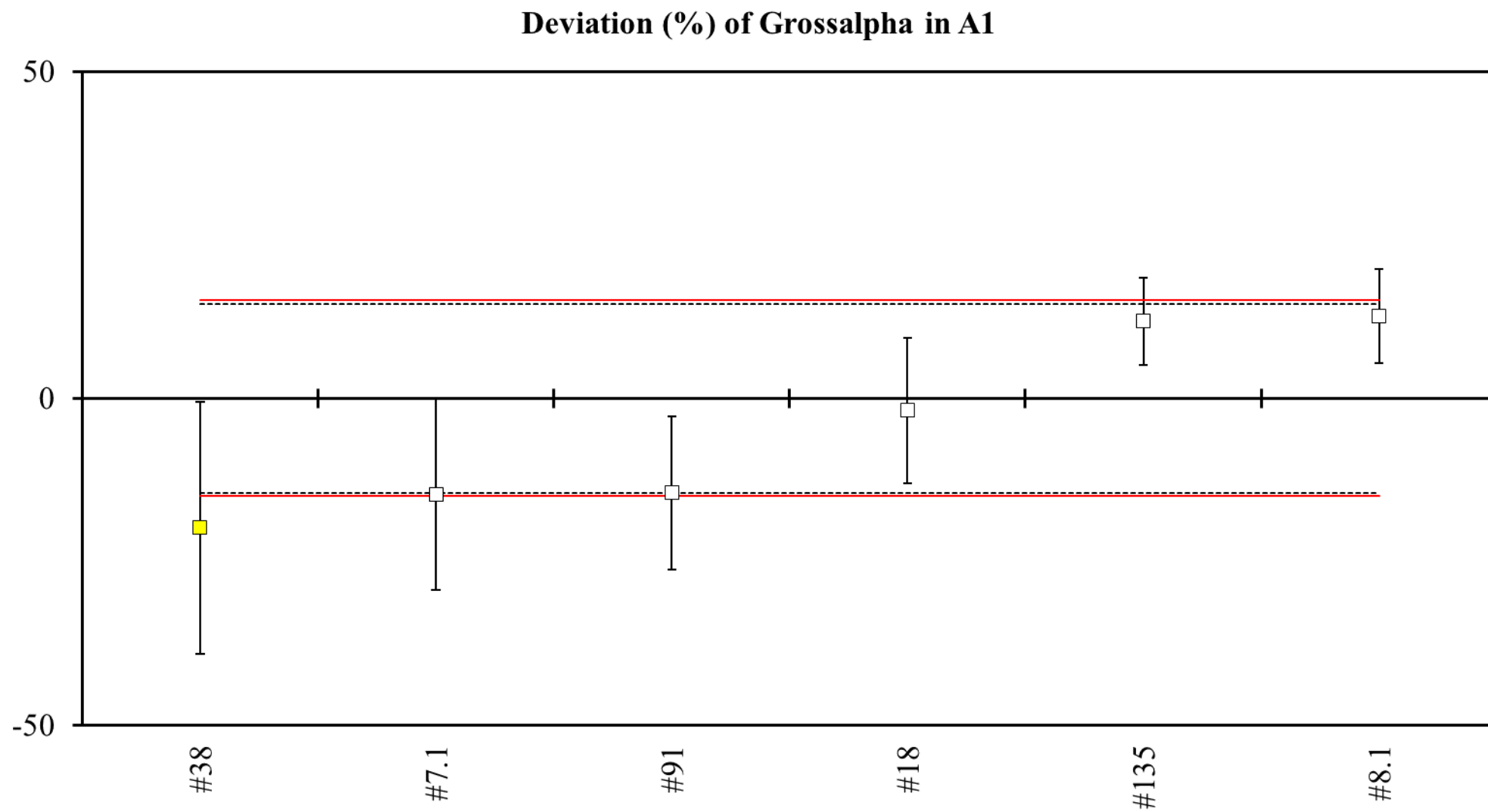


5. Alpha One (A1) Deviation Plots

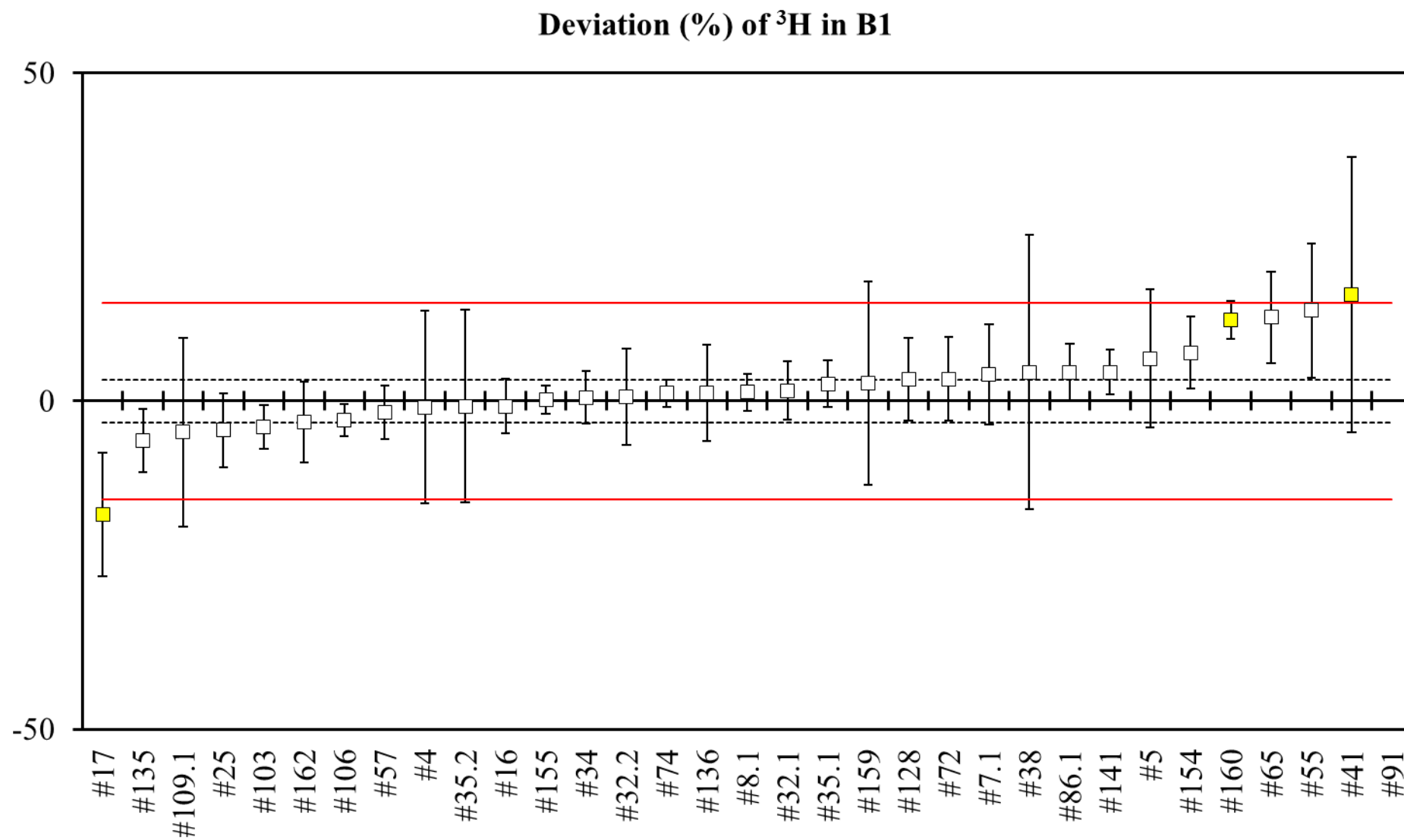


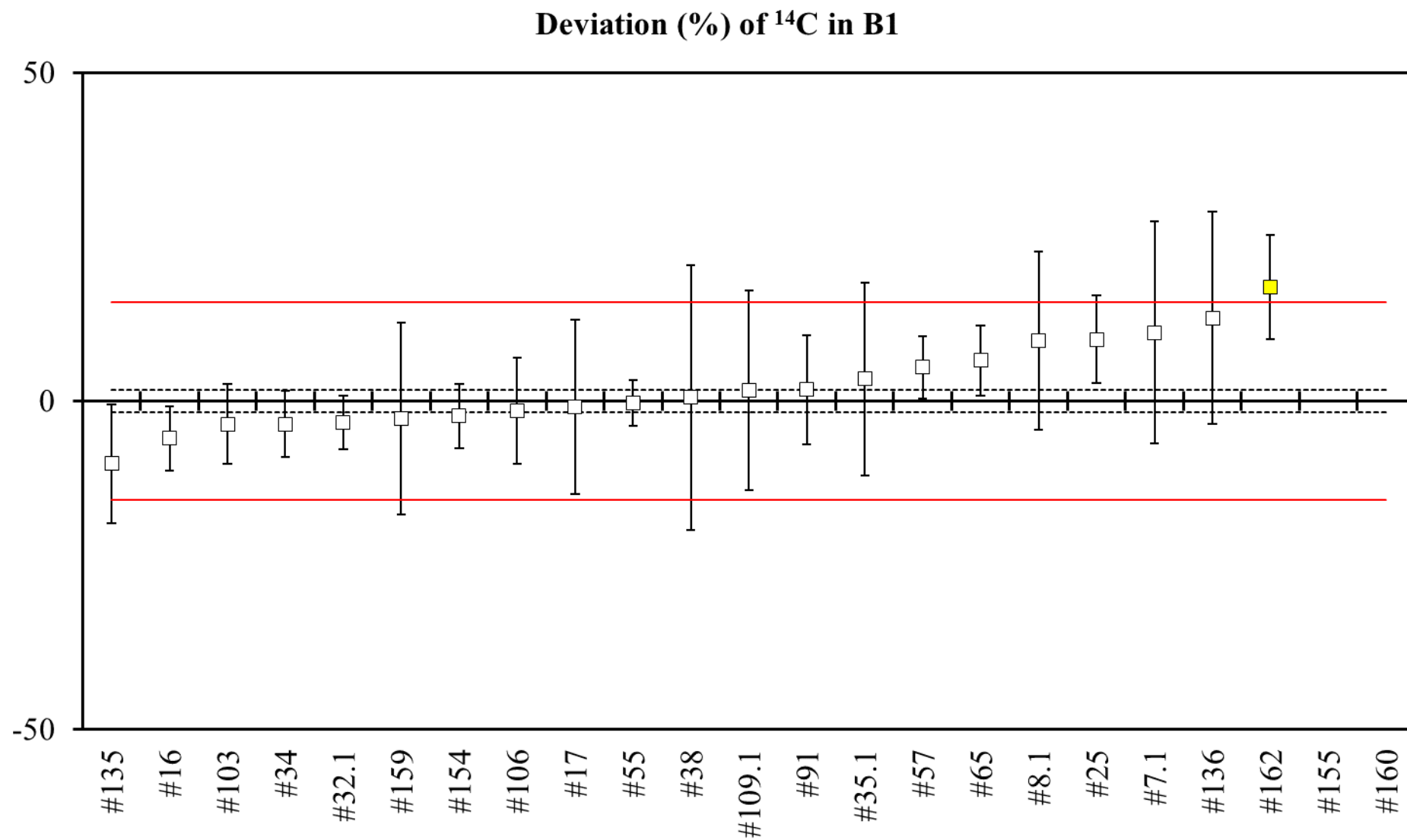


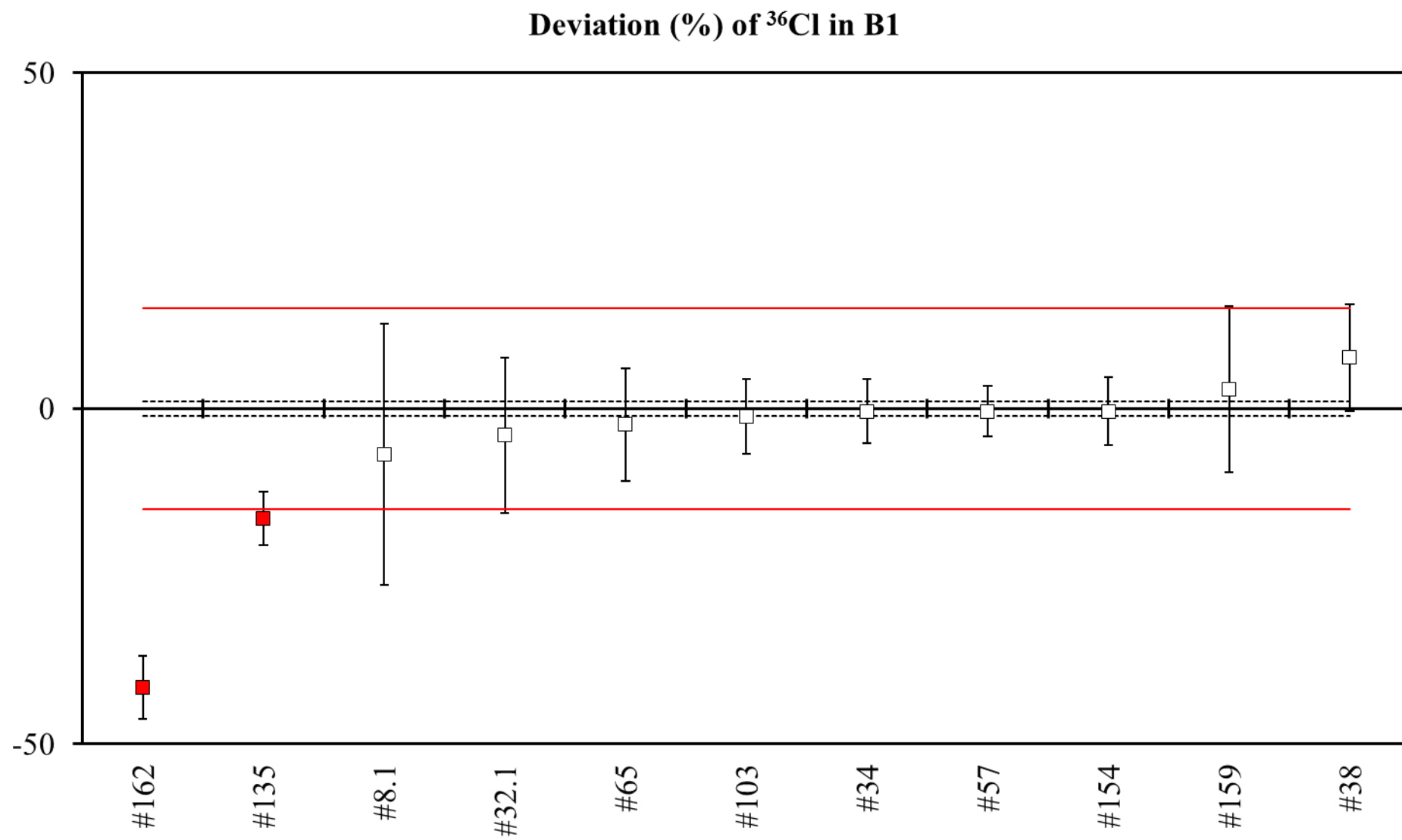




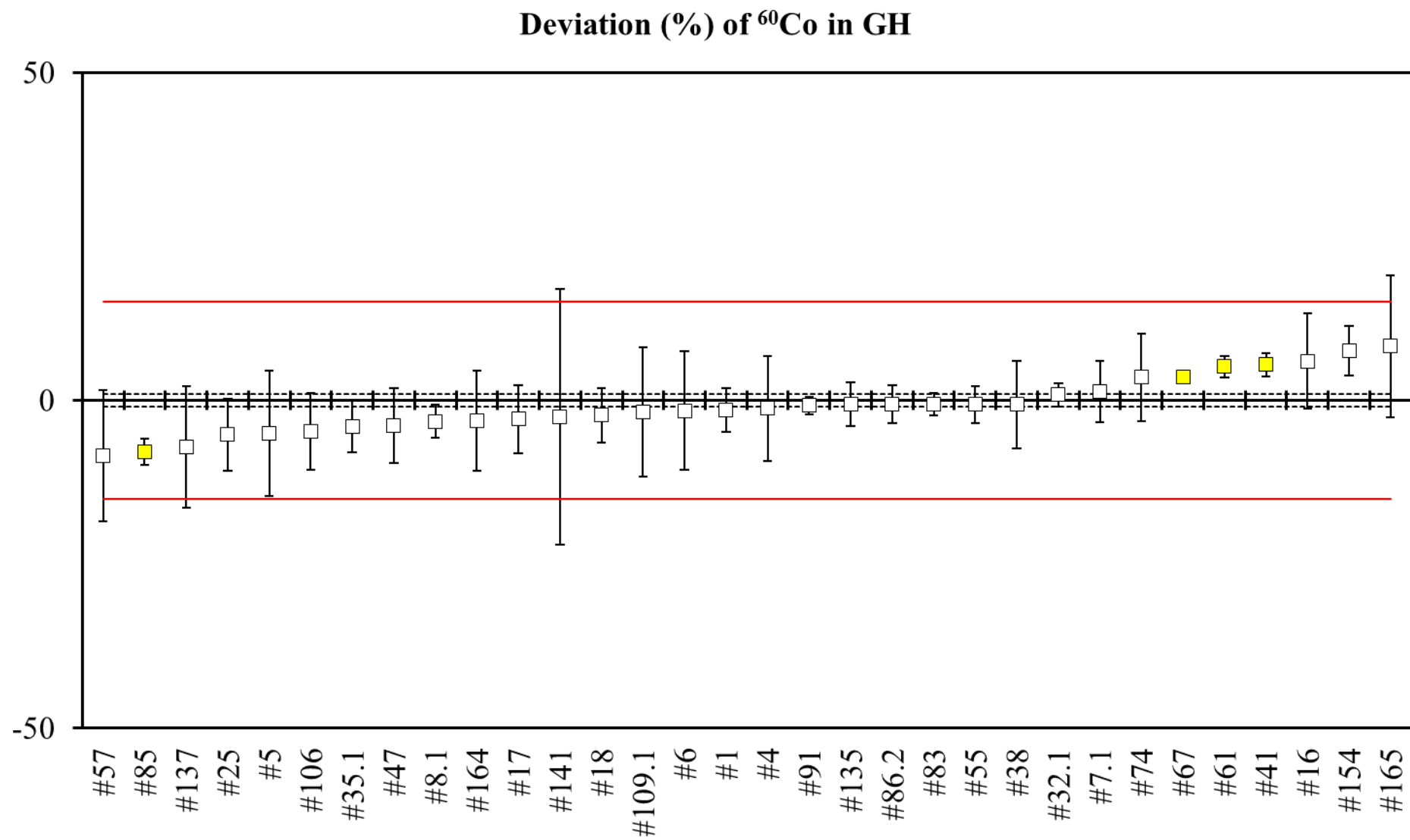
6. Beta One (B1) Deviation Plots

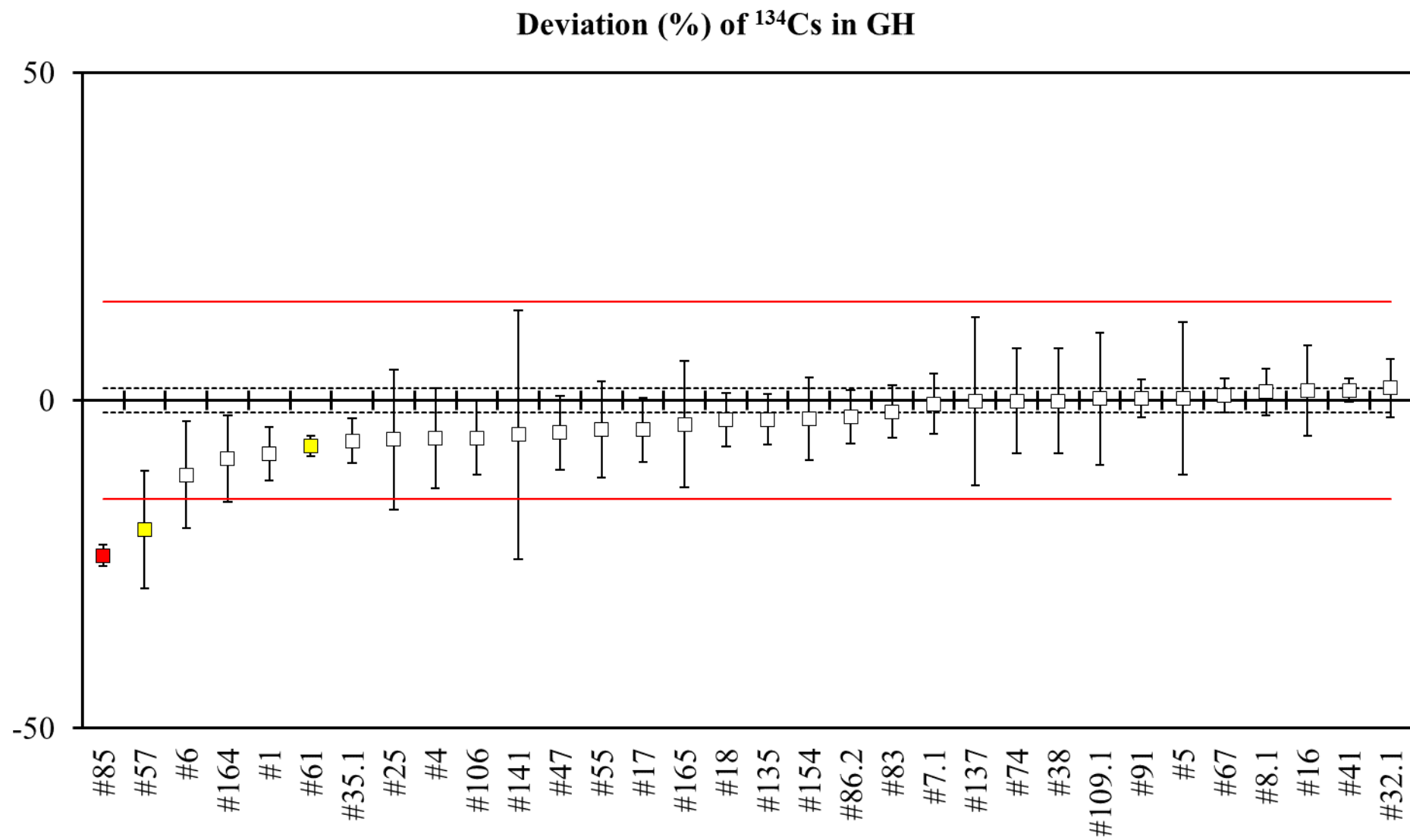


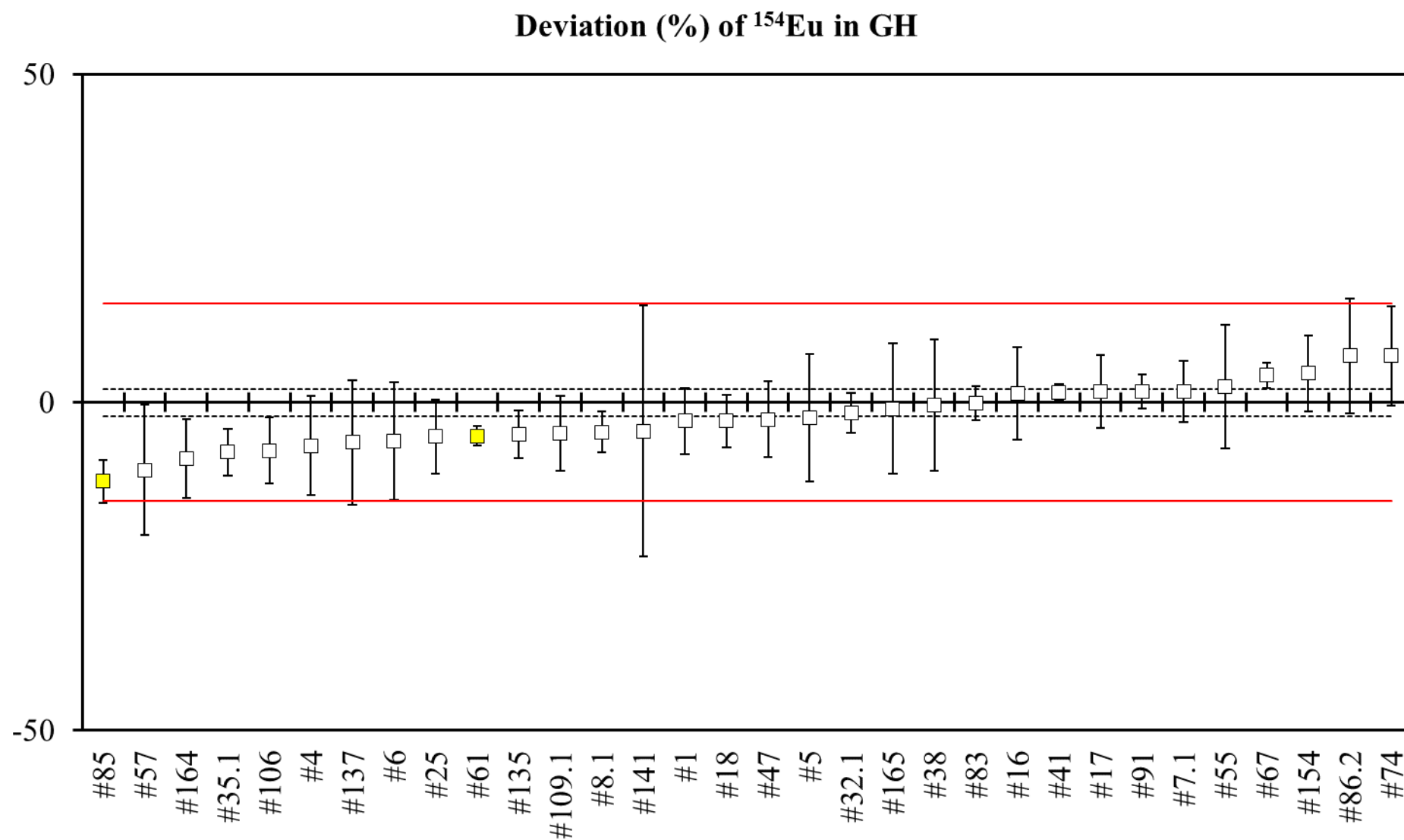




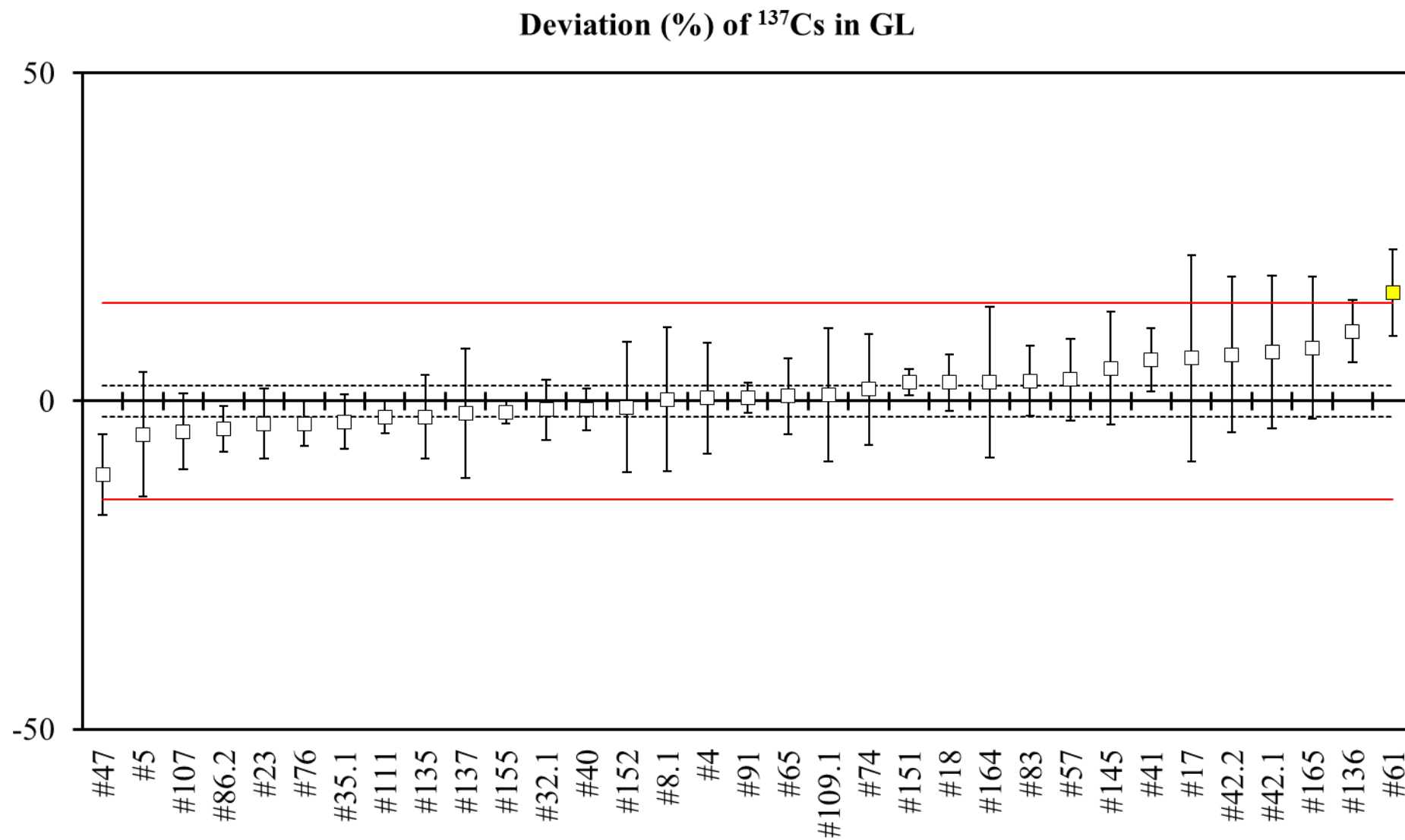
7. Gamma High (GH) Deviation Plots

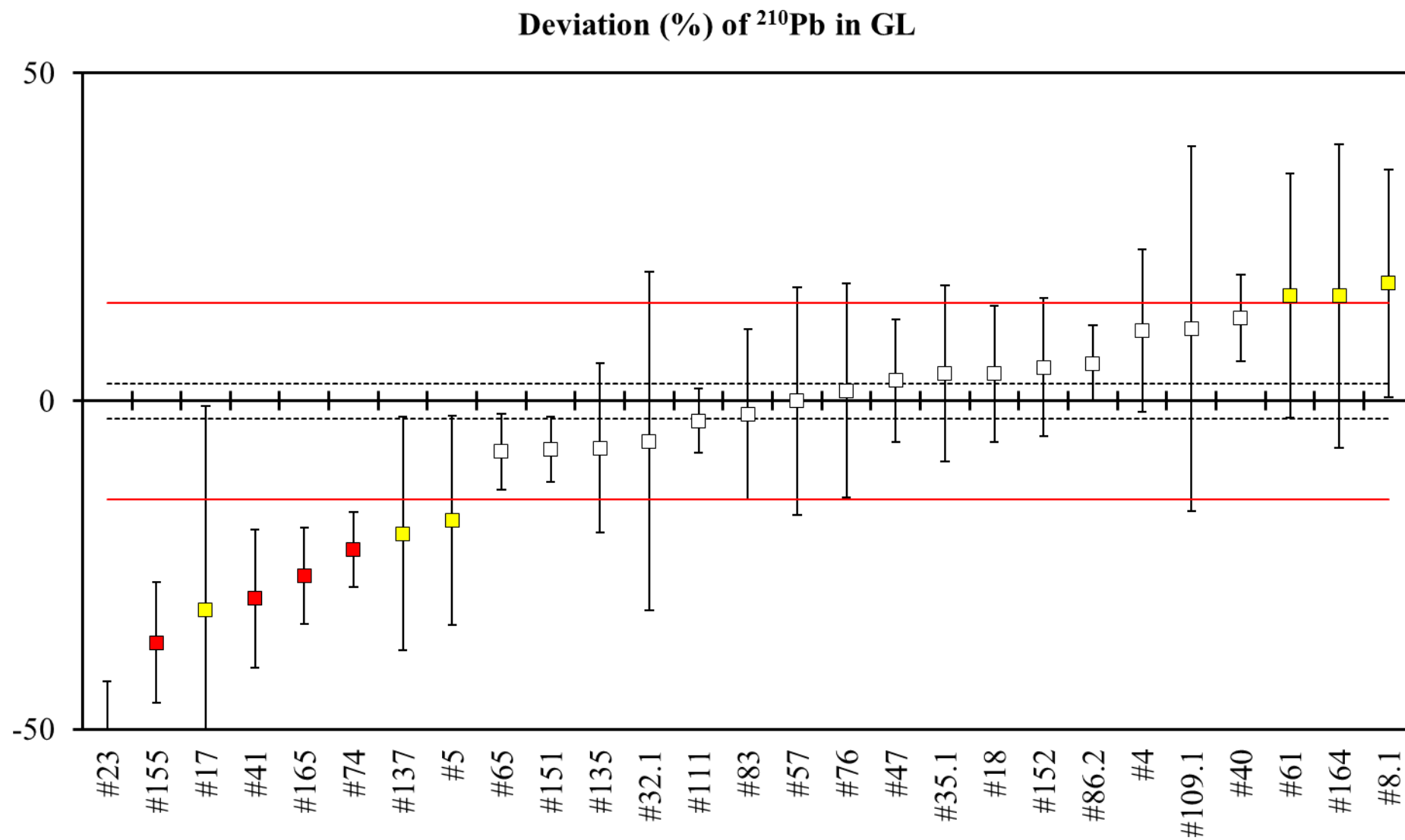


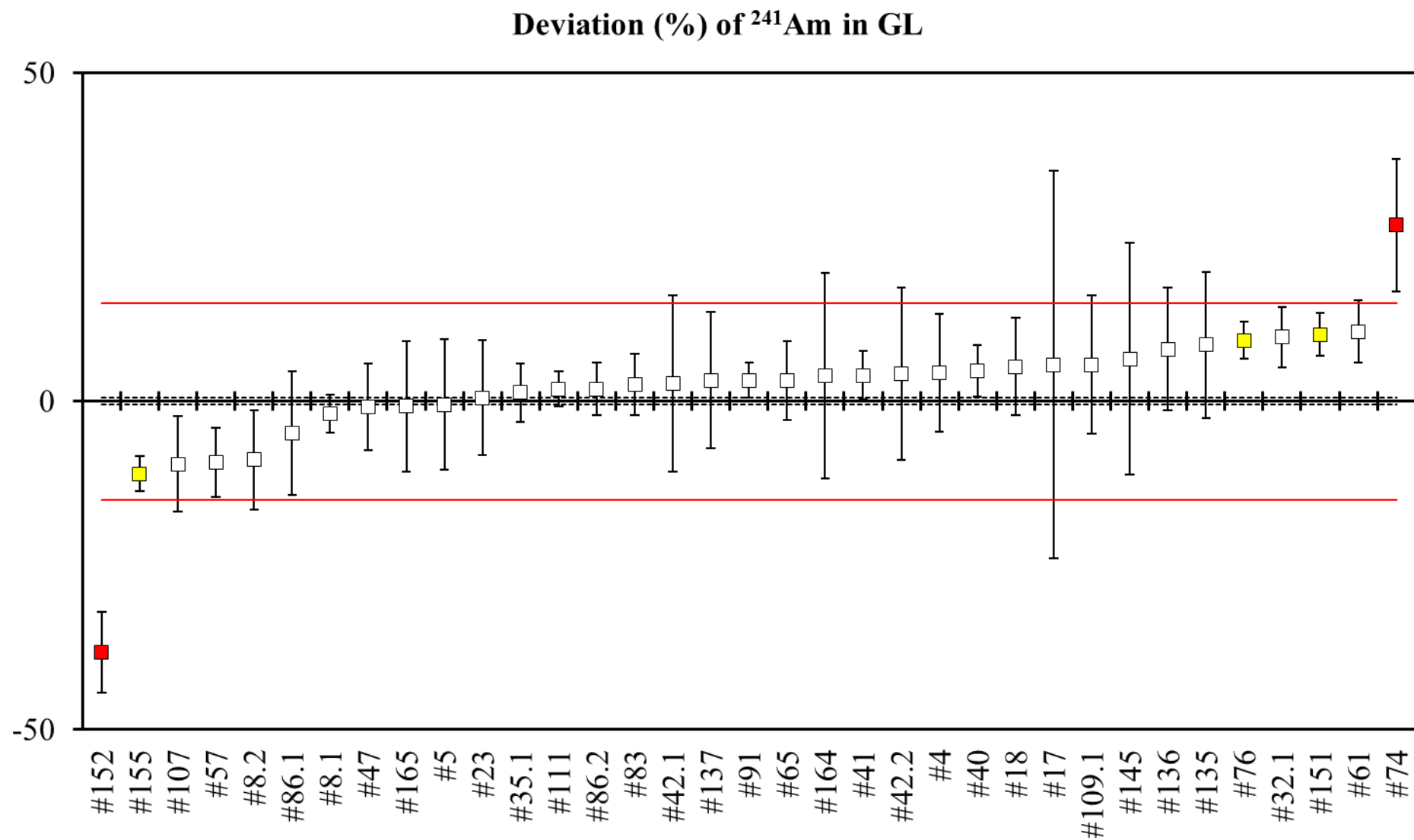




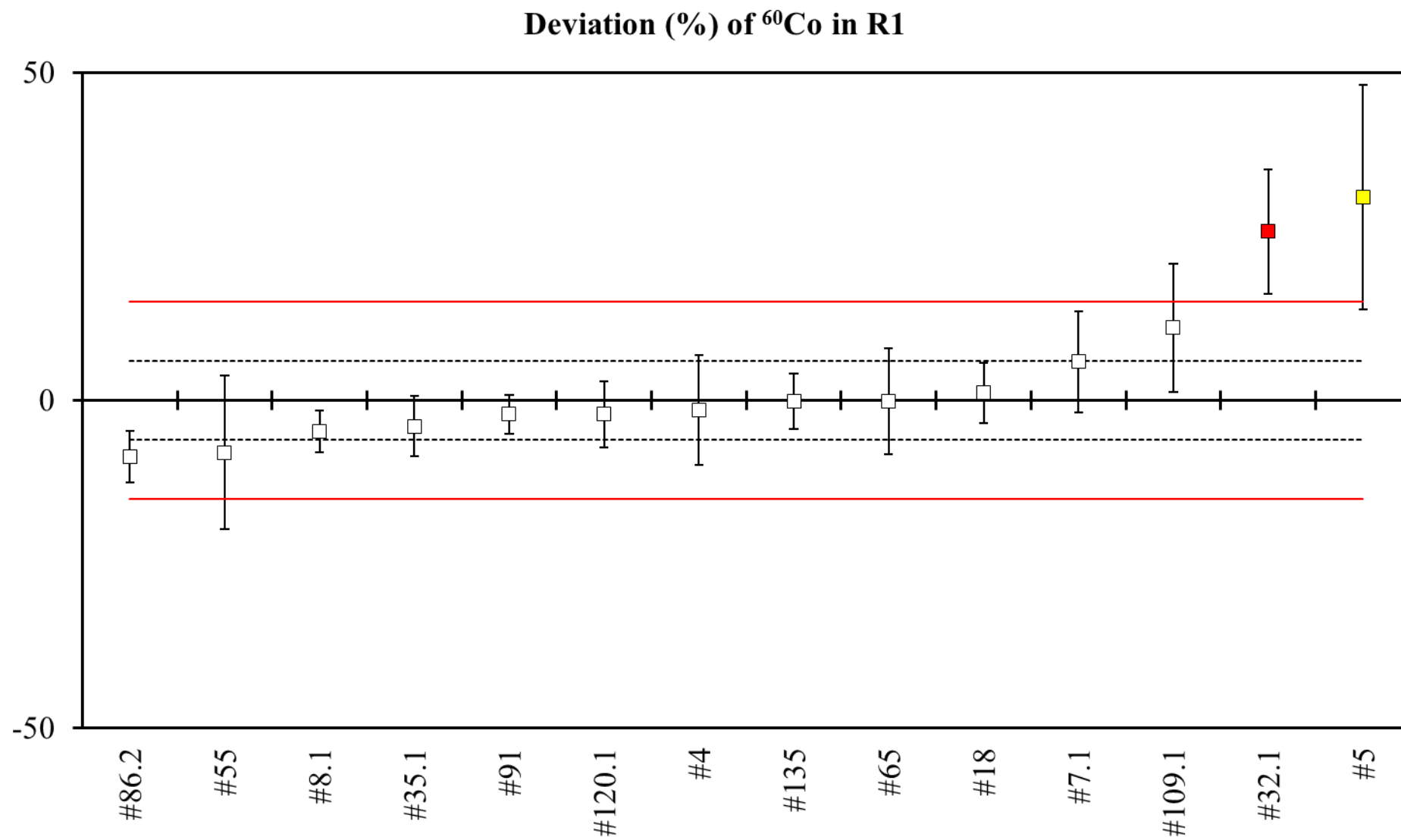
8. Gamma Low (GL) Deviation Plots

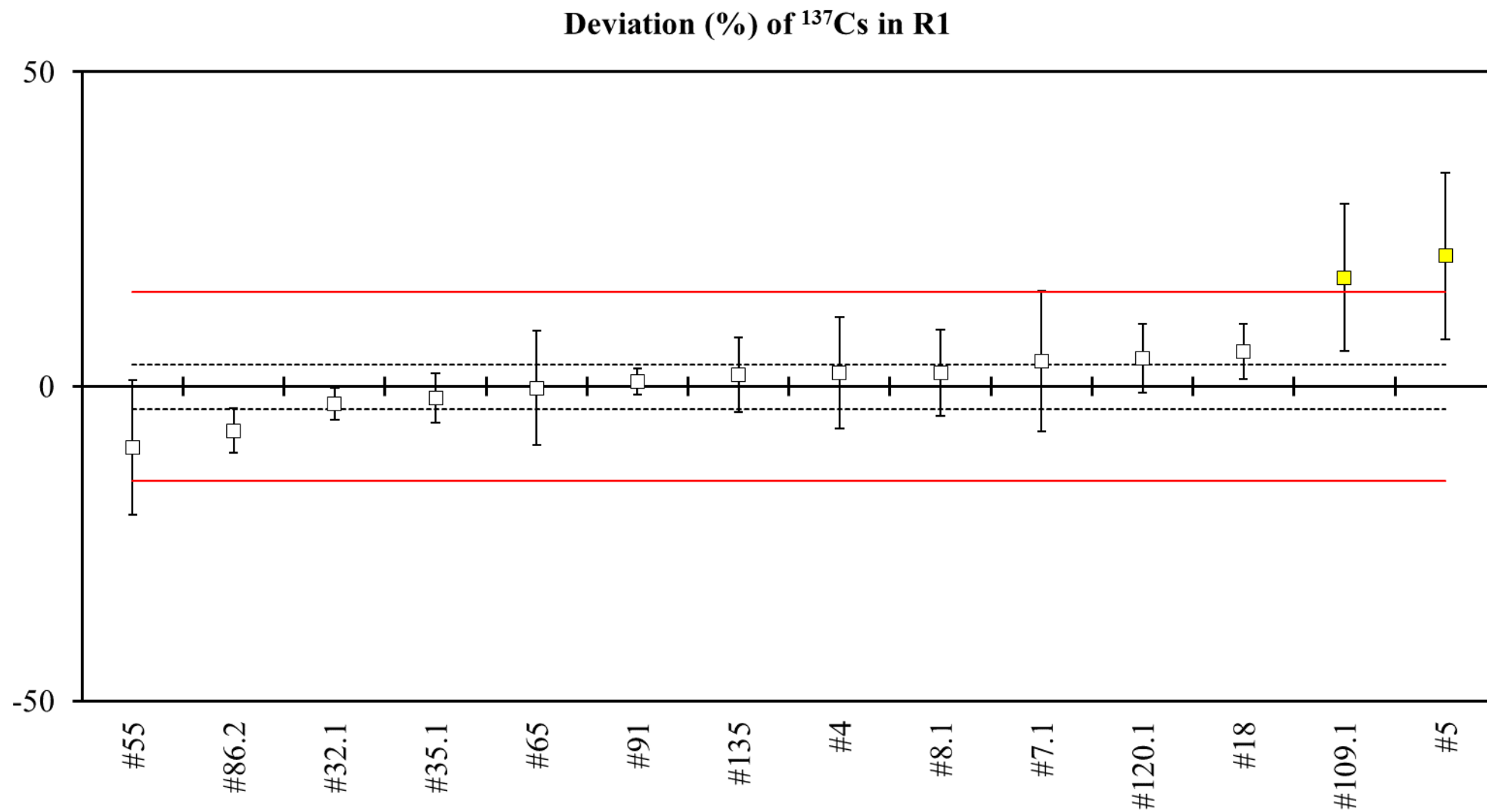


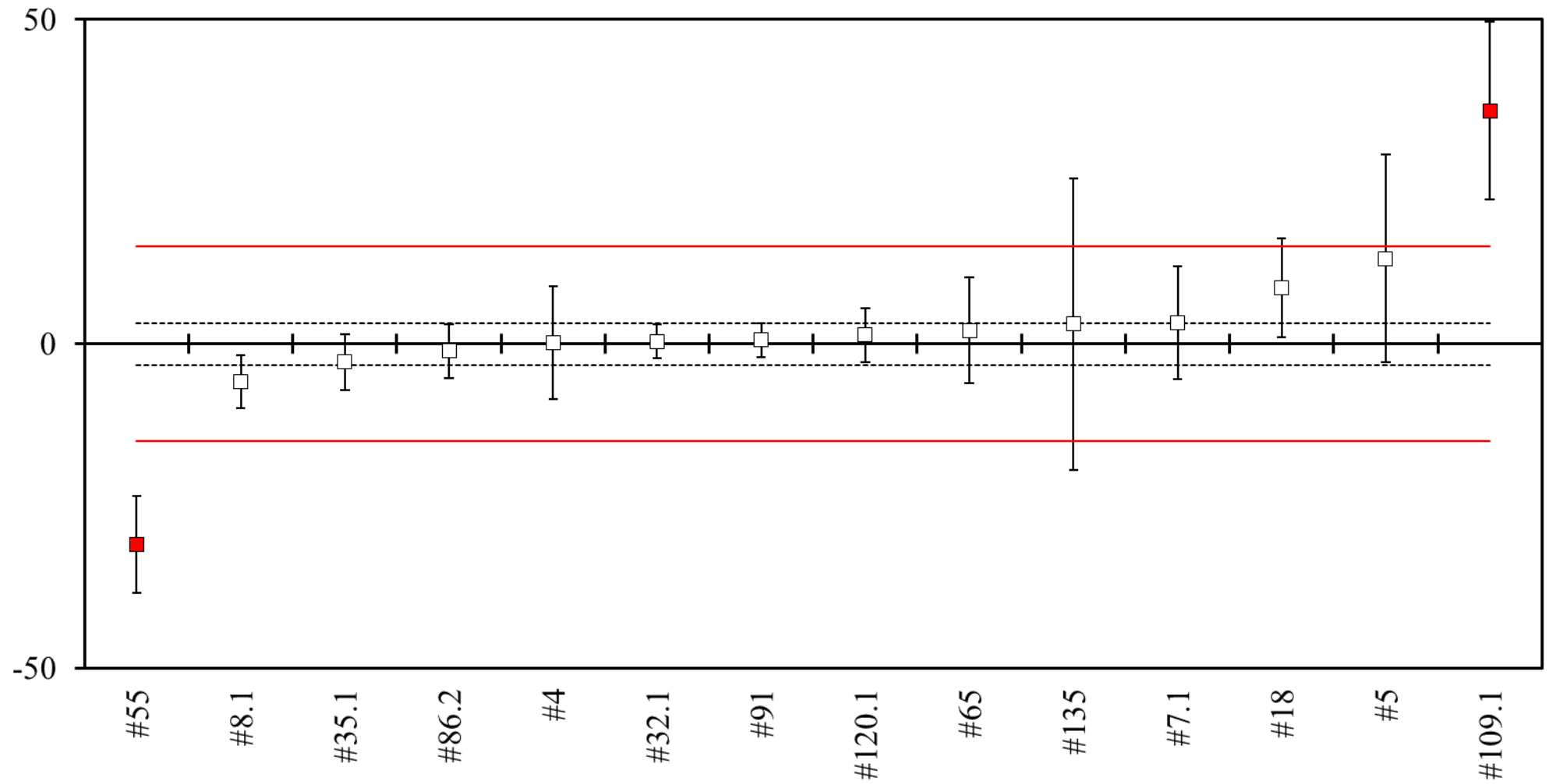




9. Resin (R1) Deviation Plot





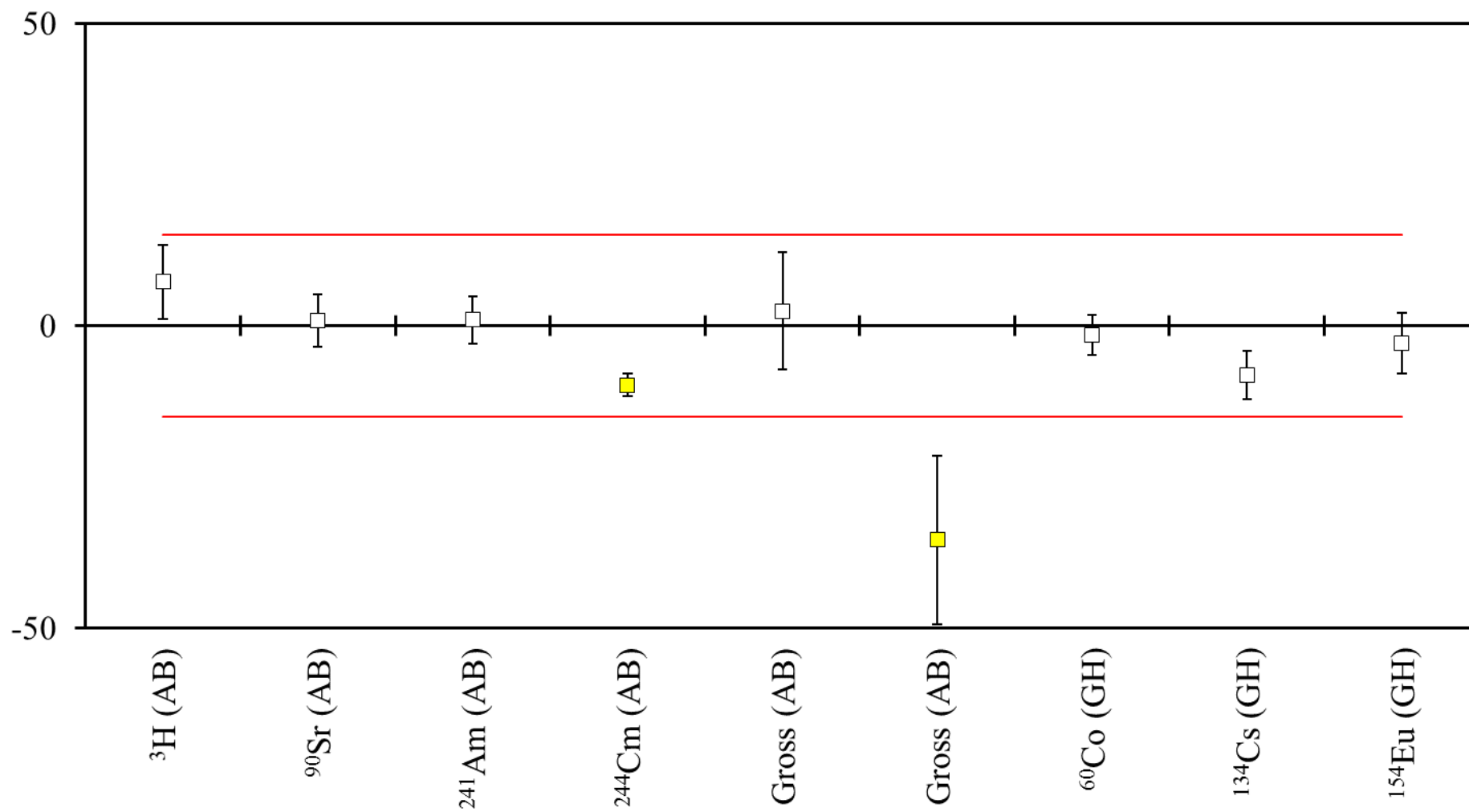
Deviation (%) of ^{241}Am in R1

10. Deviation Plots and Tabulated Results Arranged by Lab Number

NOTE:

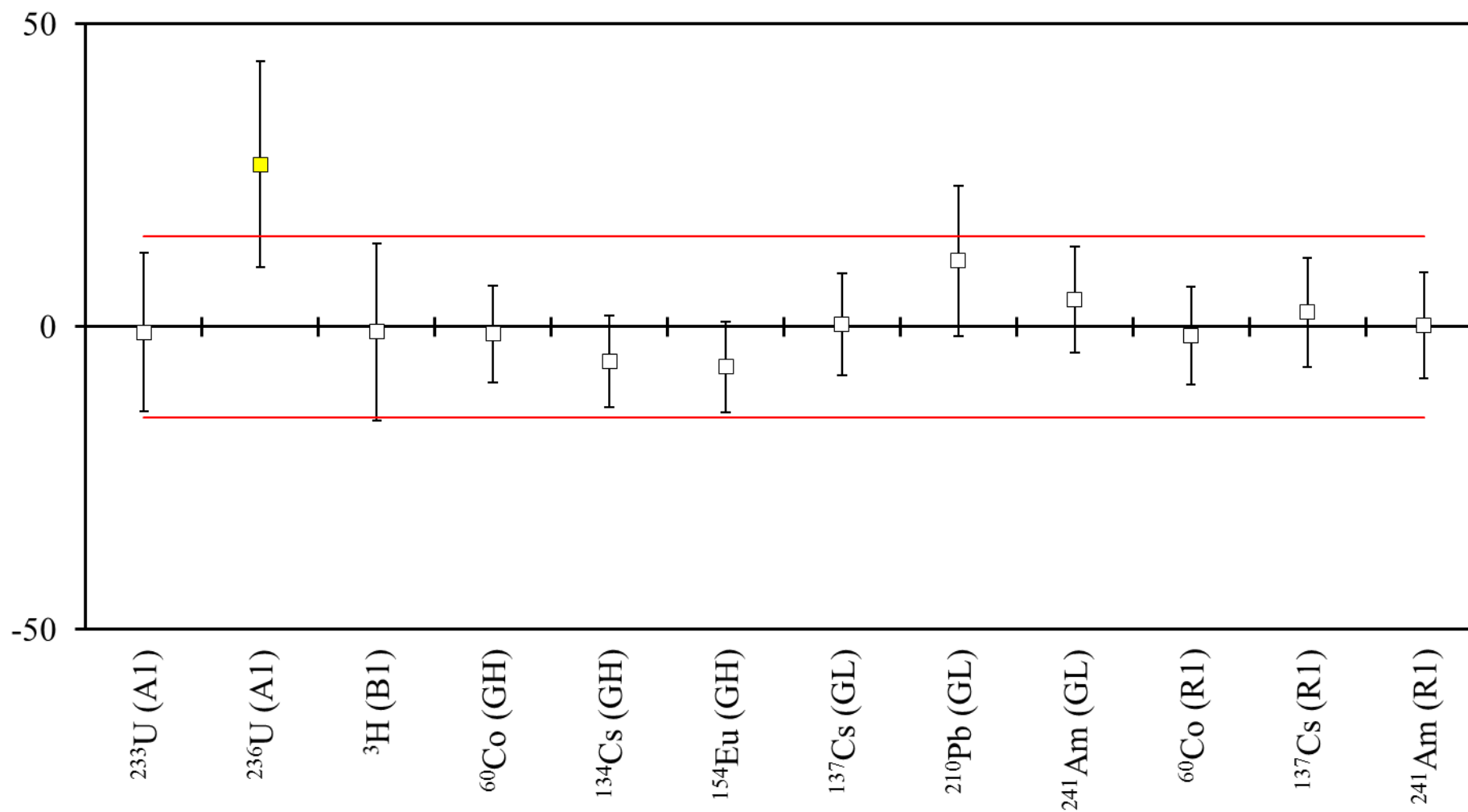
1. Data are quoted rounded, at $k=1$ (standard uncertainty). Data analysis was carried out on data as reported (i.e. before rounding). Uncertainties have been rounded to two significant figures.
2. Units of the Assigned Values and the reported results are as follows:
 - a. AB – Bq g⁻¹
 - b. A1 – Bq kg⁻¹
 - c. B1 – Bq g⁻¹
 - d. GH – Bq g⁻¹
 - e. GL – Bq g⁻¹
 - f. R1 – Bq g⁻¹

Deviation (%) of Laboratory 1



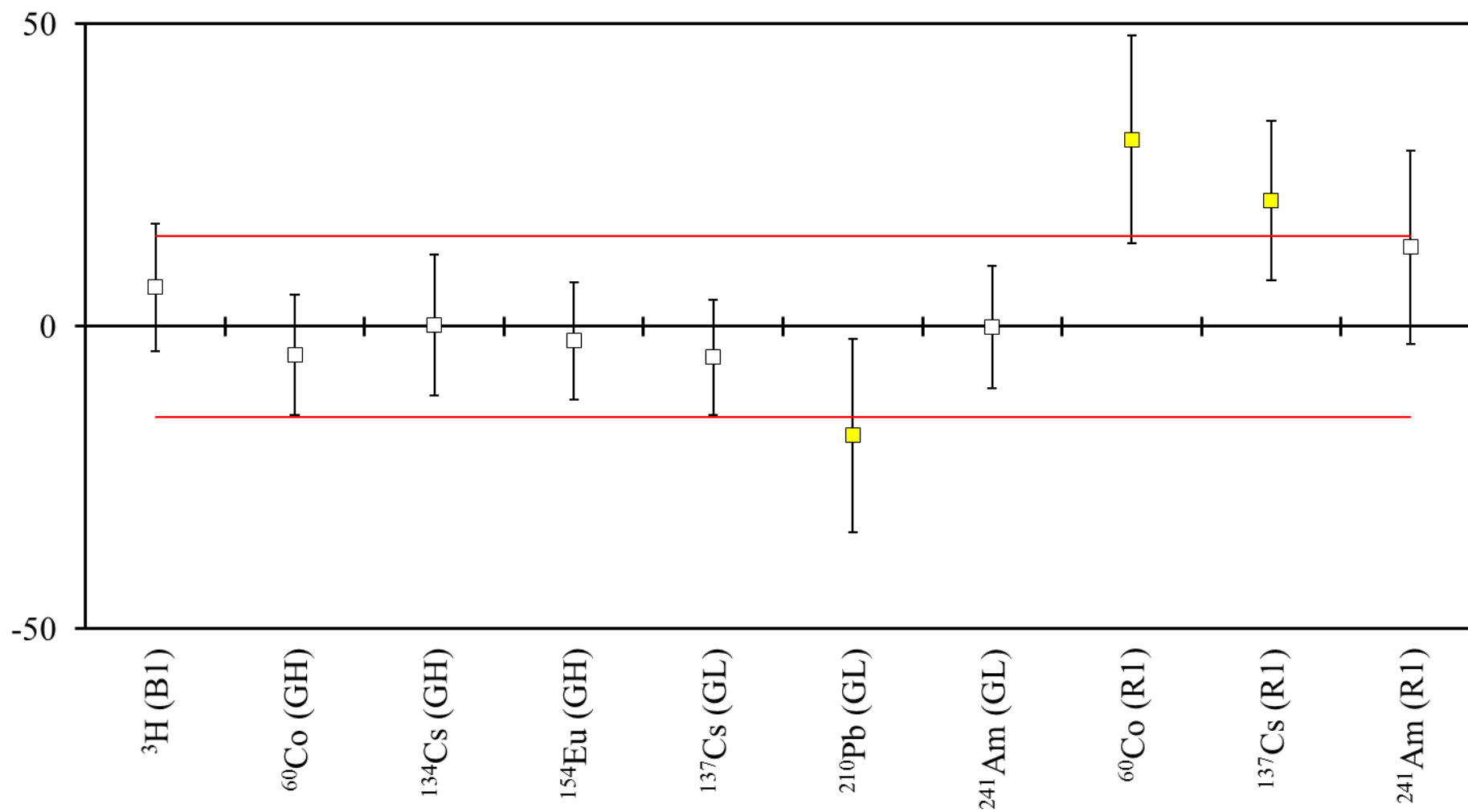
Radionuclide	Laboratory 1	NPL Assigned Value	Deviation /%	Zeta	Z Score
^3H (AB)	5.4 ± 0.3	5.031 ± 0.064	7.3	1.20	1.26
^{90}Sr (AB)	4.70 ± 0.20	4.658 ± 0.021	0.9	0.21	0.15
^{241}Am (AB)	2.60 ± 0.10	2.574 ± 0.011	1.0	0.26	0.17
^{244}Cm (AB)	14.5 ± 0.3	16.066 ± 0.054	-9.7	-5.14	-1.67
Gross alpha (AB)	20.1 ± 1.8	19.62 ± 0.61	2.4	0.25	0.42
Gross beta (AB)	6.9 ± 1.4	10.68 ± 0.81	-35.4	-2.34	-6.08
^{60}Co (GH)	11.90 ± 0.40	12.074 ± 0.047	-1.4	-0.43	-0.25
^{134}Cs (GH)	2.30 ± 0.10	2.503 ± 0.018	-8.1	-2.00	-1.39
^{154}Eu (GH)	3.90 ± 0.20	4.015 ± 0.032	-2.9	-0.57	-0.49

Deviation (%) of Laboratory 4



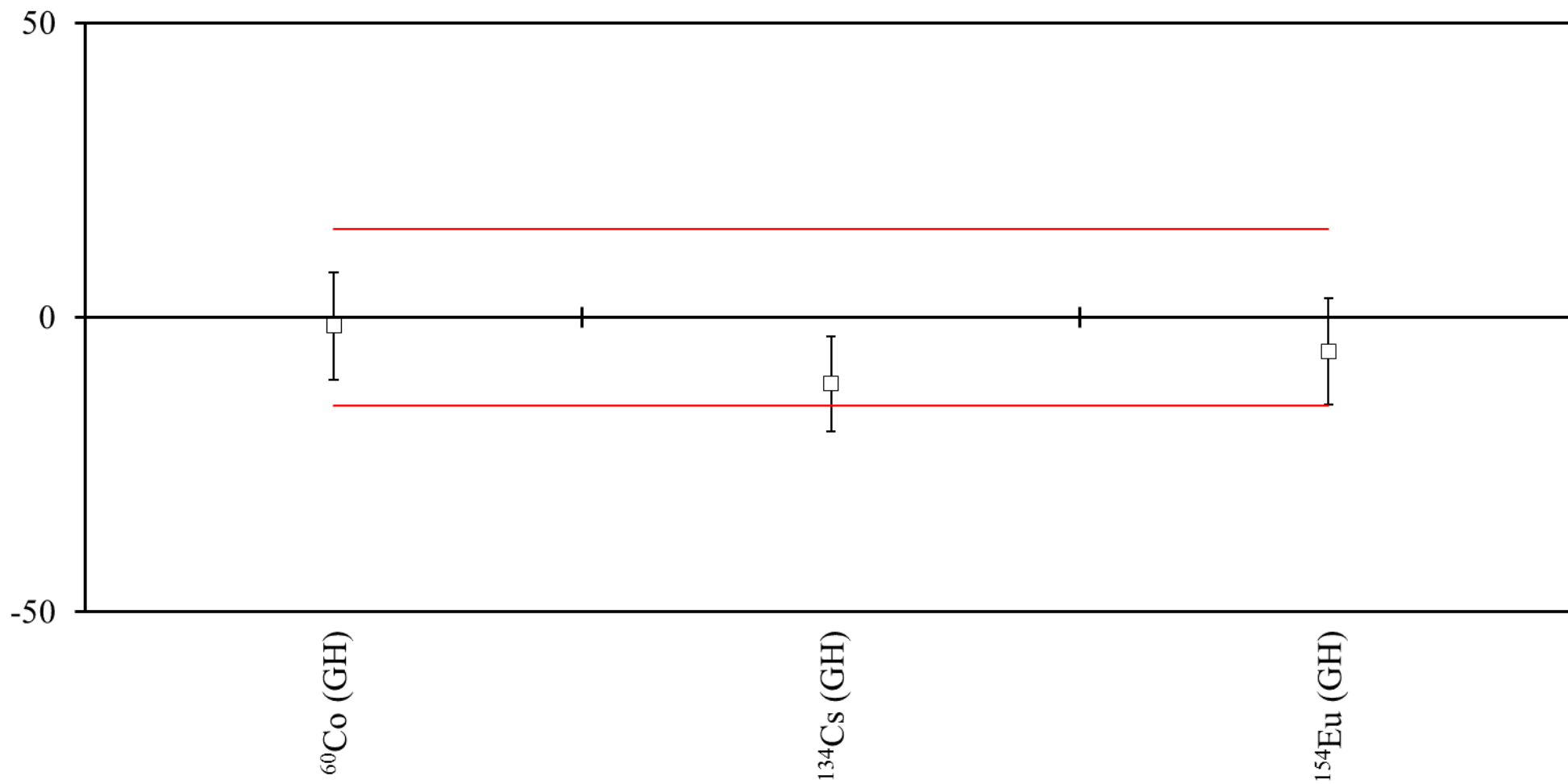
Radionuclide	Laboratory 4	NPL Assigned Value	Deviation /%	Zeta	Z Score
^{233}U (A1)	15.9 ± 2.1	16.040 ± 0.049	-0.9	-0.07	-0.15
^{236}U (A1)	14.9 ± 2.0	11.748 ± 0.029	26.8	1.58	4.61
^3H (B1)	0.95 ± 0.14	0.958 ± 0.012	-0.8	-0.06	-0.14
^{60}Co (GH)	11.93 ± 0.97	12.074 ± 0.047	-1.2	-0.15	-0.20
^{134}Cs (GH)	2.36 ± 0.19	2.503 ± 0.018	-5.7	-0.75	-0.98
^{154}Eu (GH)	3.750 ± 0.3	4.015 ± 0.032	-6.6	-0.88	-1.13
^{137}Cs (GL)	9.57 ± 0.80	9.527 ± 0.086	0.5	0.05	0.08
^{210}Pb (GL)	21.5 ± 2.4	19.39 ± 0.20	10.9	0.88	1.87
^{241}Am (GL)	15.5 ± 1.3	14.825 ± 0.032	4.6	0.52	0.78
^{60}Co (R1)	1.52 ± 0.12	1.543 ± 0.036	-1.5	-0.18	-0.26
^{137}Cs (R1)	1.95 ± 0.17	1.904 ± 0.026	2.4	0.27	0.41
^{241}Am (R1)	5.35 ± 0.46	5.338 ± 0.067	0.2	0.03	0.04

Deviation (%) of Laboratory 5



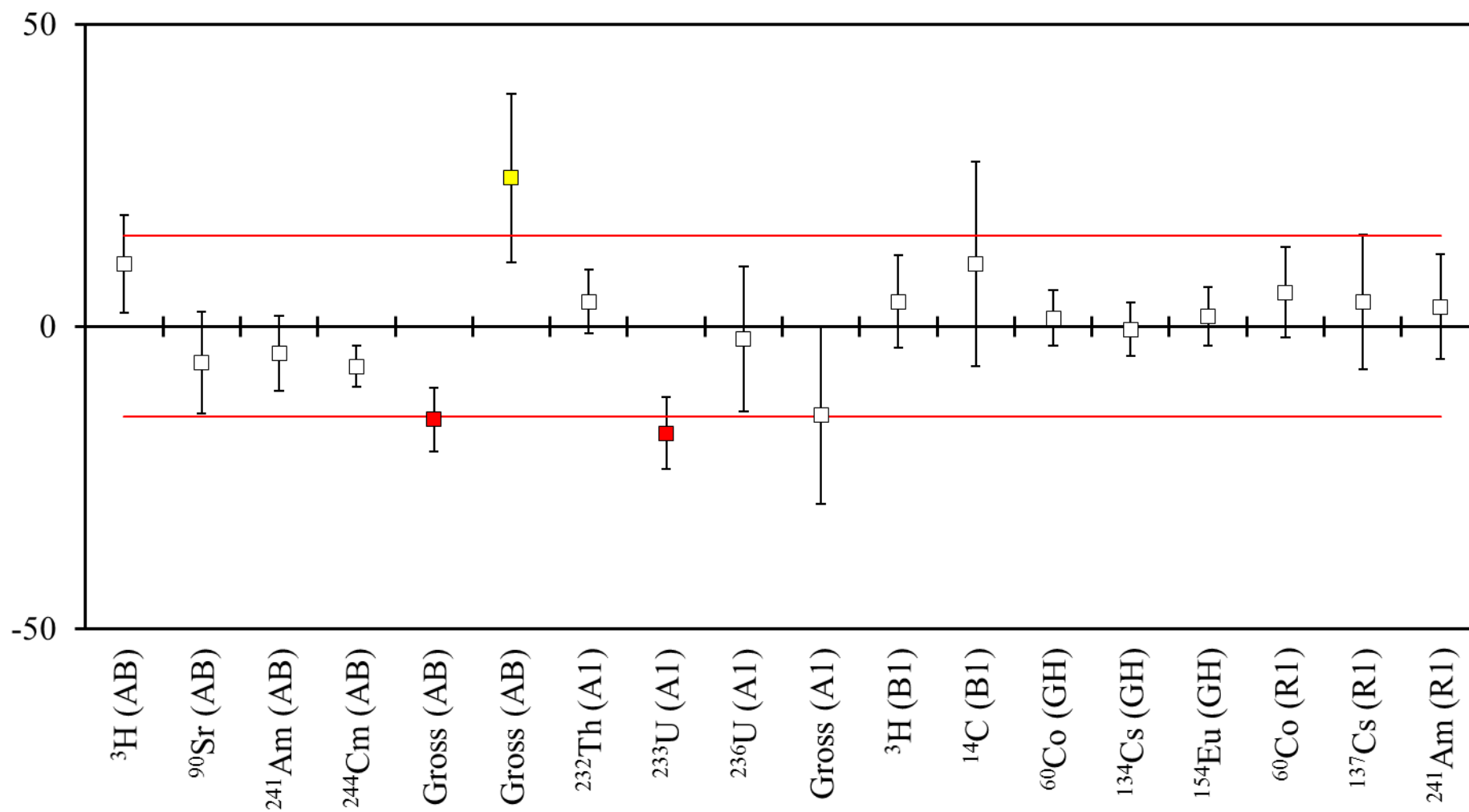
Radionuclide	Laboratory 5	NPL Assigned Value	Deviation /%	Zeta	Z Score
^3H (B1)	1.02 ± 0.10	0.958 ± 0.012	6.5	0.62	1.11
^{60}Co (GH)	11.5 ± 1.2	12.074 ± 0.047	-4.8	-0.48	-0.82
^{134}Cs (GH)	2.51 ± 0.29	2.503 ± 0.018	0.3	0.02	0.05
^{154}Eu (GH)	3.92 ± 0.39	4.015 ± 0.032	-2.4	-0.24	-0.41
^{137}Cs (GL)	9.04 ± 0.90	9.527 ± 0.086	-5.1	-0.54	-0.88
^{210}Pb (GL)	15.9 ± 3.1	19.39 ± 0.20	-18.0	-1.12	-3.09
^{241}Am (GL)	14.8 ± 1.5	14.825 ± 0.032	-0.2	-0.02	-0.03
^{60}Co (R1)	2.02 ± 0.26	1.543 ± 0.036	30.9	1.82	5.31
^{137}Cs (R1)	2.30 ± 0.25	1.904 ± 0.026	20.8	1.58	3.57
^{241}Am (R1)	6.04 ± 0.85	5.338 ± 0.067	13.2	0.82	2.26

Deviation (%) of Laboratory 6



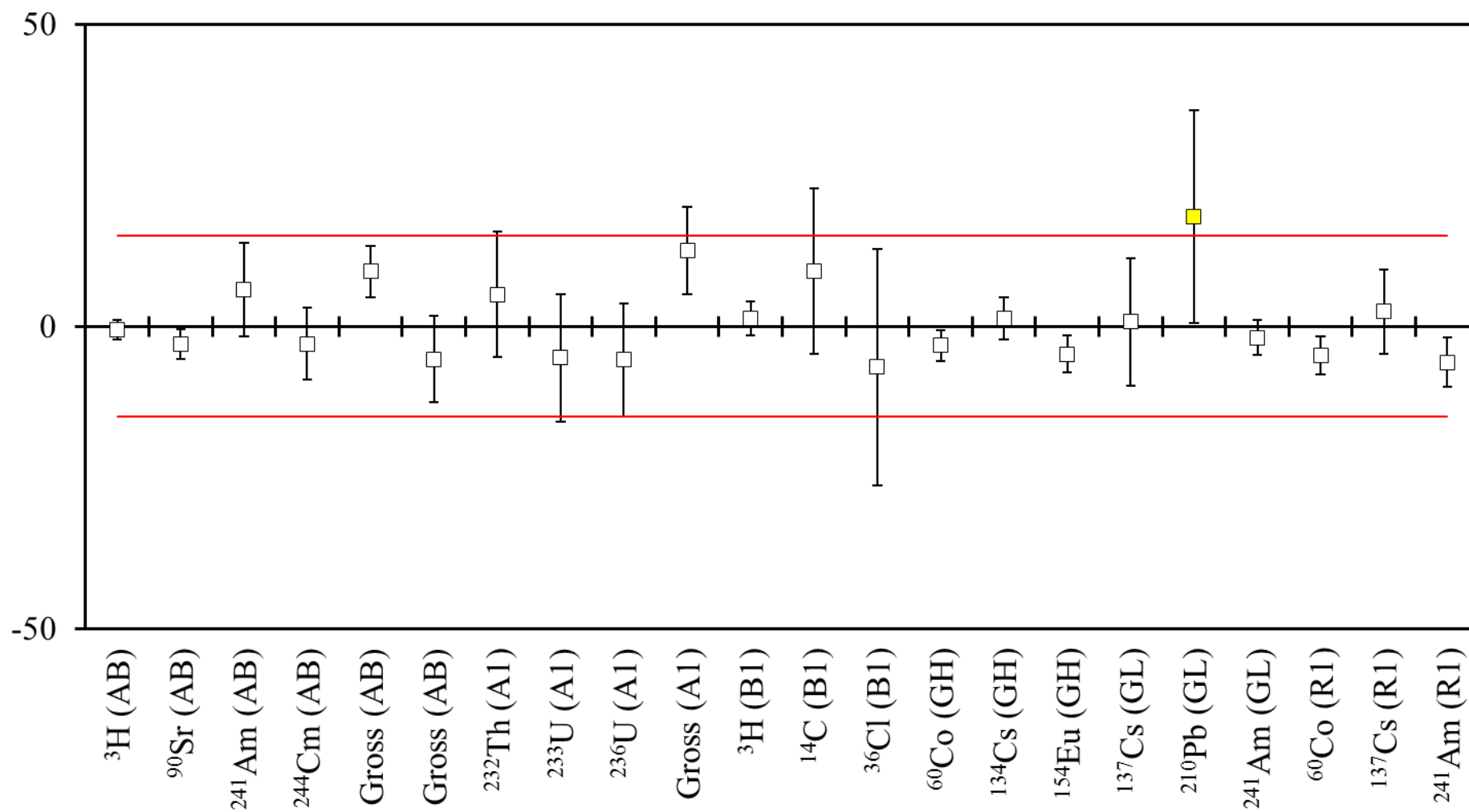
Radionuclide	Laboratory 6	NPL Assigned Value	Deviation /%	Zeta	Z Score
^{60}Co (GH)	11.9 ± 1.1	12.074 ± 0.047	-1.4	-0.16	-0.25
^{134}Cs (GH)	2.22 ± 0.20	2.503 ± 0.018	-11.3	-1.41	-1.94
^{154}Eu (GH)	3.78 ± 0.36	4.015 ± 0.032	-5.9	-0.65	-1.01

Deviation (%) of Laboratory 7.1



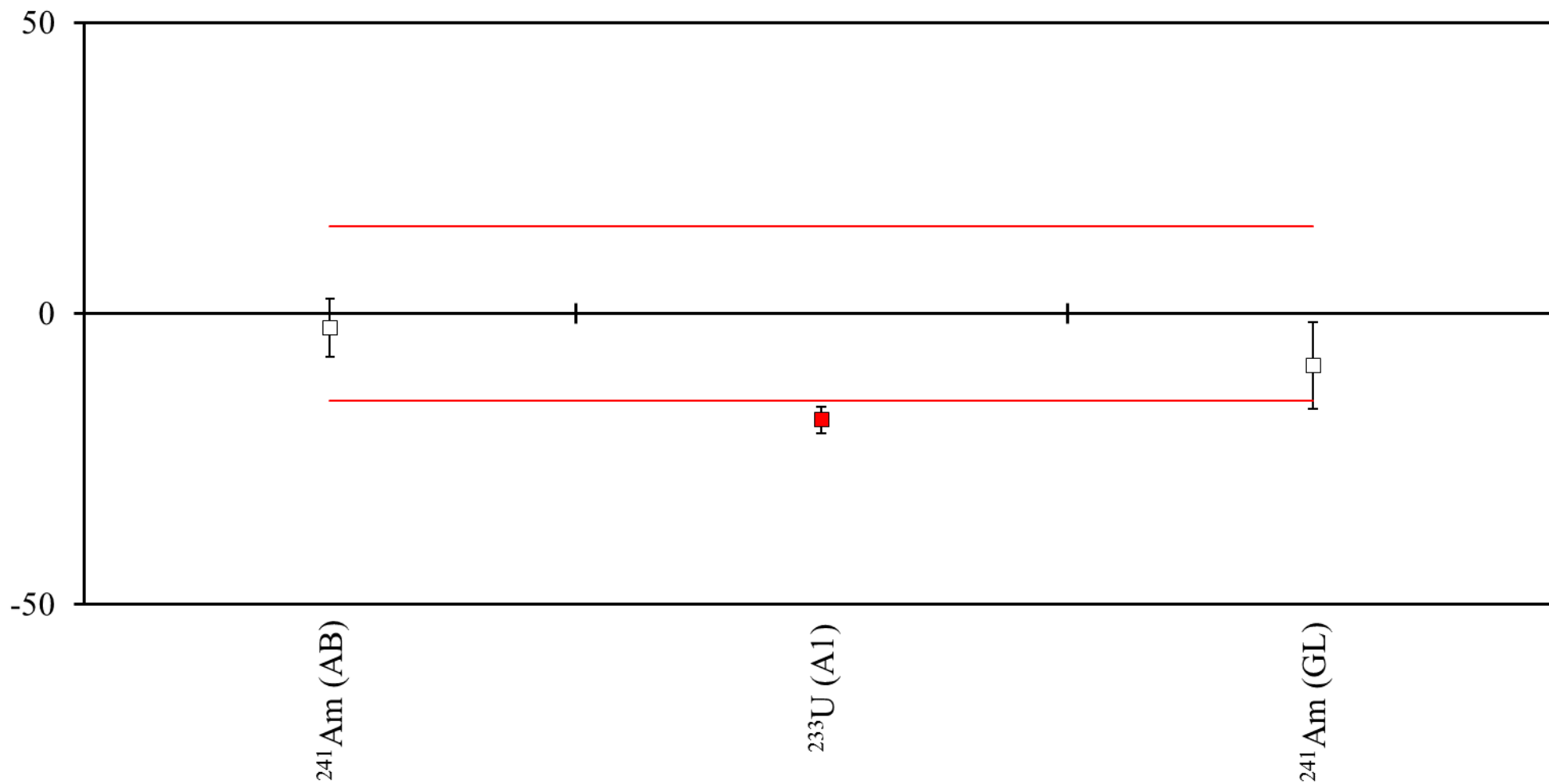
Radionuclide	Laboratory 7.1	NPL Assigned Value	Deviation /%	Zeta	Z Score
^3H (AB)	5.55 ± 0.40	5.031 ± 0.064	10.3	1.28	1.77
^{90}Sr (AB)	4.38 ± 0.39	4.658 ± 0.021	-6.0	-0.71	-1.02
^{241}Am (AB)	2.46 ± 0.16	2.574 ± 0.011	-4.4	-0.71	-0.76
^{244}Cm (AB)	15.00 ± 0.55	16.066 ± 0.054	-6.6	-1.93	-1.14
Gross alpha (AB)	16.60 ± 0.90	19.62 ± 0.61	-15.4	-2.78	-2.64
Gross beta (AB)	13.3 ± 1.1	10.68 ± 0.81	24.5	1.92	4.21
^{232}Th (A1)	3.44 ± 0.17	3.305 ± 0.032	4.1	0.78	0.70
^{233}U (A1)	13.20 ± 0.95	16.040 ± 0.049	-17.7	-2.99	-3.04
^{236}U (A1)	11.5 ± 1.4	11.748 ± 0.029	-2.1	-0.18	-0.36
Gross alpha (A1)	31.9 ± 5.2	37.4 ± 2.1	-14.7	-0.98	-2.53
^3H (B1)	0.997 ± 0.072	0.958 ± 0.012	4.1	0.53	0.70
^{14}C (B1)	0.549 ± 0.084	0.4974 ± 0.0033	10.4	0.61	1.78
Gross beta (B1)	1.62 ± 0.13	-	-	-	-
^{60}Co (GH)	12.24 ± 0.56	12.074 ± 0.047	1.4	0.30	0.24
^{134}Cs (GH)	2.49 ± 0.11	2.503 ± 0.018	-0.5	-0.12	-0.09
^{154}Eu (GH)	4.08 ± 0.19	4.015 ± 0.032	1.6	0.34	0.28
^{60}Co (R1)	1.63 ± 0.11	1.543 ± 0.036	5.6	0.75	0.97
^{137}Cs (R1)	1.98 ± 0.21	1.904 ± 0.026	4.0	0.36	0.69
^{241}Am (R1)	5.51 ± 0.46	5.338 ± 0.067	3.2	0.37	0.55

Deviation (%) of Laboratory 8.1



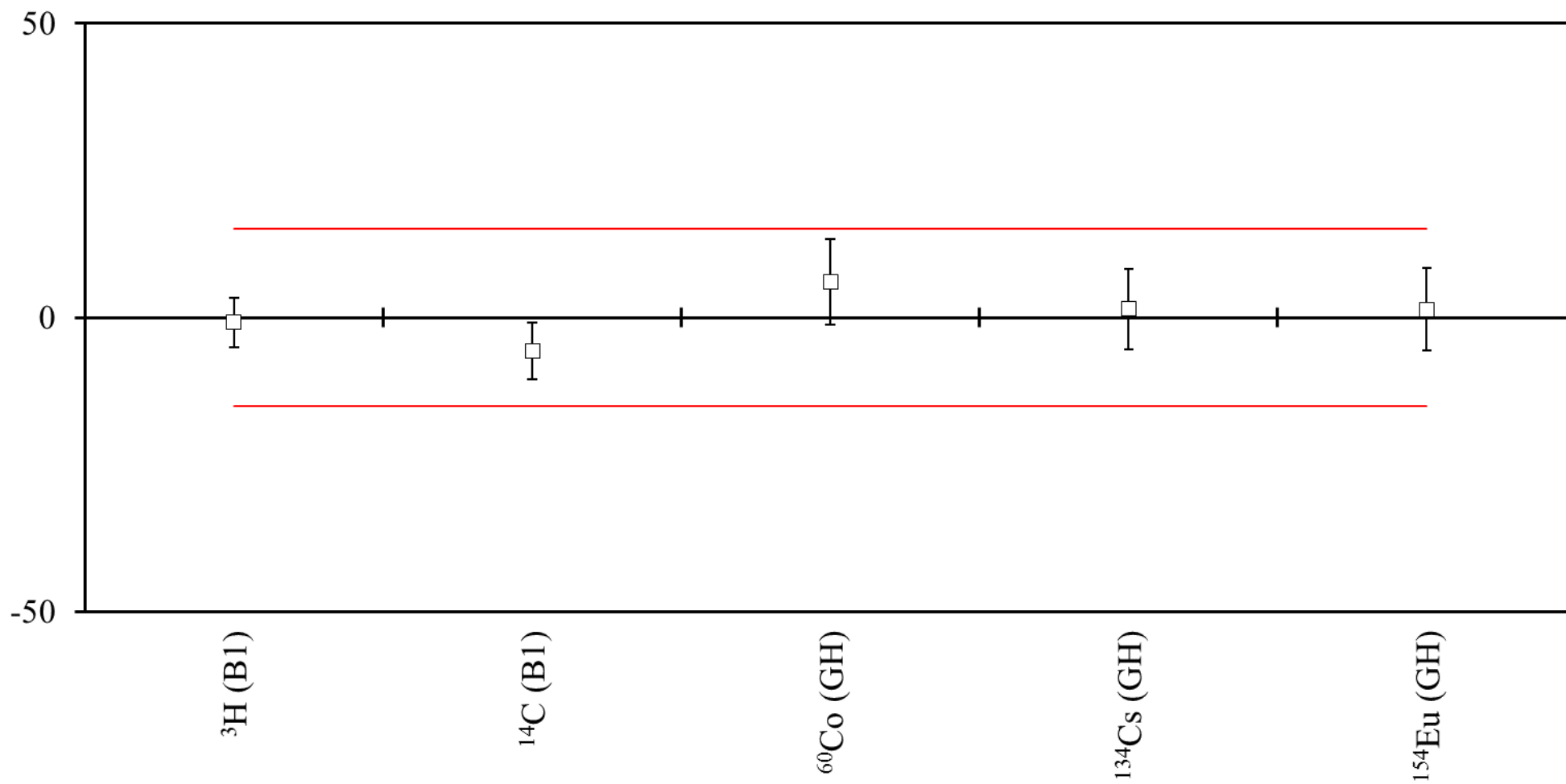
Radionuclide	Laboratory 8.1	NPL Assigned Value	Deviation /%	Zeta	Z Score
^3H (AB)	5.003 ± 0.054	5.031 ± 0.064	-0.6	-0.33	-0.10
^{90}Sr (AB)	4.52 ± 0.11	4.658 ± 0.021	-3.0	-1.23	-0.51
^{241}Am (AB)	2.73 ± 0.20	2.574 ± 0.011	6.1	0.78	1.04
^{244}Cm (AB)	15.60 ± 0.95	16.066 ± 0.054	-2.9	-0.49	-0.50
Gross alpha (AB)	21.40 ± 0.49	19.62 ± 0.61	9.1	2.27	1.56
Gross beta (AB)	10.100 ± 0.029	10.68 ± 0.81	-5.4	-0.72	-0.93
^{232}Th (A1)	3.48 ± 0.34	3.305 ± 0.032	5.3	0.51	0.91
^{233}U (A1)	15.2 ± 1.7	16.040 ± 0.049	-5.2	-0.49	-0.90
^{236}U (A1)	11.1 ± 1.1	11.748 ± 0.029	-5.5	-0.59	-0.95
Gross alpha (A1)	42.1 ± 1.3	37.4 ± 2.1	12.6	1.90	2.16
^3H (B1)	0.971 ± 0.024	0.958 ± 0.012	1.4	0.48	0.23
^{14}C (B1)	0.543 ± 0.068	0.4974 ± 0.0033	9.2	0.67	1.57
^{36}Cl (B1)	0.234 ± 0.049	0.2509 ± 0.0010	-6.7	-0.34	-1.16
^{60}Co (GH)	11.690 ± 0.3	12.074 ± 0.047	-3.2	-1.26	-0.55
^{134}Cs (GH)	2.535 ± 0.086	2.503 ± 0.018	1.3	0.36	0.22
^{154}Eu (GH)	3.83 ± 0.12	4.015 ± 0.032	-4.6	-1.49	-0.79
^{137}Cs (GL)	9.6 ± 1.0	9.527 ± 0.086	0.8	0.07	0.13
^{210}Pb (GL)	22.9 ± 3.4	19.39 ± 0.20	18.1	1.03	3.11
^{241}Am (GL)	14.55 ± 0.43	14.825 ± 0.032	-1.9	-0.64	-0.32
^{60}Co (R1)	1.469 ± 0.035	1.543 ± 0.036	-4.8	-1.47	-0.82
^{137}Cs (R1)	1.95 ± 0.13	1.904 ± 0.026	2.4	0.35	0.41
^{241}Am (R1)	5.02 ± 0.21	5.338 ± 0.067	-6.0	-1.44	-1.02

Deviation (%) of Laboratory 8.2



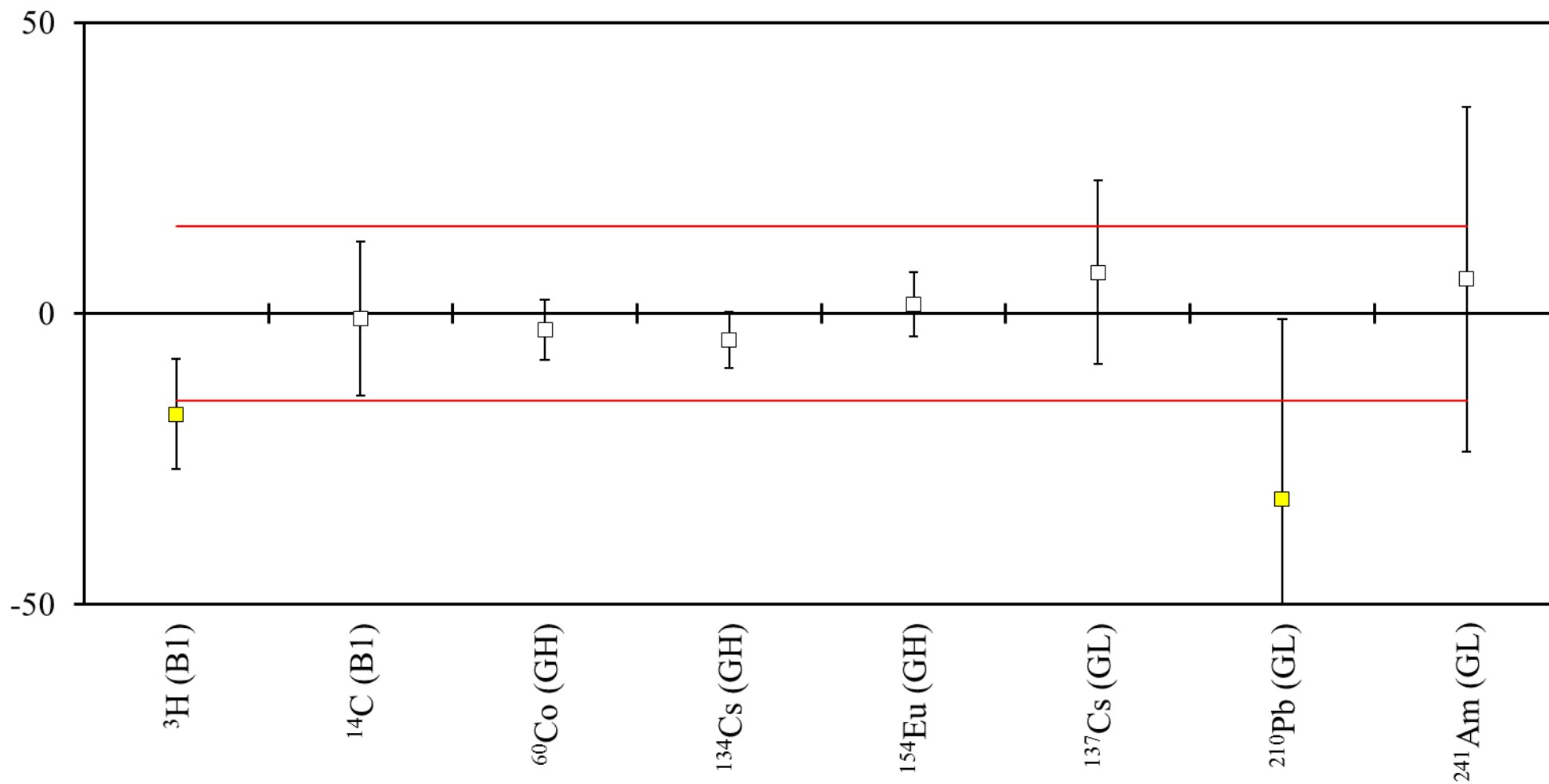
Radionuclide	Laboratory 8.2	NPL Assigned Value	Deviation /%	Zeta	Z Score
²⁴¹ Am (AB)	2.51 ± 0.13	2.574 ± 0.011	-2.5	-0.49	-0.43
²³³ U (A1)	13.10 ± 0.36	16.040 ± 0.049	-18.3	-8.09	-3.15
²⁴¹ Am (GL)	13.5 ± 1.1	14.825 ± 0.032	-8.9	-1.20	-1.53

Deviation (%) of Laboratory 16



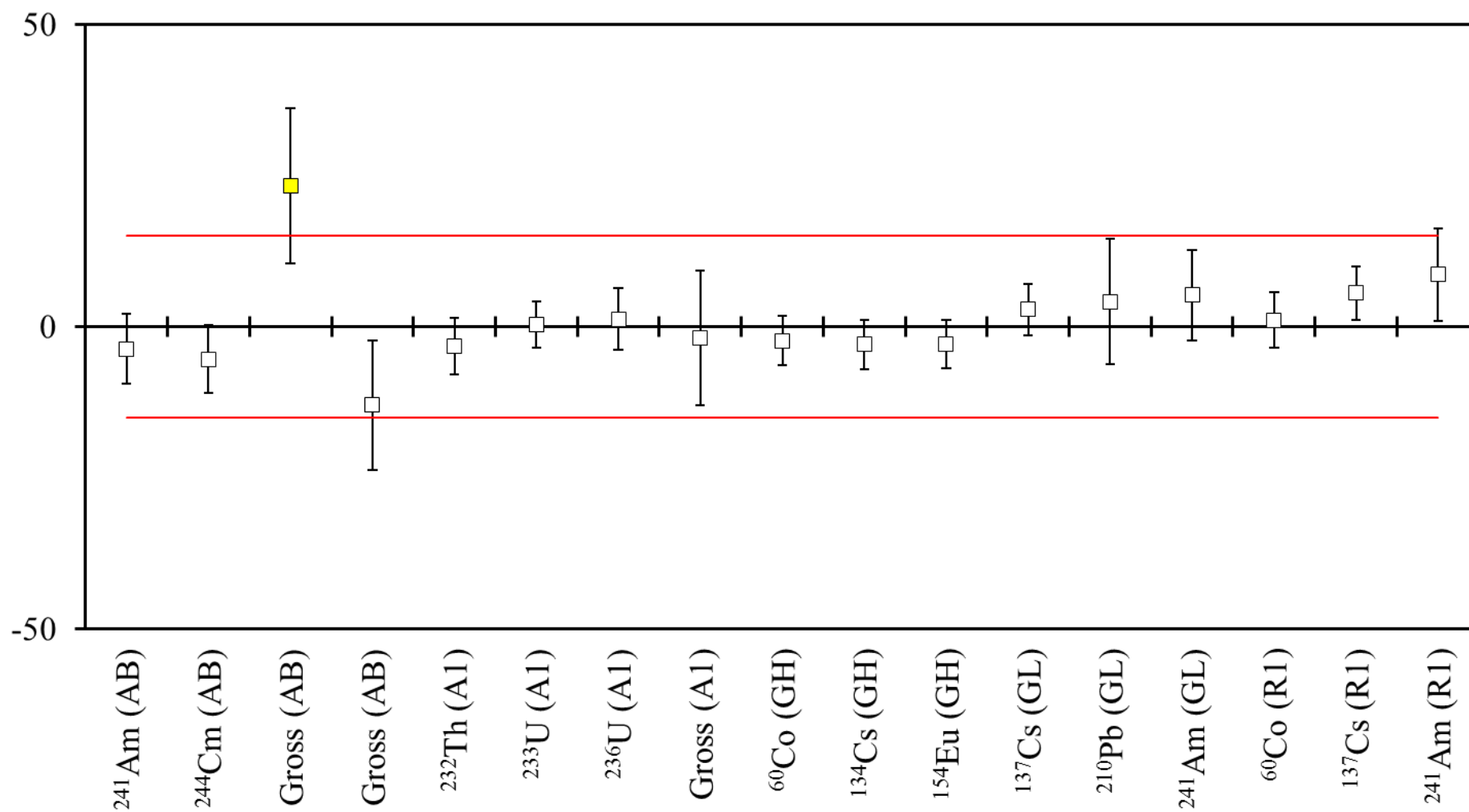
Radionuclide	Laboratory 16	NPL Assigned Value	Deviation /%	Zeta	Z Score
^3H (B1)	0.950 ± 0.038	0.958 ± 0.012	-0.8	-0.20	-0.14
^{14}C (B1)	0.469 ± 0.024	0.4974 ± 0.0033	-5.7	-1.17	-0.98
^{60}Co (GH)	12.80 ± 0.88	12.074 ± 0.047	6.0	0.82	1.03
^{134}Cs (GH)	2.54 ± 0.17	2.503 ± 0.018	1.5	0.22	0.25
^{154}Eu (GH)	4.07 ± 0.28	4.015 ± 0.032	1.4	0.20	0.24

Deviation (%) of Laboratory 17



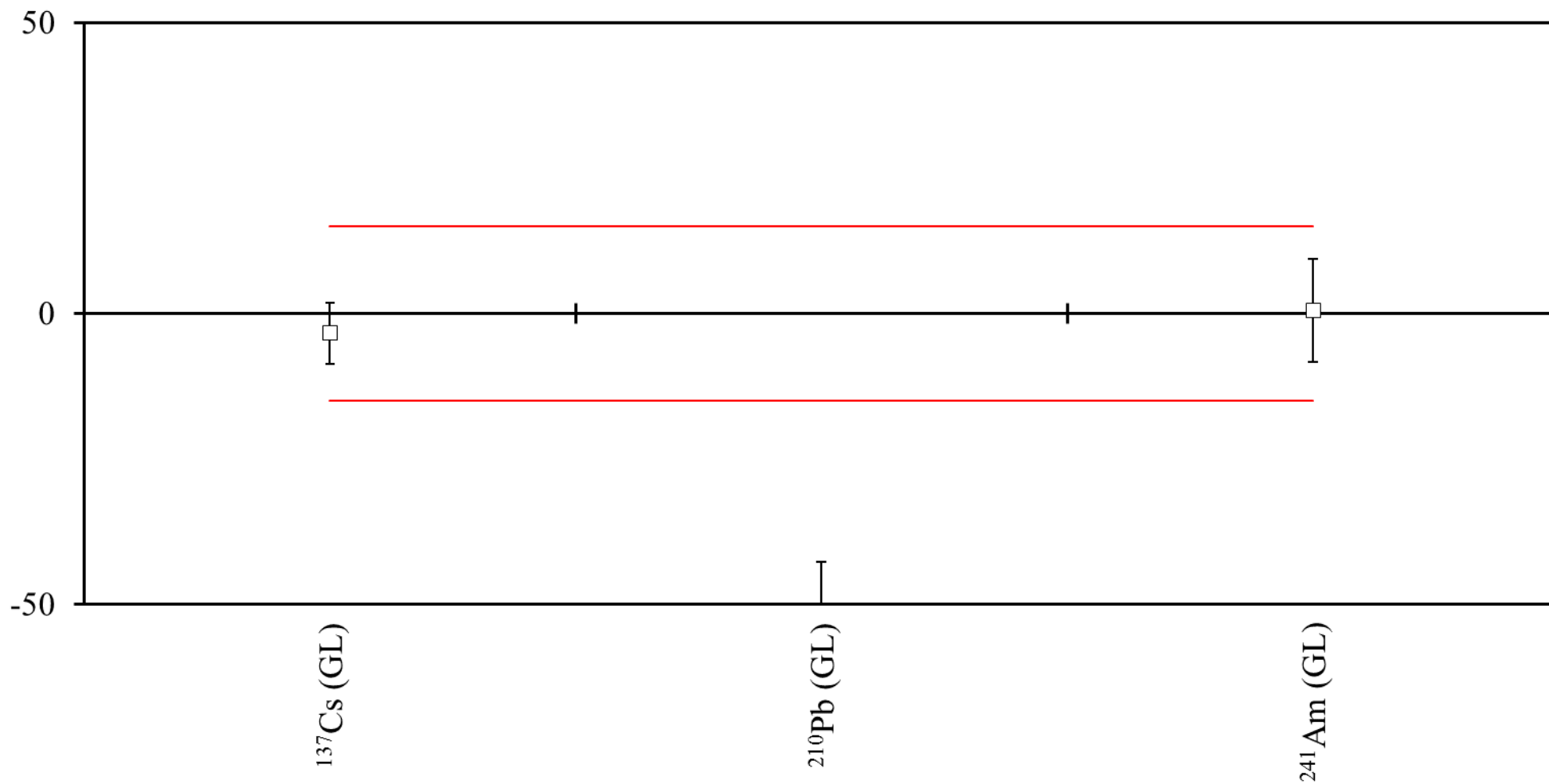
Radionuclide	Laboratory 17	NPL Assigned Value	Deviation /%	Zeta	Z Score
³ H (B1)	0.7920 ± 0.09	0.958 ± 0.012	-17.3	-1.83	-2.98
¹⁴ C (B1)	0.493 ± 0.066	0.4974 ± 0.0033	-0.9	-0.07	-0.15
⁶⁰ Co (GH)	11.73 ± 0.62	12.074 ± 0.047	-2.8	-0.55	-0.49
¹³⁴ Cs (GH)	2.39 ± 0.12	2.503 ± 0.018	-4.5	-0.93	-0.78
¹⁵⁴ Eu (GH)	4.08 ± 0.22	4.015 ± 0.032	1.6	0.29	0.28
¹³⁷ Cs (GL)	10.2 ± 1.5	9.527 ± 0.086	7.1	0.45	1.21
²¹⁰ Pb (GL)	13.2 ± 6.0	19.39 ± 0.20	-31.9	-1.03	-5.48
²⁴¹ Am (GL)	15.7 ± 4.4	14.825 ± 0.032	5.9	0.20	1.01

Deviation (%) of Laboratory 18



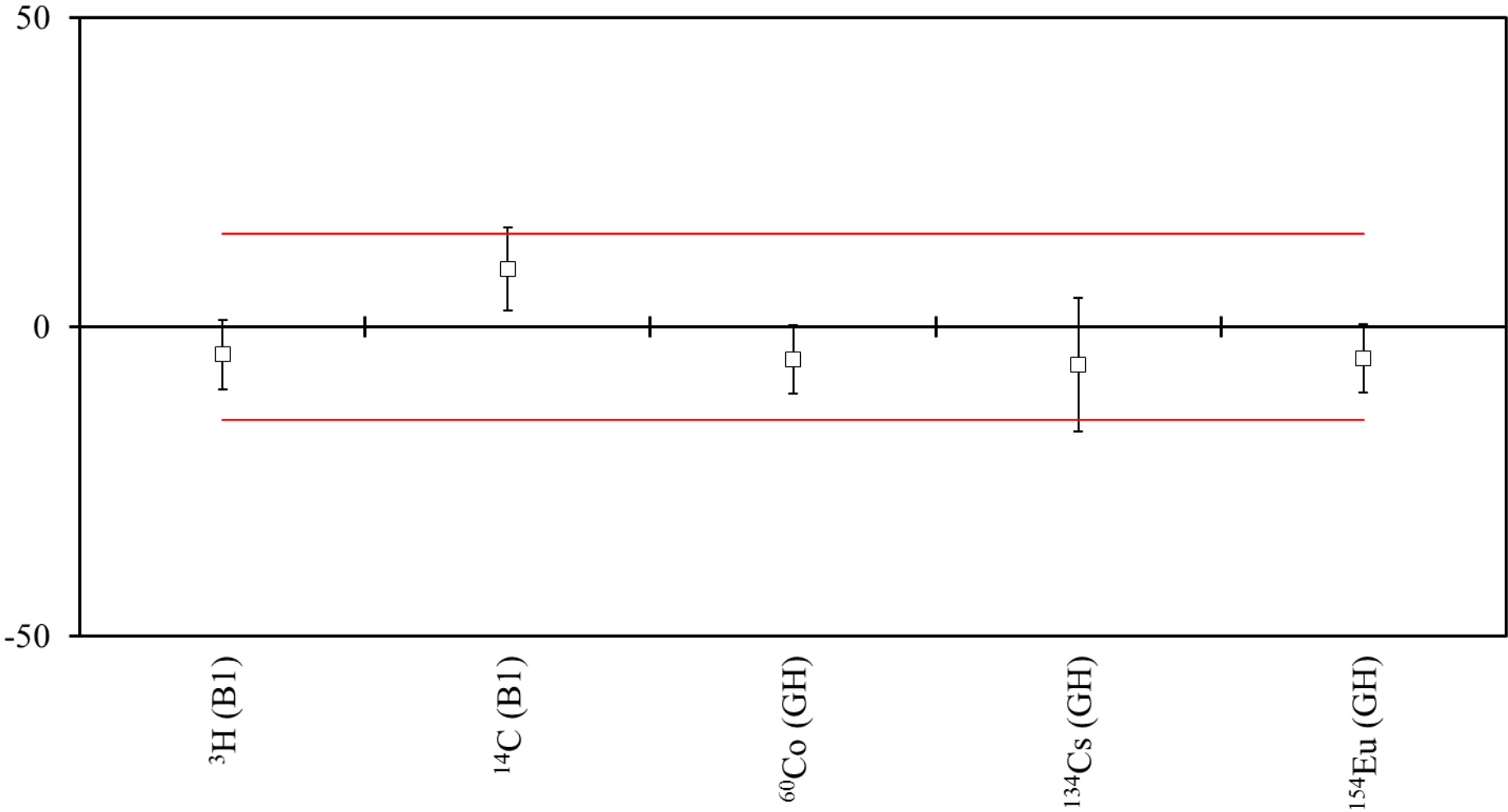
Radionuclide	Laboratory 18	NPL Assigned Value	Deviation /%	Zeta	Z Score
²⁴¹ Am (AB)	2.48 ± 0.15	2.574 ± 0.011	-3.7	-0.62	-0.63
²⁴⁴ Cm (AB)	15.20 ± 0.90	16.066 ± 0.054	-5.4	-0.96	-0.93
Gross alpha (AB)	24.2 ± 2.4	19.62 ± 0.61	23.3	1.85	4.01
Gross beta (AB)	9.30 ± 0.90	10.68 ± 0.81	-12.9	-1.14	-2.22
²³² Th (A1)	3.20 ± 0.15	3.305 ± 0.032	-3.2	-0.68	-0.55
²³³ U (A1)	16.1 ± 0.6	16.040 ± 0.049	0.4	0.10	0.06
²³⁶ U (A1)	11.9 ± 0.6	11.748 ± 0.029	1.3	0.25	0.22
Gross alpha (A1)	36.7 ± 3.6	37.4 ± 2.1	-1.9	-0.17	-0.32
⁶⁰ Co (GH)	11.80 ± 0.50	12.074 ± 0.047	-2.3	-0.55	-0.39
¹³⁴ Cs (GH)	2.43 ± 0.10	2.503 ± 0.018	-2.9	-0.72	-0.50
¹⁵⁴ Eu (GH)	3.90 ± 0.16	4.015 ± 0.032	-2.9	-0.70	-0.49
¹³⁷ Cs (GL)	9.80 ± 0.40	9.527 ± 0.086	2.9	0.67	0.49
²¹⁰ Pb (GL)	20.2 ± 2.0	19.39 ± 0.20	4.2	0.40	0.72
²⁴¹ Am (GL)	15.6 ± 1.1	14.825 ± 0.032	5.2	0.70	0.90
⁶⁰ Co (R1)	1.56 ± 0.06	1.543 ± 0.036	1.1	0.24	0.19
¹³⁷ Cs (R1)	2.010 ± 0.080	1.904 ± 0.026	5.6	1.26	0.96
²⁴¹ Am (R1)	5.80 ± 0.40	5.338 ± 0.067	8.7	1.14	1.49

Deviation (%) of Laboratory 23



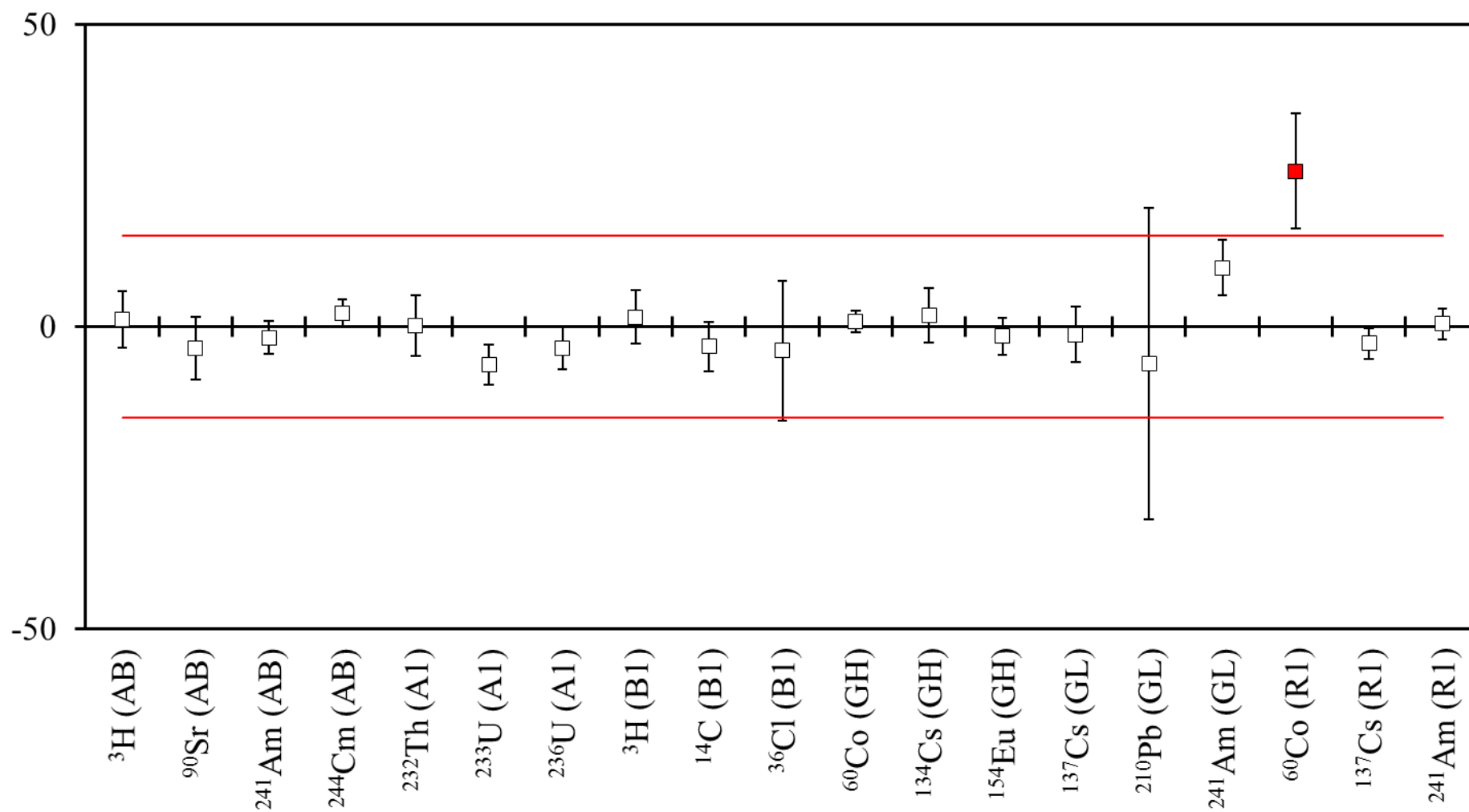
Radionuclide	Laboratory 23	NPL Assigned Value	Deviation /%	Zeta	Z Score
¹³⁷ Cs (GL)	9.20 ± 0.50	9.527 ± 0.086	-3.4	-0.64	-0.59
²¹⁰ Pb (GL)	9.0 ± 2.1	19.39 ± 0.20	-53.6	-4.93	-9.20
²⁴¹ Am (GL)	14.9 ± 1.3	14.825 ± 0.032	0.5	0.06	0.09

Deviation (%) of Laboratory 25



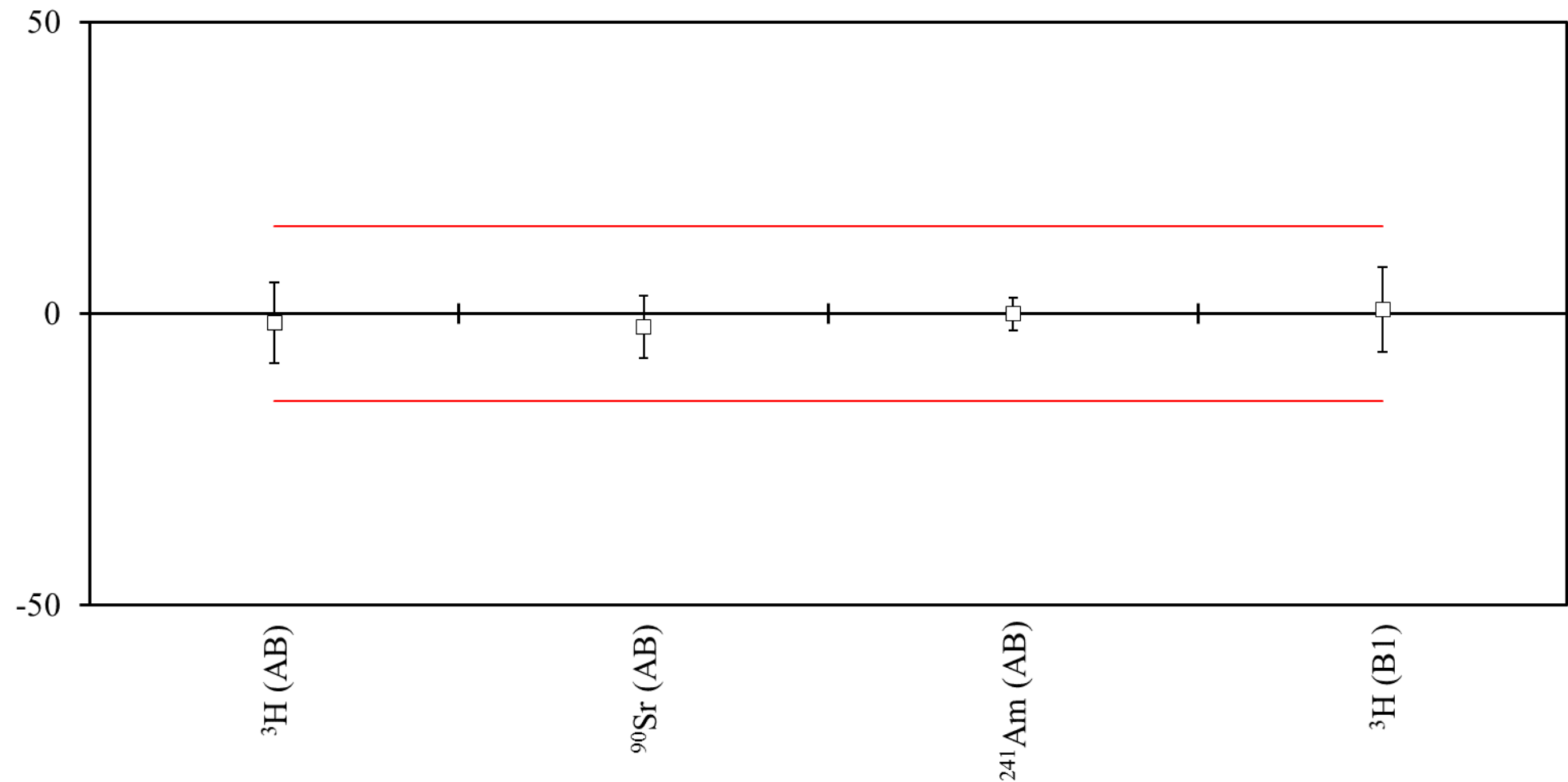
Radionuclide	Laboratory 25	NPL Assigned Value	Deviation /%	Zeta	Z Score
^3H (B1)	0.915 ± 0.053	0.958 ± 0.012	-4.5	-0.79	-0.77
^{14}C (B1)	0.544 ± 0.033	0.4974 ± 0.0033	9.4	1.41	1.61
Gross beta (B1)	0.289 ± 0.027	-	-	-	-
^{60}Co (GH)	11.44 ± 0.66	12.074 ± 0.047	-5.3	-0.96	-0.90
^{134}Cs (GH)	2.35 ± 0.27	2.503 ± 0.018	-6.1	-0.57	-1.05
^{154}Eu (GH)	3.81 ± 0.22	4.015 ± 0.032	-5.1	-0.92	-0.88

Deviation (%) of Laboratory 32.1



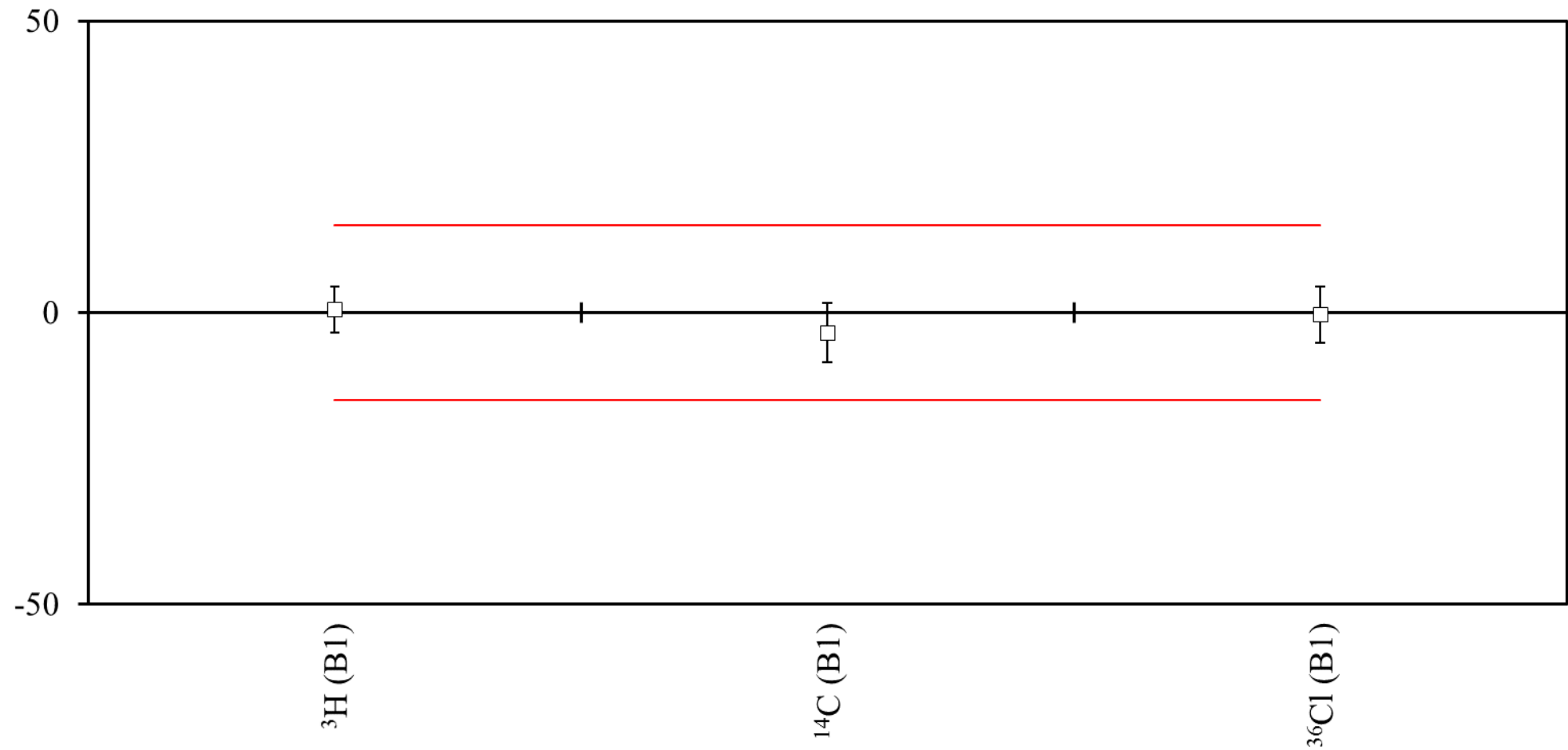
Radionuclide	Laboratory 32.1	NPL Assigned Value	Deviation /%	Zeta	Z Score
³ H (AB)	5.09 ± 0.23	5.031 ± 0.064	1.2	0.25	0.20
⁹⁰ Sr (AB)	4.49 ± 0.24	4.658 ± 0.021	-3.6	-0.70	-0.62
²⁴¹ Am (AB)	2.526 ± 0.069	2.574 ± 0.011	-1.9	-0.69	-0.32
²⁴⁴ Cm (AB)	16.43 ± 0.35	16.066 ± 0.054	2.3	1.03	0.39
²³² Th (A1)	3.31 ± 0.16	3.305 ± 0.032	0.2	0.03	0.03
²³³ U (A1)	15.03 ± 0.52	16.040 ± 0.049	-6.3	-1.93	-1.08
²³⁶ U (A1)	11.33 ± 0.41	11.748 ± 0.029	-3.6	-1.02	-0.61
³ H (B1)	0.973 ± 0.041	0.958 ± 0.012	1.6	0.35	0.27
¹⁴ C (B1)	0.481 ± 0.020	0.4974 ± 0.0033	-3.3	-0.81	-0.57
³⁶ Cl (B1)	0.241 ± 0.029	0.2509 ± 0.0010	-3.9	-0.34	-0.68
⁶⁰ Co (GH)	12.18 ± 0.21	12.074 ± 0.047	0.9	0.49	0.15
¹³⁴ Cs (GH)	2.55 ± 0.11	2.503 ± 0.018	1.9	0.42	0.32
¹⁵⁴ Eu (GH)	3.95 ± 0.12	4.015 ± 0.032	-1.6	-0.52	-0.28
¹³⁷ Cs (GL)	9.40 ± 0.43	9.527 ± 0.086	-1.3	-0.29	-0.23
²¹⁰ Pb (GL)	18.2 ± 5.0	19.39 ± 0.20	-6.1	-0.24	-1.05
²⁴¹ Am (GL)	16.27 ± 0.68	14.825 ± 0.032	9.7	2.12	1.67
⁶⁰ Co (R1)	1.94 ± 0.14	1.543 ± 0.036	25.7	2.75	4.42
¹³⁷ Cs (R1)	1.851 ± 0.041	1.904 ± 0.026	-2.8	-1.09	-0.48
²⁴¹ Am (R1)	5.36 ± 0.12	5.338 ± 0.067	0.4	0.16	0.07

Deviation (%) of Laboratory 32.2



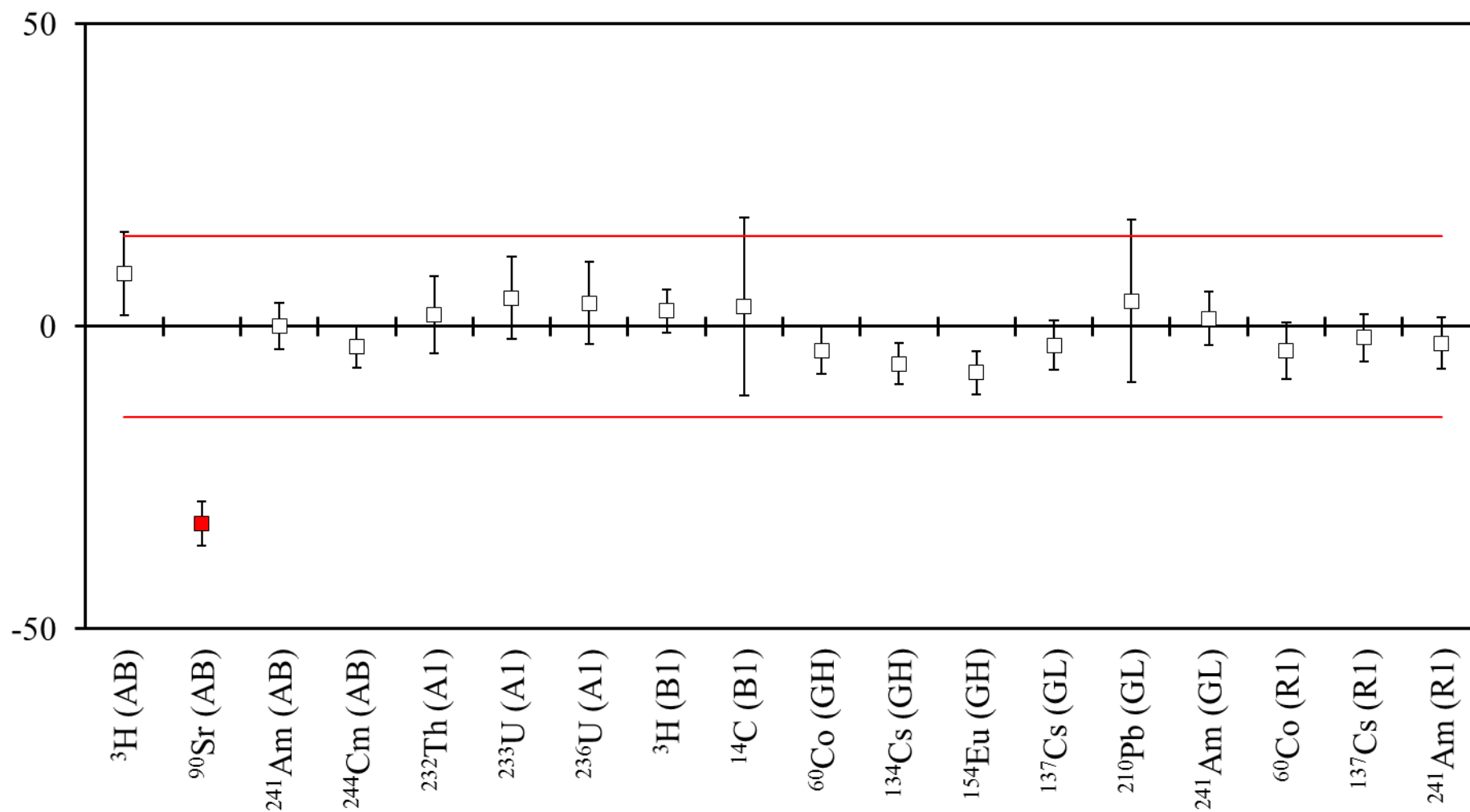
Radionuclide	Laboratory 32.2	NPL Assigned Value	Deviation /%	Zeta	Z Score
^3H (AB)	4.95 ± 0.34	5.031 ± 0.064	-1.6	-0.23	-0.28
^{90}Sr (AB)	4.55 ± 0.25	4.658 ± 0.021	-2.3	-0.43	-0.40
^{241}Am (AB)	2.5710 ± 0.07	2.574 ± 0.011	-0.1	-0.04	-0.02
^3H (B1)	0.964 ± 0.069	0.958 ± 0.012	0.6	0.09	0.11

Deviation (%) of Laboratory 34



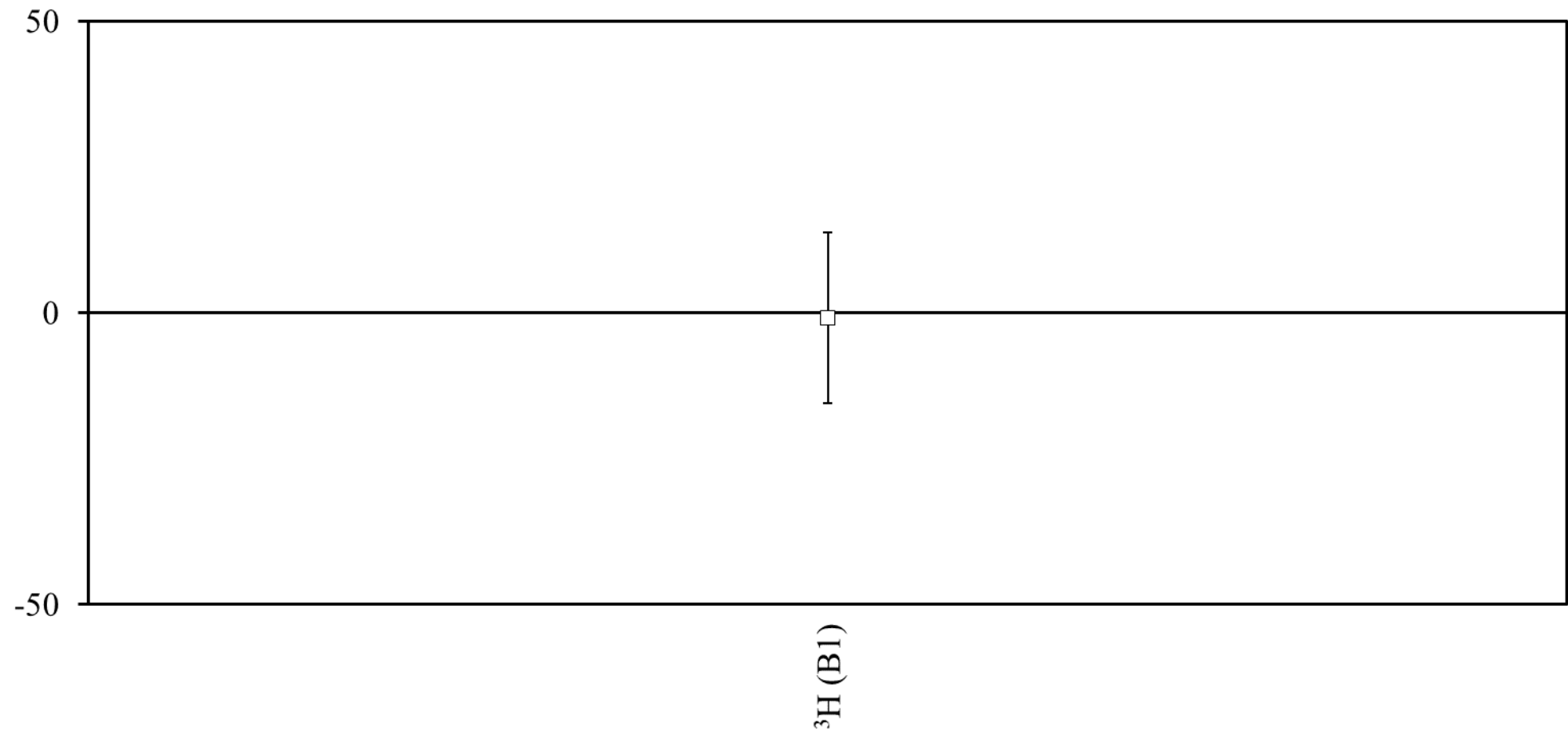
Radionuclide	Laboratory 34	NPL Assigned Value	Deviation /%	Zeta	Z Score
^3H (B1)	0.963 ± 0.036	0.958 ± 0.012	0.5	0.13	0.09
^{14}C (B1)	0.480 ± 0.025	0.4974 ± 0.0033	-3.5	-0.69	-0.60
^{36}Cl (B1)	0.250 ± 0.012	0.2509 ± 0.0010	-0.4	-0.07	-0.06

Deviation (%) of Laboratory 35.1



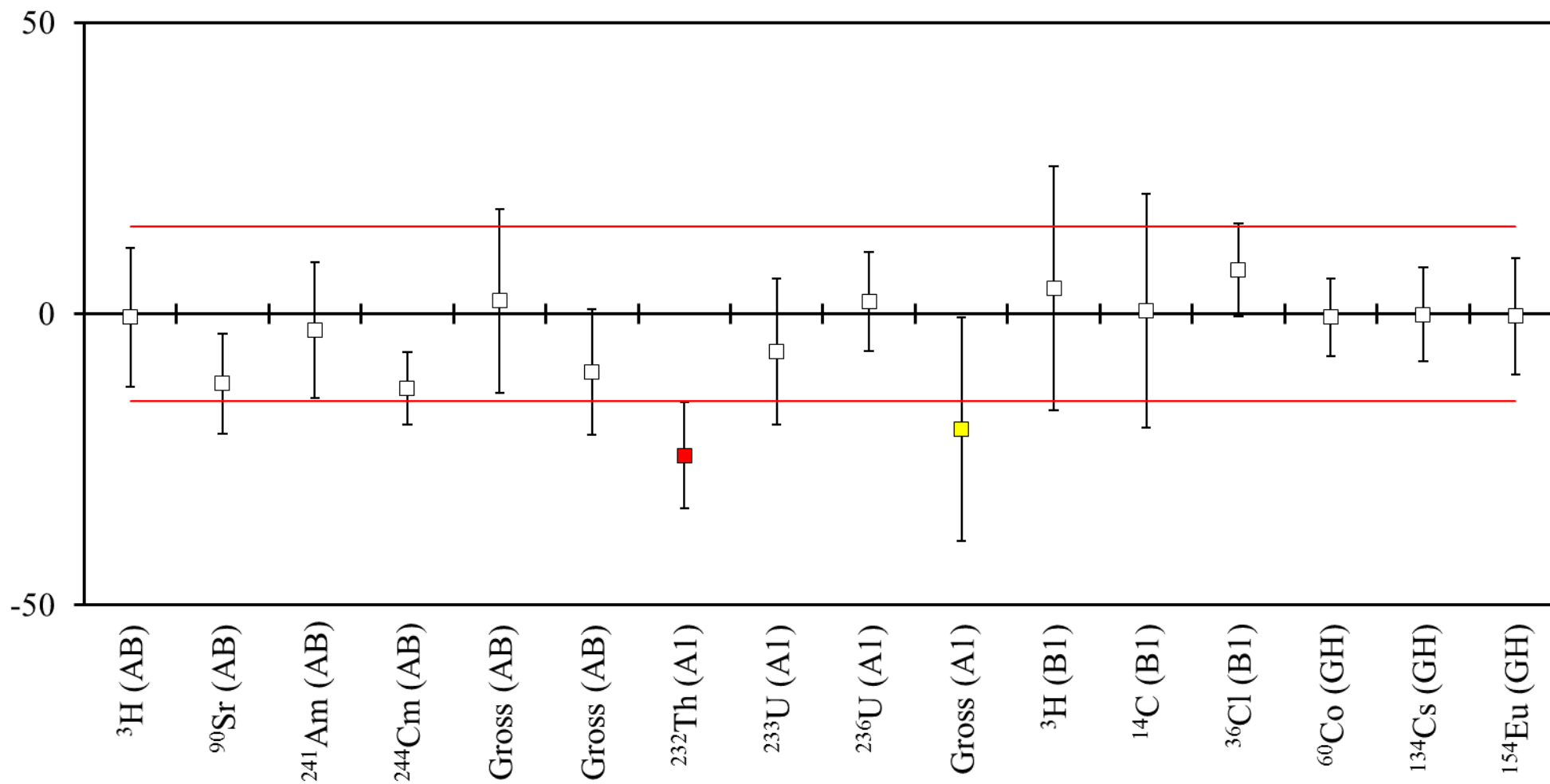
Radionuclide	Laboratory 35.1	NPL Assigned Value	Deviation /%	Zeta	Z Score
³ H (AB)	5.47 ± 0.34	5.031 ± 0.064	8.7	1.27	1.50
⁹⁰ Sr (AB)	3.14 ± 0.17	4.658 ± 0.021	-32.6	-8.86	-5.60
²⁴¹ Am (AB)	2.575 ± 0.099	2.574 ± 0.011	0.0	0.01	0.01
²⁴⁴ Cm (AB)	15.53 ± 0.56	16.066 ± 0.054	-3.3	-0.95	-0.57
²³² Th (A1)	3.37 ± 0.21	3.305 ± 0.032	2.0	0.31	0.34
²³³ U (A1)	16.8 ± 1.1	16.040 ± 0.049	4.7	0.69	0.81
²³⁶ U (A1)	12.20 ± 0.80	11.748 ± 0.029	3.8	0.56	0.66
³ H (B1)	0.983 ± 0.032	0.958 ± 0.012	2.6	0.73	0.45
¹⁴ C (B1)	0.514 ± 0.073	0.4974 ± 0.0033	3.3	0.23	0.57
⁶⁰ Co (GH)	11.60 ± 0.48	12.074 ± 0.047	-3.9	-0.98	-0.67
¹³⁴ Cs (GH)	2.348 ± 0.084	2.503 ± 0.018	-6.2	-1.80	-1.06
¹⁵⁴ Eu (GH)	3.71 ± 0.14	4.015 ± 0.032	-7.6	-2.12	-1.30
¹³⁷ Cs (GL)	9.23 ± 0.38	9.527 ± 0.086	-3.1	-0.76	-0.54
²¹⁰ Pb (GL)	20.2 ± 2.6	19.39 ± 0.20	4.2	0.31	0.72
²⁴¹ Am (GL)	15.02 ± 0.66	14.825 ± 0.032	1.3	0.30	0.23
⁶⁰ Co (R1)	1.481 ± 0.062	1.543 ± 0.036	-4.0	-0.86	-0.69
¹³⁷ Cs (R1)	1.8690 ± 0.07	1.904 ± 0.026	-1.8	-0.47	-0.32
²⁴¹ Am (R1)	5.19 ± 0.22	5.338 ± 0.067	-2.8	-0.64	-0.48

Deviation (%) of Laboratory 35.2



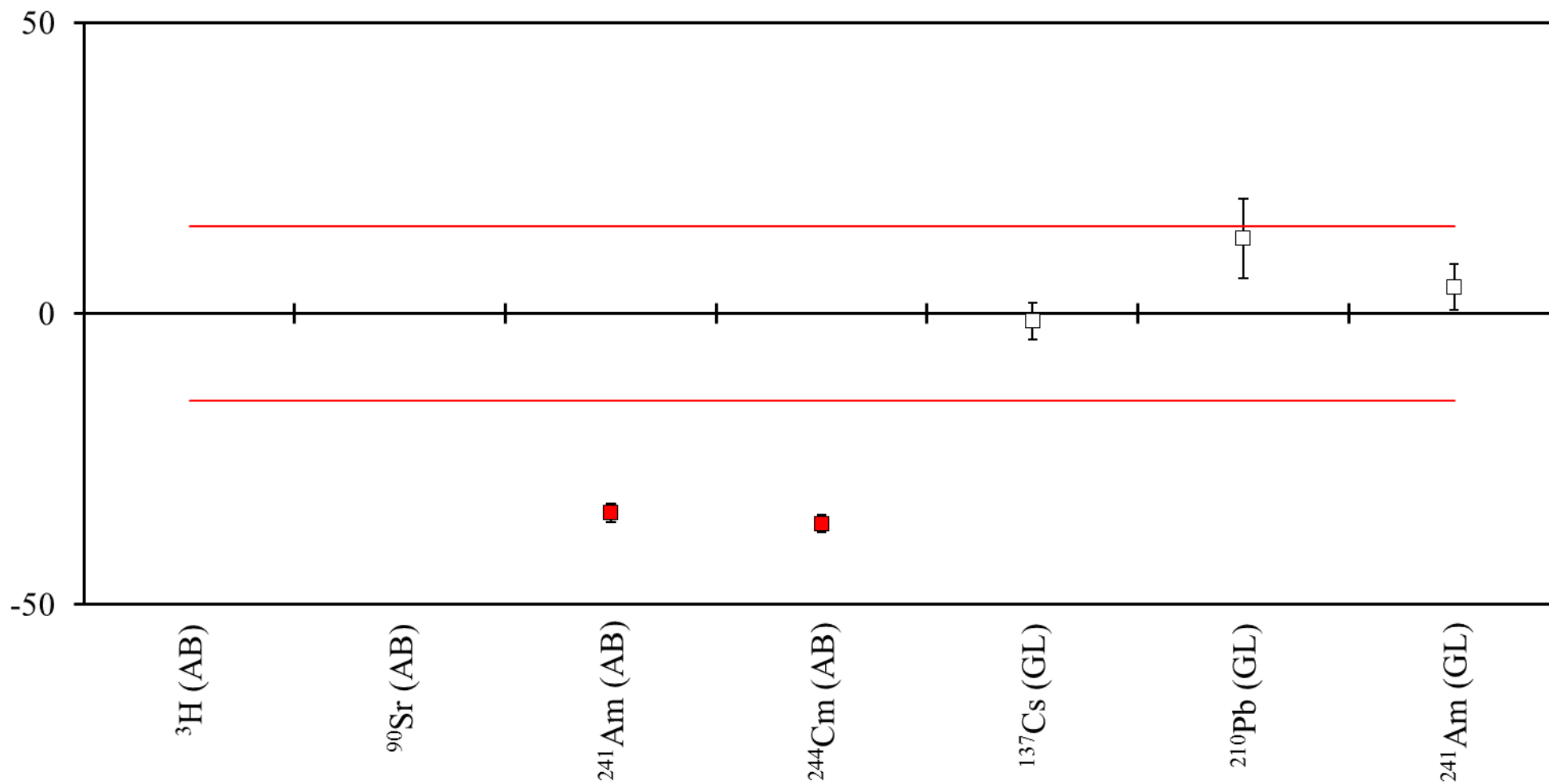
Radionuclide	Laboratory 35.2	NPL Assigned Value	Deviation /%	Zeta	Z Score
^3H (B1)	0.95 ± 0.14	0.958 ± 0.012	-0.8	-0.06	-0.14

Deviation (%) of Laboratory 38



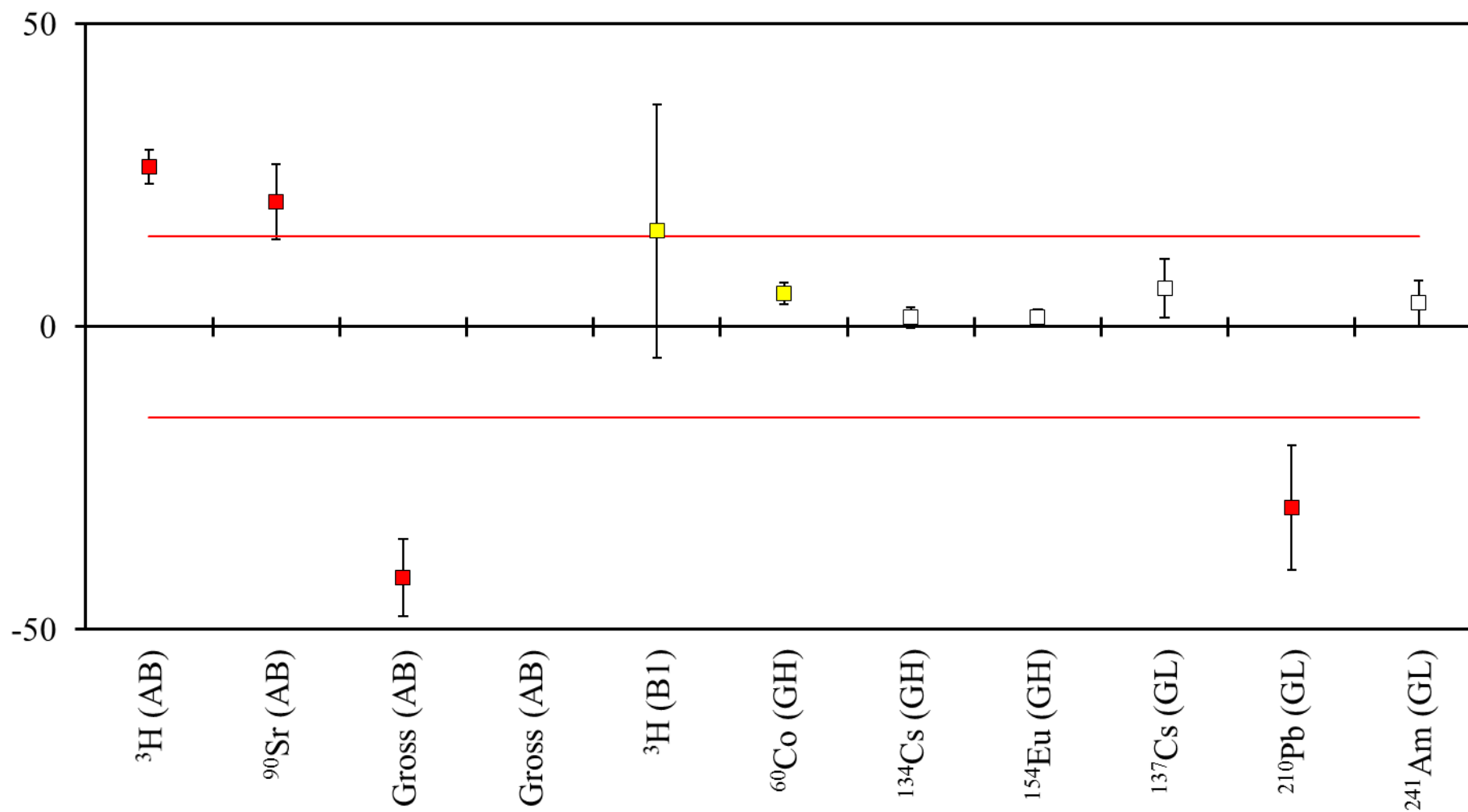
Radionuclide	Laboratory 38	NPL Assigned Value	Deviation /%	Zeta	Z Score
^3H (AB)	5.0 ± 0.6	5.031 ± 0.064	-0.6	-0.05	-0.11
^{90}Sr (AB)	4.10 ± 0.40	4.658 ± 0.021	-12.0	-1.39	-2.06
^{241}Am (AB)	2.5 ± 0.3	2.574 ± 0.011	-2.9	-0.25	-0.49
^{244}Cm (AB)	14.0 ± 1.0	16.066 ± 0.054	-12.9	-2.06	-2.21
Gross alpha (AB)	20.0 ± 3.0	19.62 ± 0.61	1.9	0.12	0.33
Gross beta (AB)	10.0 ± 1.0	10.68 ± 0.81	-6.4	-0.53	-1.09
^{232}Th (A1)	2.5 ± 0.3	3.305 ± 0.032	-24.4	-2.67	-4.18
^{233}U (A1)	15.0 ± 2.0	16.040 ± 0.049	-6.5	-0.52	-1.11
^{236}U (A1)	12.0 ± 1.0	11.748 ± 0.029	2.1	0.25	0.37
Gross alpha (A1)	30.0 ± 7.0	37.4 ± 2.1	-19.8	-1.01	-3.40
^3H (B1)	1.00 ± 0.20	0.958 ± 0.012	4.4	0.21	0.75
^{14}C (B1)	0.50 ± 0.10	0.4974 ± 0.0033	0.5	0.03	0.09
^{36}Cl (B1)	0.270 ± 0.020	0.2509 ± 0.0010	7.6	0.95	1.31
^{60}Co (GH)	12.00 ± 0.80	12.074 ± 0.047	-0.6	-0.09	-0.11
^{134}Cs (GH)	2.50 ± 0.20	2.503 ± 0.018	-0.1	-0.01	-0.02
^{154}Eu (GH)	4.00 ± 0.40	4.015 ± 0.032	-0.4	-0.04	-0.06

Deviation (%) of Laboratory 40



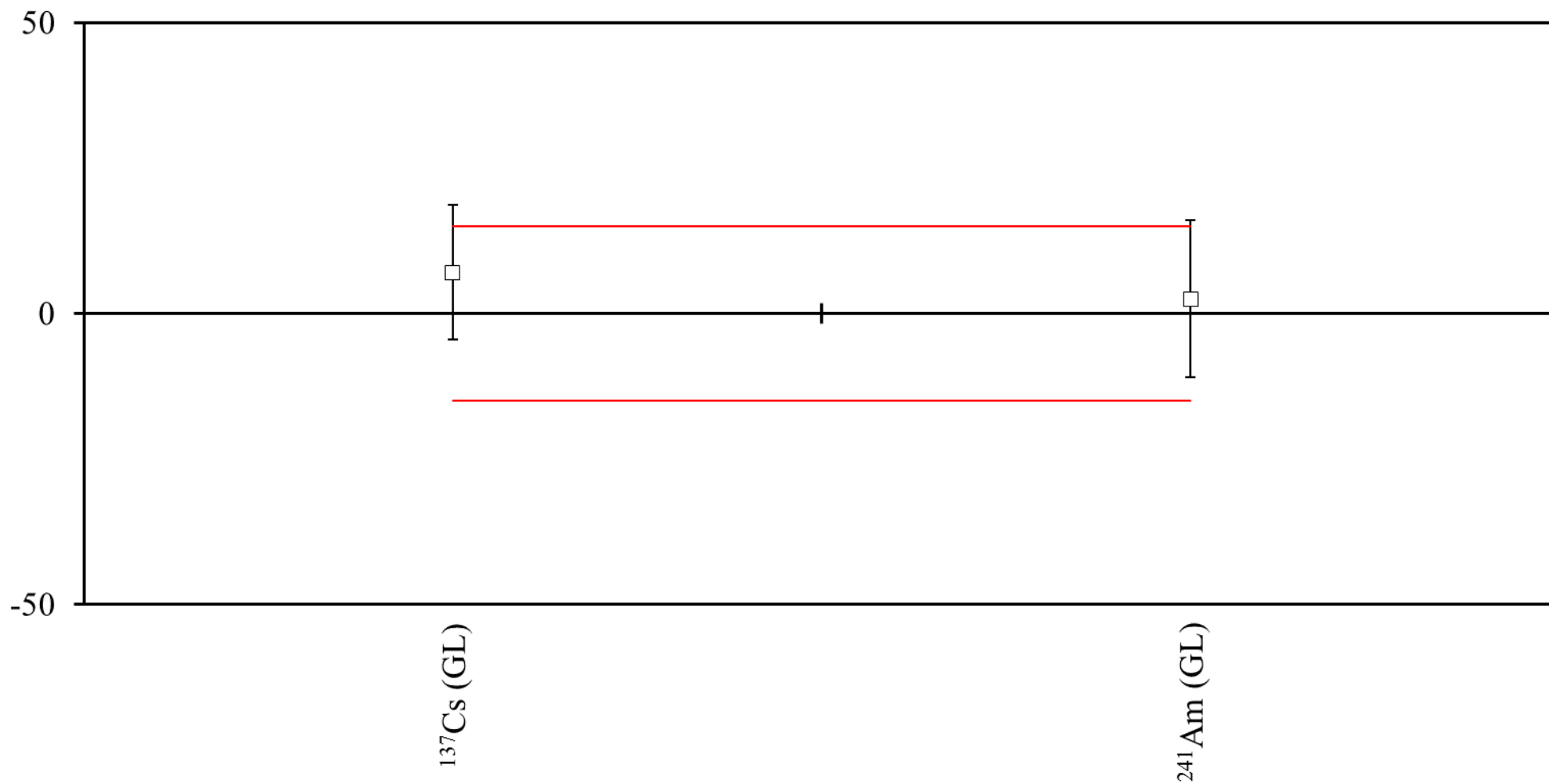
Radionuclide	Laboratory 40	NPL Assigned Value	Deviation /%	Zeta	Z Score
³ H (AB)	8.90 ± 0.11	5.031 ± 0.064	76.9	30.40	13.21
⁹⁰ Sr (AB)	0.0253 ± 0.0048	4.658 ± 0.021	-99.5	-215.06	-17.08
²⁴¹ Am (AB)	1.693 ± 0.040	2.574 ± 0.011	-34.2	-21.24	-5.88
²⁴⁴ Cm (AB)	10.27 ± 0.24	16.066 ± 0.054	-36.1	-23.56	-6.20
¹³⁷ Cs (GL)	9.41 ± 0.29	9.527 ± 0.086	-1.2	-0.39	-0.21
²¹⁰ Pb (GL)	21.9 ± 1.3	19.39 ± 0.20	12.9	1.91	2.22
²⁴¹ Am (GL)	15.51 ± 0.59	14.825 ± 0.032	4.6	1.16	0.79

Deviation (%) of Laboratory 41



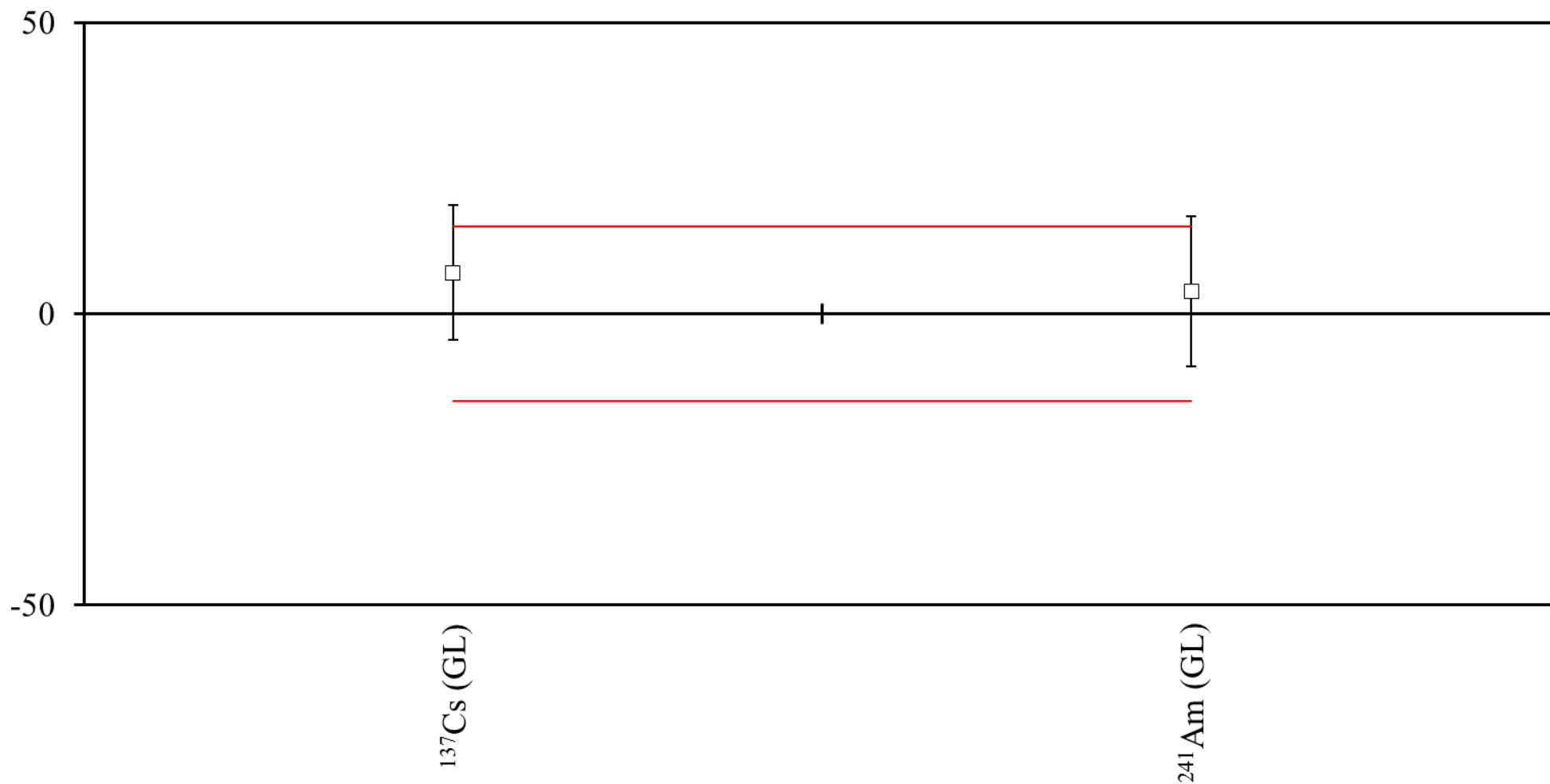
Radionuclide	Laboratory 41	NPL Assigned Value	Deviation /%	Zeta	Z Score
³ H (AB)	6.36 ± 0.12	5.031 ± 0.064	26.4	9.77	4.54
⁹⁰ Sr (AB)	5.62 ± 0.29	4.658 ± 0.021	20.7	3.31	3.55
Gross alpha (AB)	11.5 ± 1.2	19.62 ± 0.61	-41.4	-6.03	-7.11
Gross beta (AB)	19.57 ± 0.71	10.68 ± 0.81	83.2	8.25	14.29
³ H (B1)	1.11 ± 0.20	0.958 ± 0.012	15.9	0.76	2.72
Gross beta (B1)	0.300 ± 0.010	-	-	-	-
⁶⁰ Co (GH)	12.73 ± 0.21	12.074 ± 0.047	5.4	3.05	0.93
¹³⁴ Cs (GH)	2.541 ± 0.040	2.503 ± 0.018	1.5	0.87	0.26
¹⁵⁴ Eu (GH)	4.077 ± 0.040	4.015 ± 0.032	1.5	1.21	0.27
¹³⁷ Cs (GL)	10.13 ± 0.45	9.527 ± 0.086	6.3	1.32	1.09
²¹⁰ Pb (GL)	13.6 ± 2.0	19.39 ± 0.20	-29.9	-2.88	-5.13
²⁴¹ Am (GL)	15.41 ± 0.55	14.825 ± 0.032	3.9	1.06	0.68

Deviation (%) of Laboratory 42.1



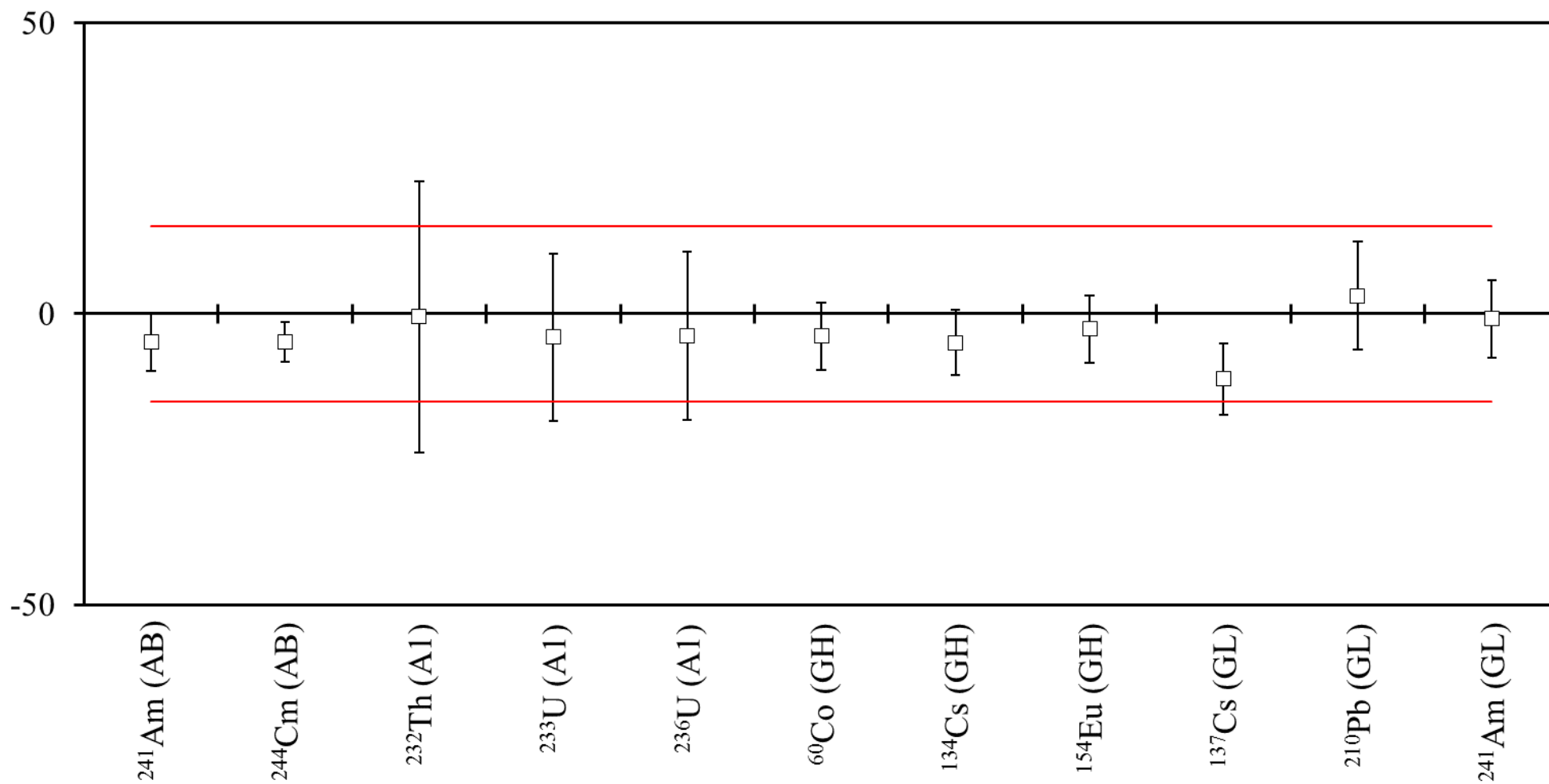
Radionuclide	Laboratory 42.1	NPL Assigned Value	Deviation /%	Zeta	Z Score
¹³⁷ Cs (GL)	10.2 ± 1.1	9.527 ± 0.086	7.1	0.61	1.21
²⁴¹ Am (GL)	15.2 ± 2.0	14.825 ± 0.032	2.5	0.19	0.43

Deviation (%) of Laboratory 42.2



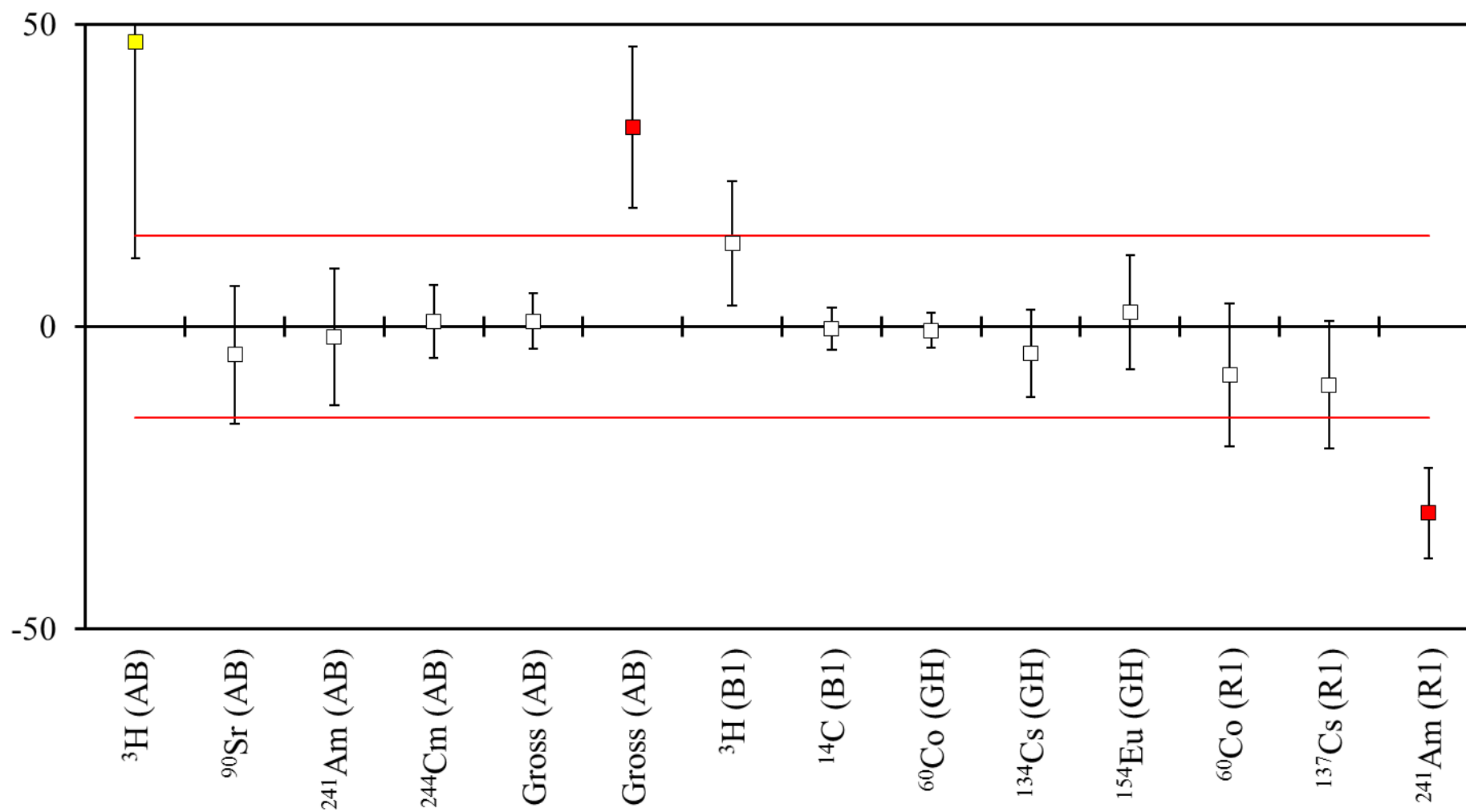
Radionuclide	Laboratory 42.2	NPL Assigned Value	Deviation /%	Zeta	Z Score
¹³⁷ Cs (GL)	10.2 ± 1.1	9.527 ± 0.086	7.1	0.61	1.21
²⁴¹ Am (GL)	15.4 ± 1.9	14.825 ± 0.032	3.9	0.30	0.67

Deviation (%) of Laboratory 47



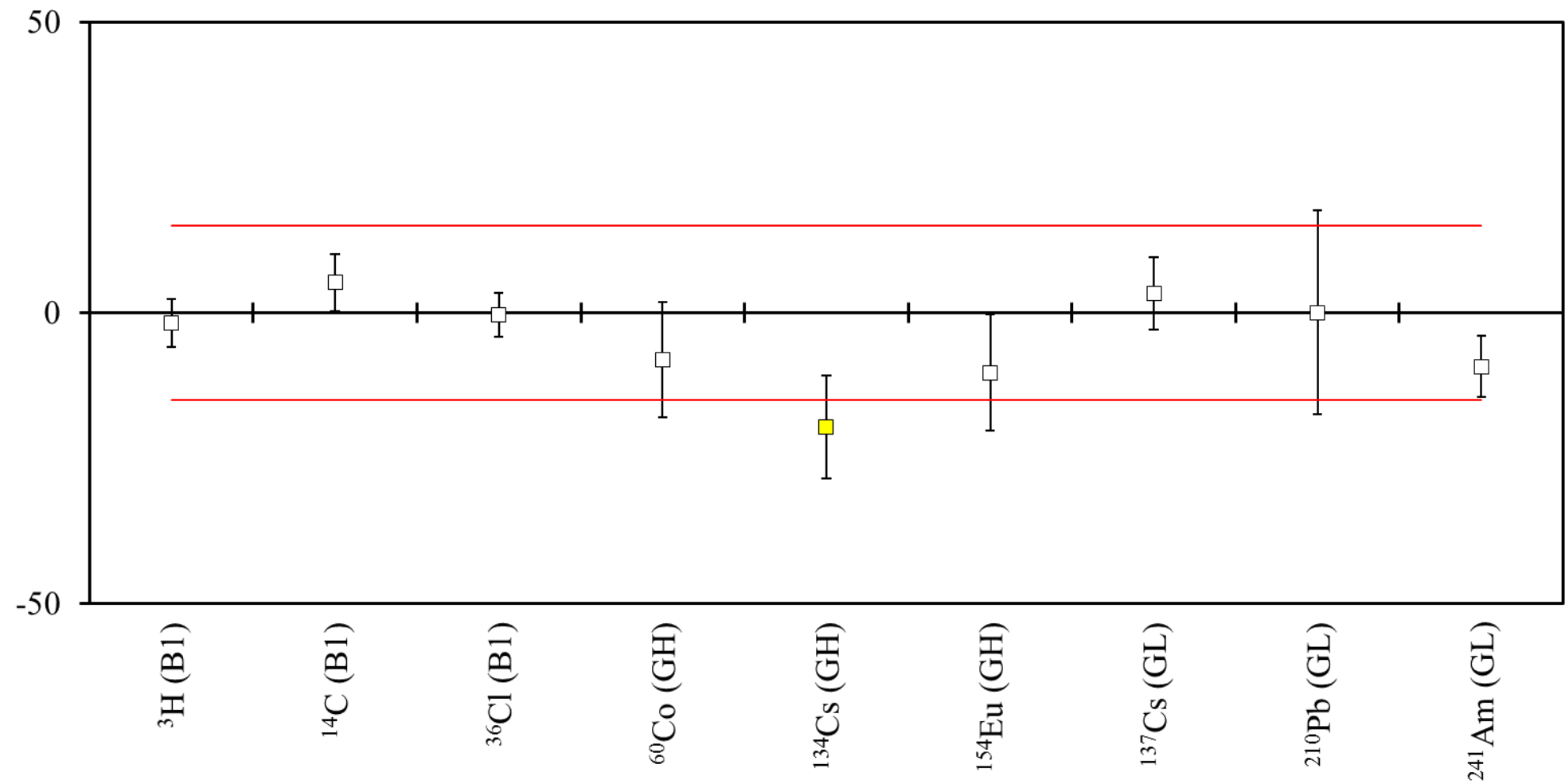
Radionuclide	Laboratory 47	NPL Assigned Value	Deviation /%	Zeta	Z Score
²⁴¹ Am (AB)	2.45 ± 0.13	2.574 ± 0.011	-4.8	-0.95	-0.83
²⁴⁴ Cm (AB)	15.29 ± 0.55	16.066 ± 0.054	-4.8	-1.40	-0.83
²³² Th (A1)	3.29 ± 0.77	3.305 ± 0.032	-0.5	-0.02	-0.08
²³³ U (A1)	15.4 ± 2.3	16.040 ± 0.049	-4.0	-0.28	-0.69
²³⁶ U (A1)	11.3 ± 1.7	11.748 ± 0.029	-3.8	-0.26	-0.65
⁶⁰ Co (GH)	11.61 ± 0.69	12.074 ± 0.047	-3.8	-0.67	-0.66
¹³⁴ Cs (GH)	2.38 ± 0.14	2.503 ± 0.018	-4.9	-0.87	-0.84
¹⁵⁴ Eu (GH)	3.91 ± 0.23	4.015 ± 0.032	-2.6	-0.45	-0.45
¹³⁷ Cs (GL)	8.46 ± 0.58	9.527 ± 0.086	-11.2	-1.82	-1.92
²¹⁰ Pb (GL)	20.0 ± 1.8	19.39 ± 0.20	3.1	0.34	0.54
²⁴¹ Am (GL)	14.70 ± 0.98	14.825 ± 0.032	-0.8	-0.13	-0.14

Deviation (%) of Laboratory 55



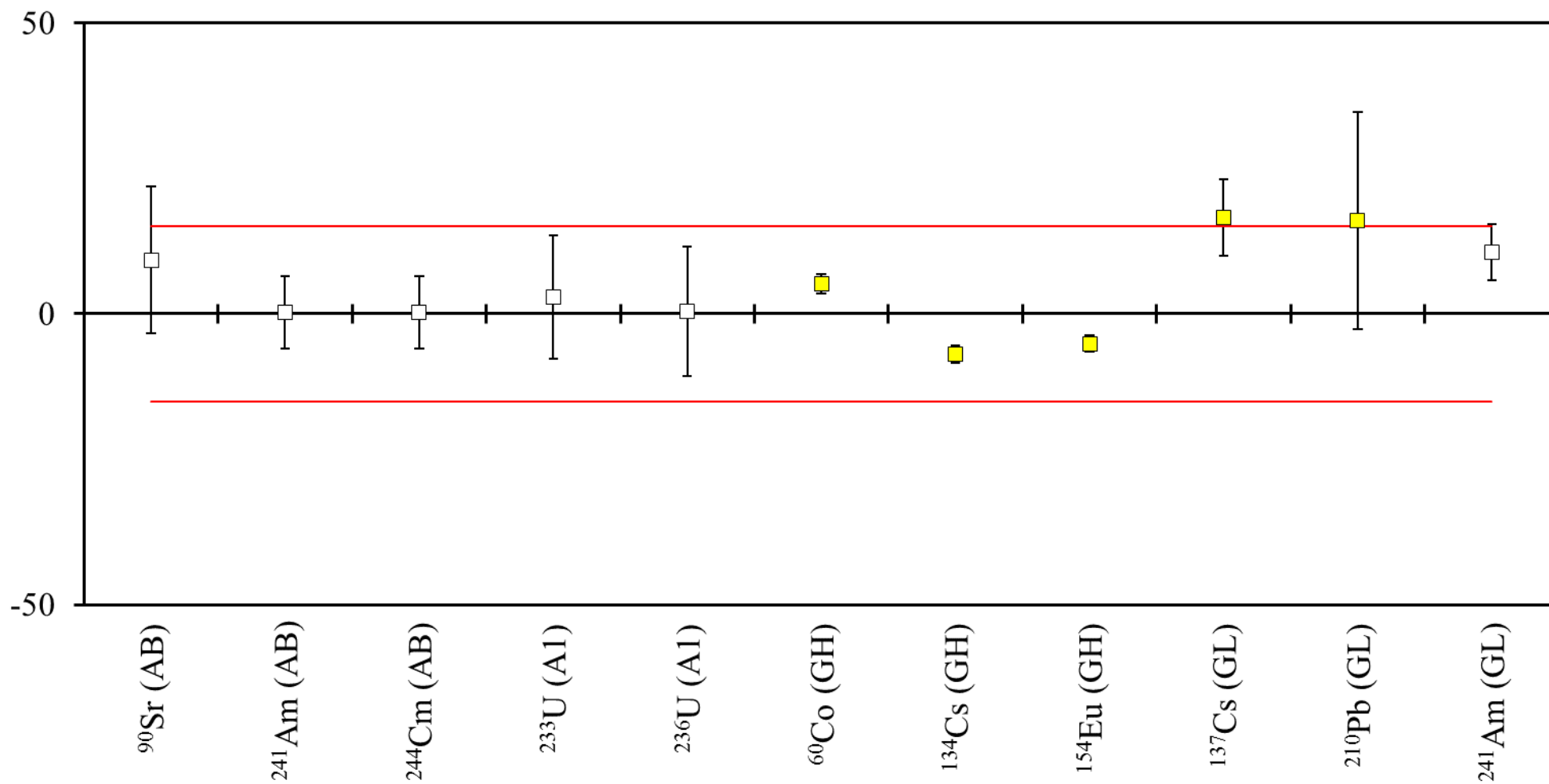
Radionuclide	Laboratory 55	NPL Assigned Value	Deviation /%	Zeta	Z Score
³ H (AB)	7.4 ± 1.8	5.031 ± 0.064	47.1	1.32	8.09
⁹⁰ Sr (AB)	4.44 ± 0.53	4.658 ± 0.021	-4.7	-0.41	-0.80
²⁴¹ Am (AB)	2.53 ± 0.29	2.574 ± 0.011	-1.7	-0.15	-0.29
²⁴⁴ Cm (AB)	16.20 ± 0.97	16.066 ± 0.054	0.8	0.14	0.14
Gross alpha (AB)	19.80 ± 0.67	19.62 ± 0.61	0.9	0.20	0.16
Gross beta (AB)	14.20 ± 0.94	10.68 ± 0.81	33.0	2.84	5.66
³ H (B1)	1.090 ± 0.097	0.958 ± 0.012	13.8	1.35	2.37
¹⁴ C (B1)	0.496 ± 0.017	0.4974 ± 0.0033	-0.3	-0.08	-0.05
⁶⁰ Co (GH)	12.00 ± 0.34	12.074 ± 0.047	-0.6	-0.22	-0.11
¹³⁴ Cs (GH)	2.39 ± 0.18	2.503 ± 0.018	-4.5	-0.62	-0.78
¹⁵⁴ Eu (GH)	4.11 ± 0.38	4.015 ± 0.032	2.4	0.25	0.41
⁶⁰ Co (R1)	1.42 ± 0.18	1.543 ± 0.036	-8.0	-0.67	-1.37
¹³⁷ Cs (R1)	1.72 ± 0.20	1.904 ± 0.026	-9.7	-0.91	-1.66
²⁴¹ Am (R1)	3.69 ± 0.40	5.338 ± 0.067	-30.9	-4.06	-5.30

Deviation (%) of Laboratory 57



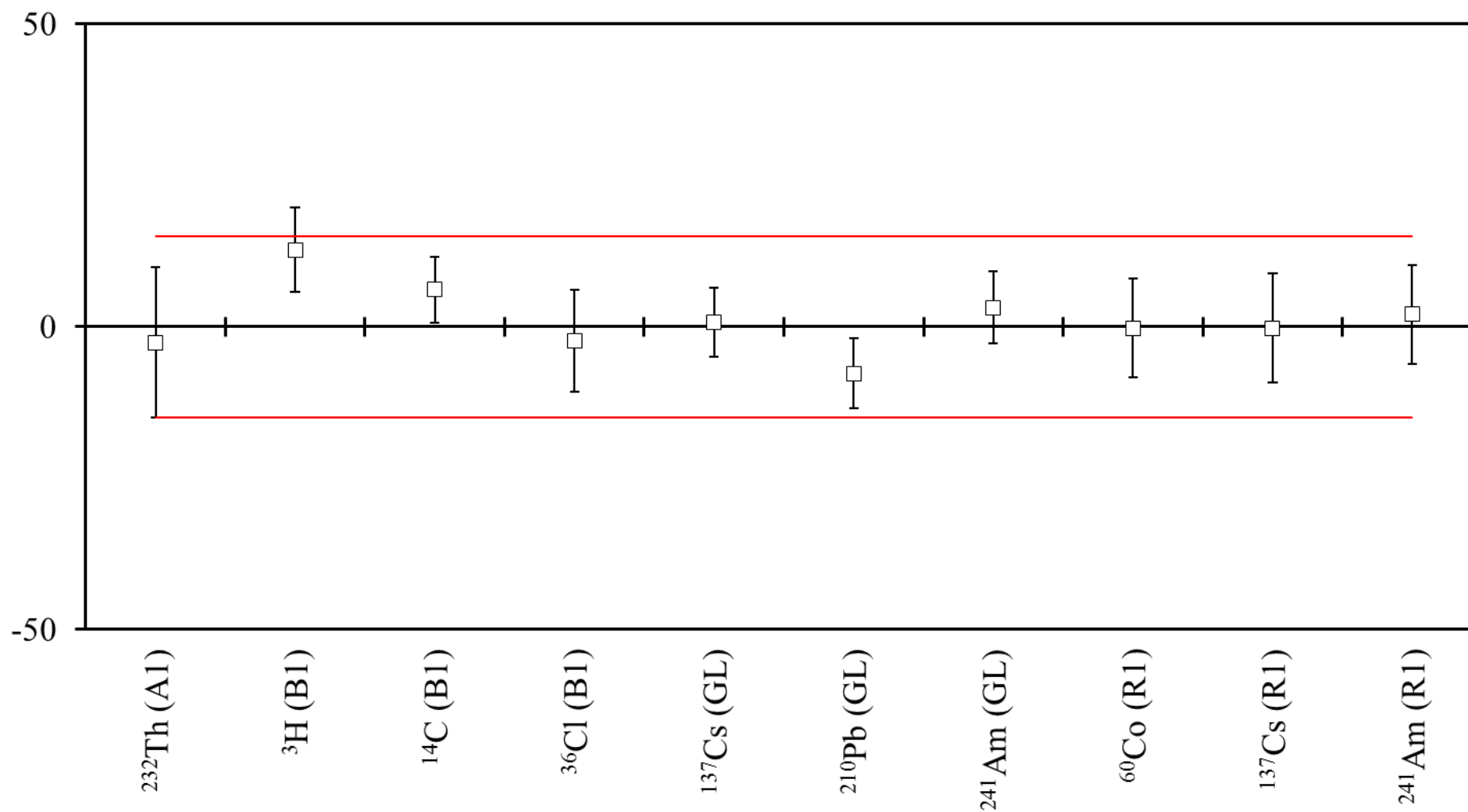
Radionuclide	Laboratory 57	NPL Assigned Value	Deviation /%	Zeta	Z Score
^3H (B1)	0.941 ± 0.038	0.958 ± 0.012	-1.8	-0.43	-0.30
^{14}C (B1)	0.523 ± 0.024	0.4974 ± 0.0033	5.1	1.06	0.88
^{36}Cl (B1)	0.2500 ± 0.0095	0.2509 ± 0.0010	-0.4	-0.09	-0.06
^{60}Co (GH)	11.1 ± 1.2	12.074 ± 0.047	-8.1	-0.81	-1.39
^{134}Cs (GH)	2.01 ± 0.22	2.503 ± 0.018	-19.7	-2.23	-3.38
^{154}Eu (GH)	3.60 ± 0.40	4.015 ± 0.032	-10.3	-1.03	-1.78
^{137}Cs (GL)	9.84 ± 0.59	9.527 ± 0.086	3.3	0.52	0.56
^{210}Pb (GL)	19.4 ± 3.4	19.39 ± 0.20	0.1	0.00	0.01
^{241}Am (GL)	13.45 ± 0.78	14.825 ± 0.032	-9.3	-1.76	-1.59

Deviation (%) of Laboratory 61



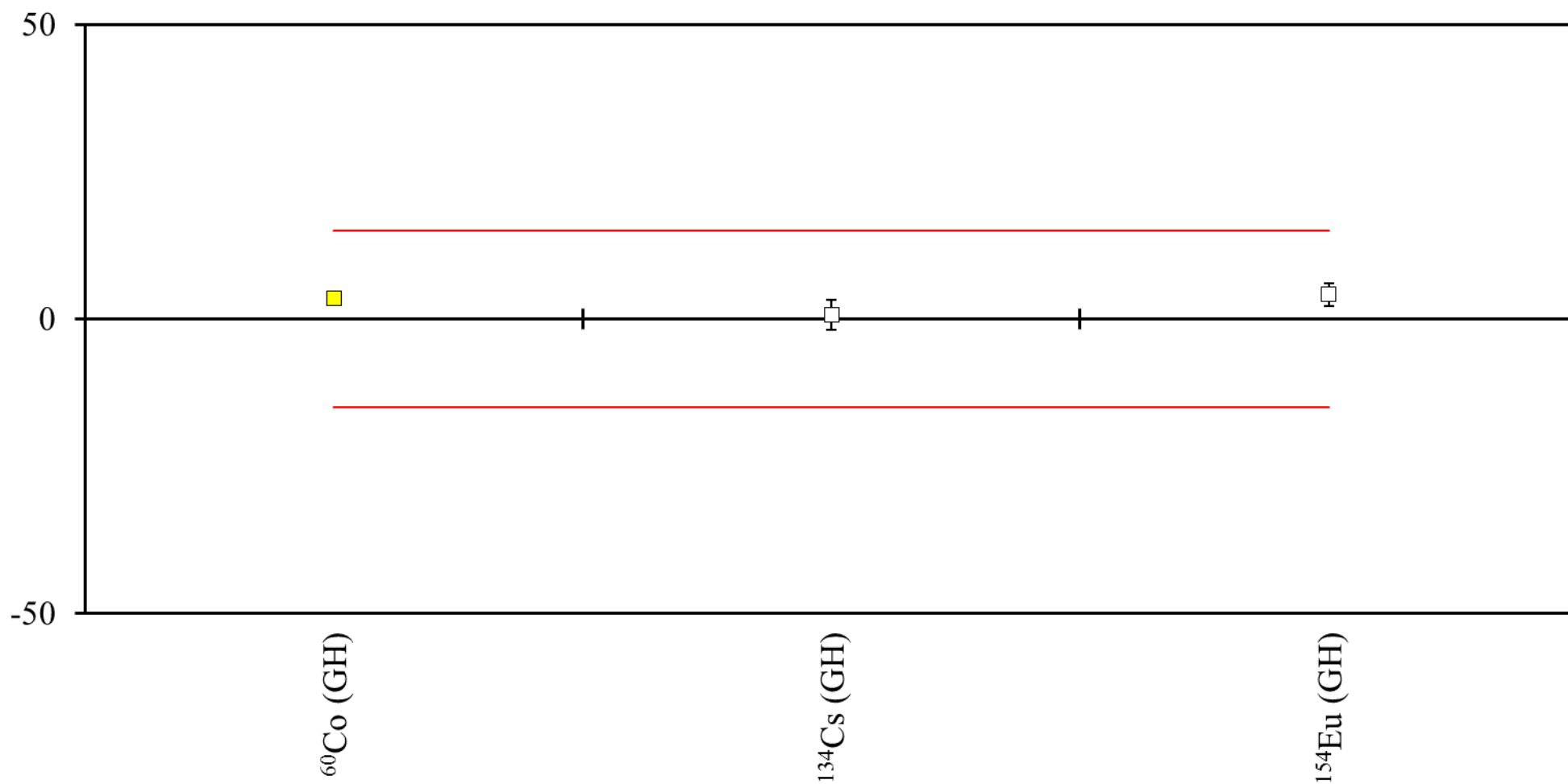
Radionuclide	Laboratory 61	NPL Assigned Value	Deviation /%	Zeta	Z Score
⁹⁰ Sr (AB)	5.09 ± 0.59	4.658 ± 0.021	9.3	0.73	1.59
²⁴¹ Am (AB)	2.58 ± 0.16	2.574 ± 0.011	0.2	0.04	0.04
²⁴⁴ Cm (AB)	16.1 ± 1.0	16.066 ± 0.054	0.2	0.03	0.04
²³³ U (A1)	16.5 ± 1.7	16.040 ± 0.049	2.9	0.27	0.49
²³⁶ U (A1)	11.8 ± 1.3	11.748 ± 0.029	0.4	0.04	0.08
⁶⁰ Co (GH)	12.70 ± 0.19	12.074 ± 0.047	5.2	3.20	0.89
¹³⁴ Cs (GH)	2.330 ± 0.035	2.503 ± 0.018	-6.9	-4.40	-1.19
¹⁵⁴ Eu (GH)	3.810 ± 0.050	4.015 ± 0.032	-5.1	-3.45	-0.88
¹³⁷ Cs (GL)	11.10 ± 0.62	9.527 ± 0.086	16.5	2.51	2.84
²¹⁰ Pb (GL)	22.5 ± 3.6	19.39 ± 0.20	16.0	0.86	2.75
²⁴¹ Am (GL)	16.40 ± 0.71	14.825 ± 0.032	10.6	2.22	1.82

Deviation (%) of Laboratory 65



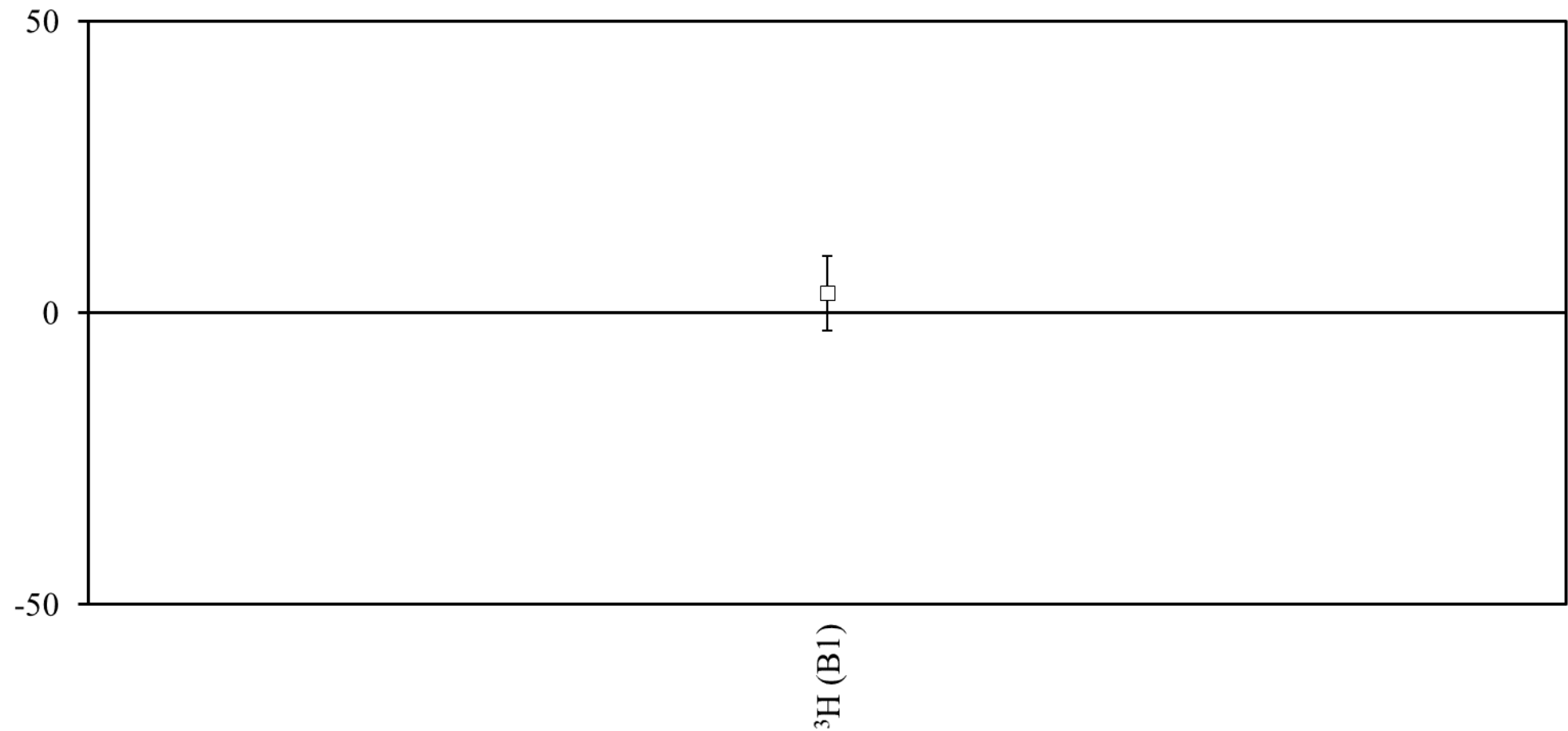
Radionuclide	Laboratory 65	NPL Assigned Value	Deviation /%	Zeta	Z Score
²³² Th (A1)	3.22 ± 0.41	3.305 ± 0.032	-2.6	-0.21	-0.44
³ H (B1)	1.080 ± 0.065	0.958 ± 0.012	12.7	1.85	2.19
¹⁴ C (B1)	0.528 ± 0.027	0.4974 ± 0.0033	6.2	1.12	1.06
³⁶ Cl (B1)	0.245 ± 0.021	0.2509 ± 0.0010	-2.4	-0.28	-0.40
¹³⁷ Cs (GL)	9.60 ± 0.54	9.527 ± 0.086	0.8	0.13	0.13
²¹⁰ Pb (GL)	17.9 ± 1.1	19.39 ± 0.20	-7.7	-1.33	-1.32
²⁴¹ Am (GL)	15.30 ± 0.89	14.825 ± 0.032	3.2	0.53	0.55
⁶⁰ Co (R1)	1.54 ± 0.12	1.543 ± 0.036	-0.2	-0.02	-0.03
¹³⁷ Cs (R1)	1.90 ± 0.17	1.904 ± 0.026	-0.2	-0.02	-0.04
²⁴¹ Am (R1)	5.45 ± 0.43	5.338 ± 0.067	2.1	0.26	0.36

Deviation (%) of Laboratory 67



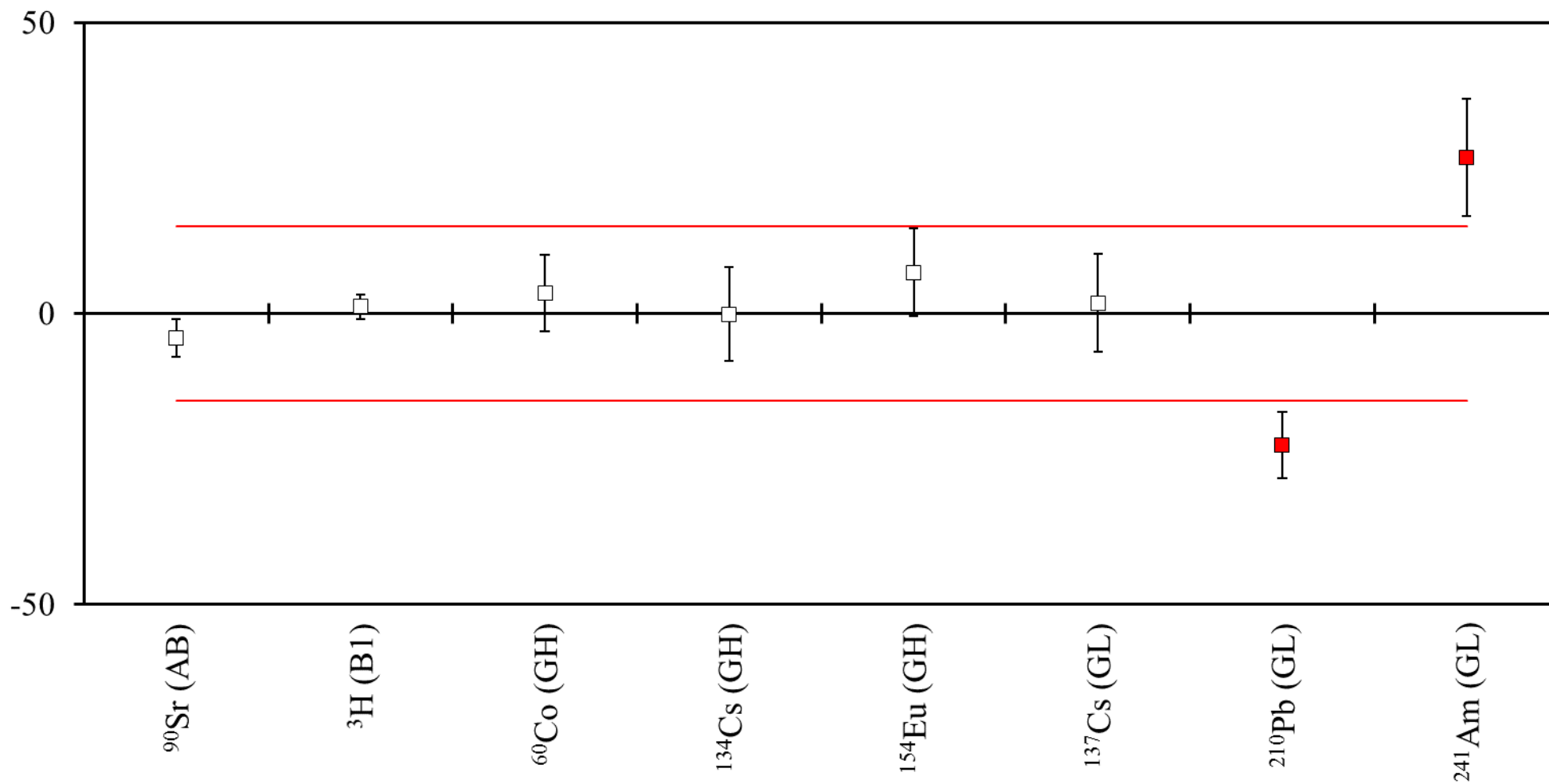
Radionuclide	Laboratory 67	NPL Assigned Value	Deviation /%	Zeta	Z Score
⁶⁰ Co (GH)	12.50 ± 0.11	12.074 ± 0.047	3.5	3.56	0.61
¹³⁴ Cs (GH)	2.520 ± 0.063	2.503 ± 0.018	0.7	0.26	0.12
¹⁵⁴ Eu (GH)	4.180 ± 0.072	4.015 ± 0.032	4.1	2.09	0.71

Deviation (%) of Laboratory 72



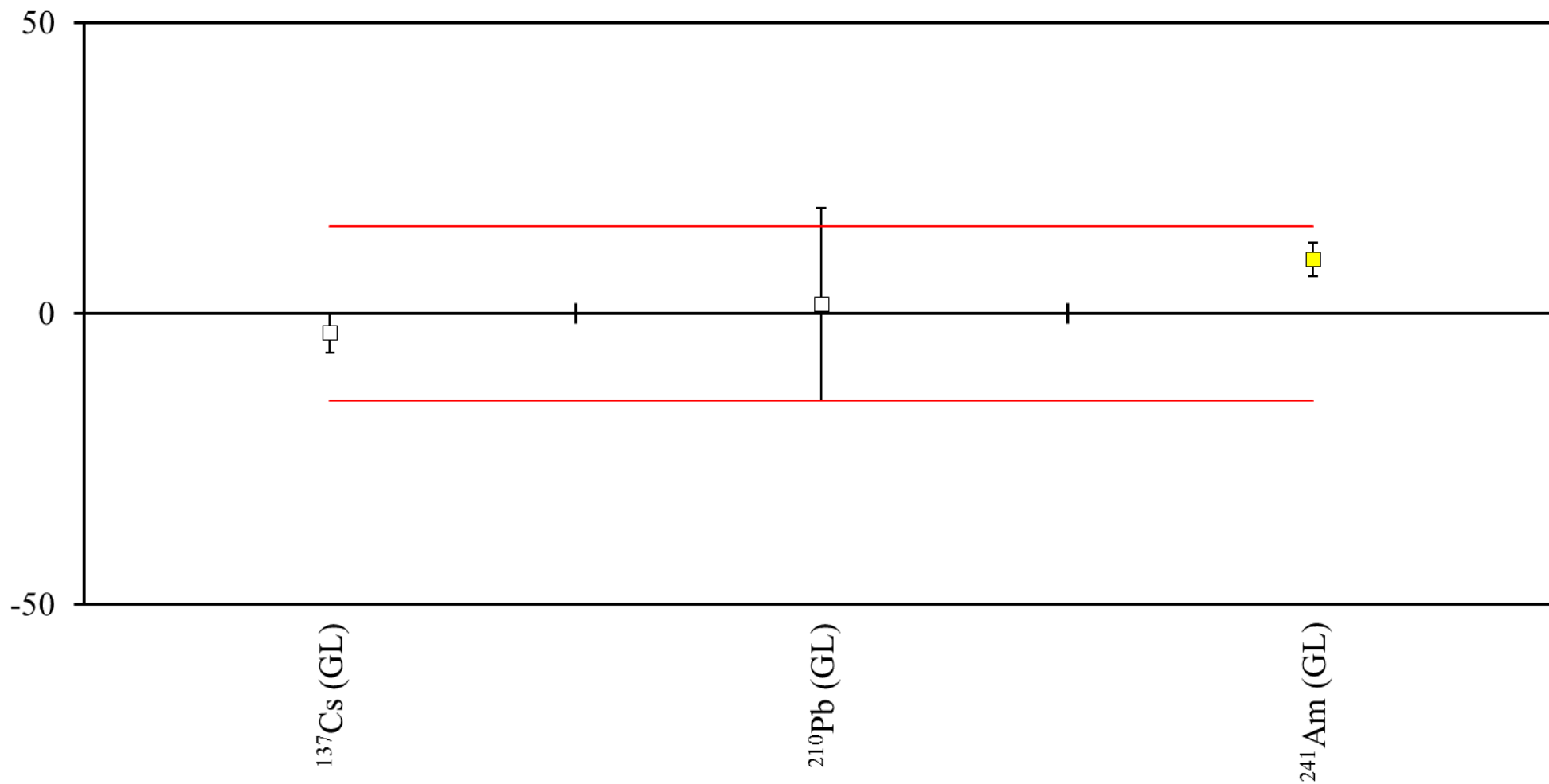
Radionuclide	Laboratory 72	NPL Assigned Value	Deviation /%	Zeta	Z Score
^3H (B1)	0.99 ± 0.06	0.958 ± 0.012	3.3	0.52	0.57

Deviation (%) of Laboratory 74



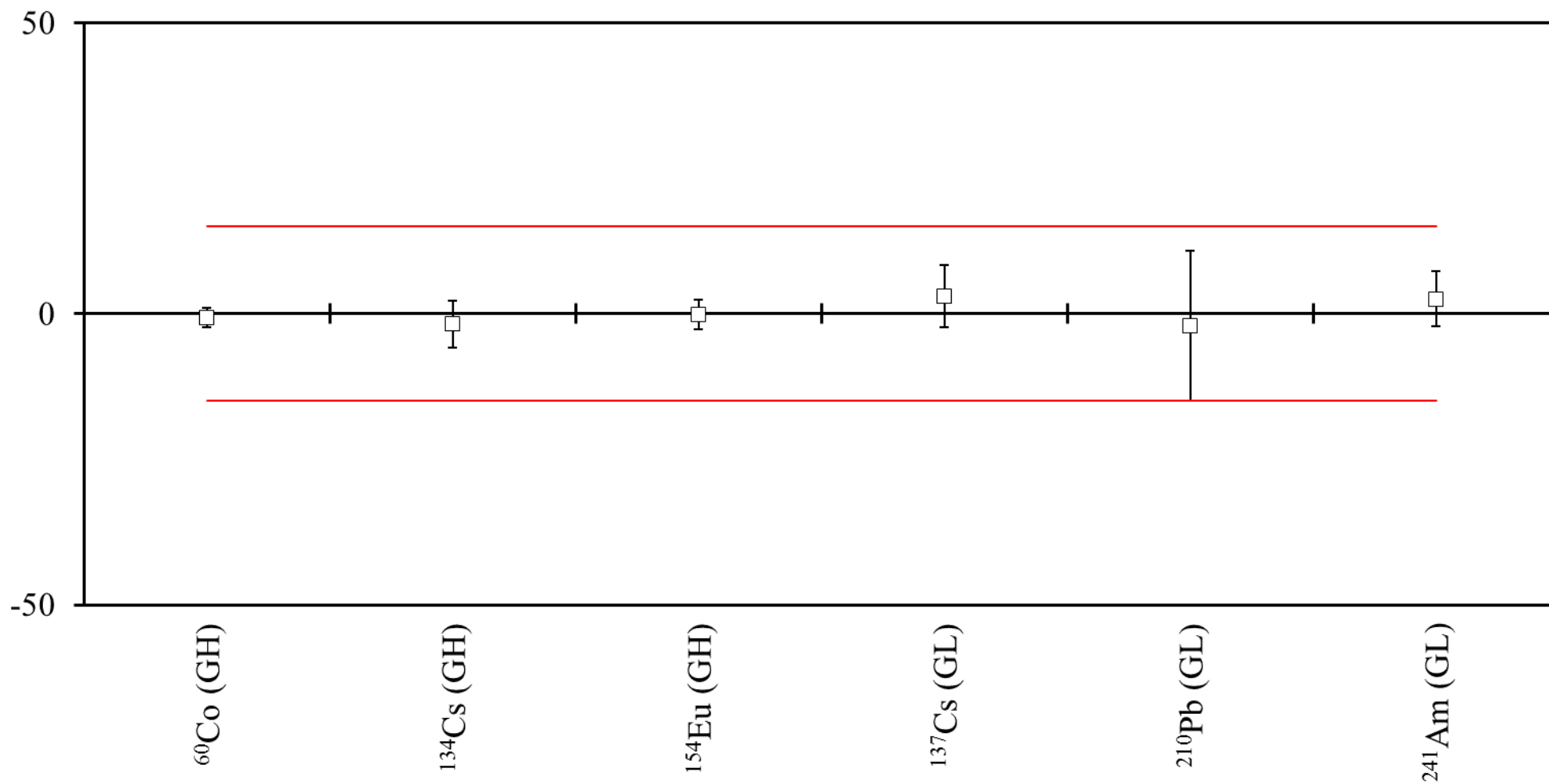
Radionuclide	Laboratory 74	NPL Assigned Value	Deviation /%	Zeta	Z Score
⁹⁰ Sr (AB)	4.46 ± 0.15	4.658 ± 0.021	-4.3	-1.31	-0.73
³ H (B1)	0.969 ± 0.016	0.958 ± 0.012	1.1	0.55	0.20
⁶⁰ Co (GH)	12.50 ± 0.80	12.074 ± 0.047	3.5	0.53	0.61
¹³⁴ Cs (GH)	2.50 ± 0.20	2.503 ± 0.018	-0.1	-0.01	-0.02
¹⁵⁴ Eu (GH)	4.3 ± 0.3	4.015 ± 0.032	7.1	0.94	1.22
¹³⁷ Cs (GL)	9.70 ± 0.80	9.527 ± 0.086	1.8	0.22	0.31
²¹⁰ Pb (GL)	15.0 ± 1.1	19.39 ± 0.20	-22.6	-3.93	-3.89
²⁴¹ Am (GL)	18.8 ± 1.5	14.825 ± 0.032	26.8	2.65	4.60

Deviation (%) of Laboratory 76

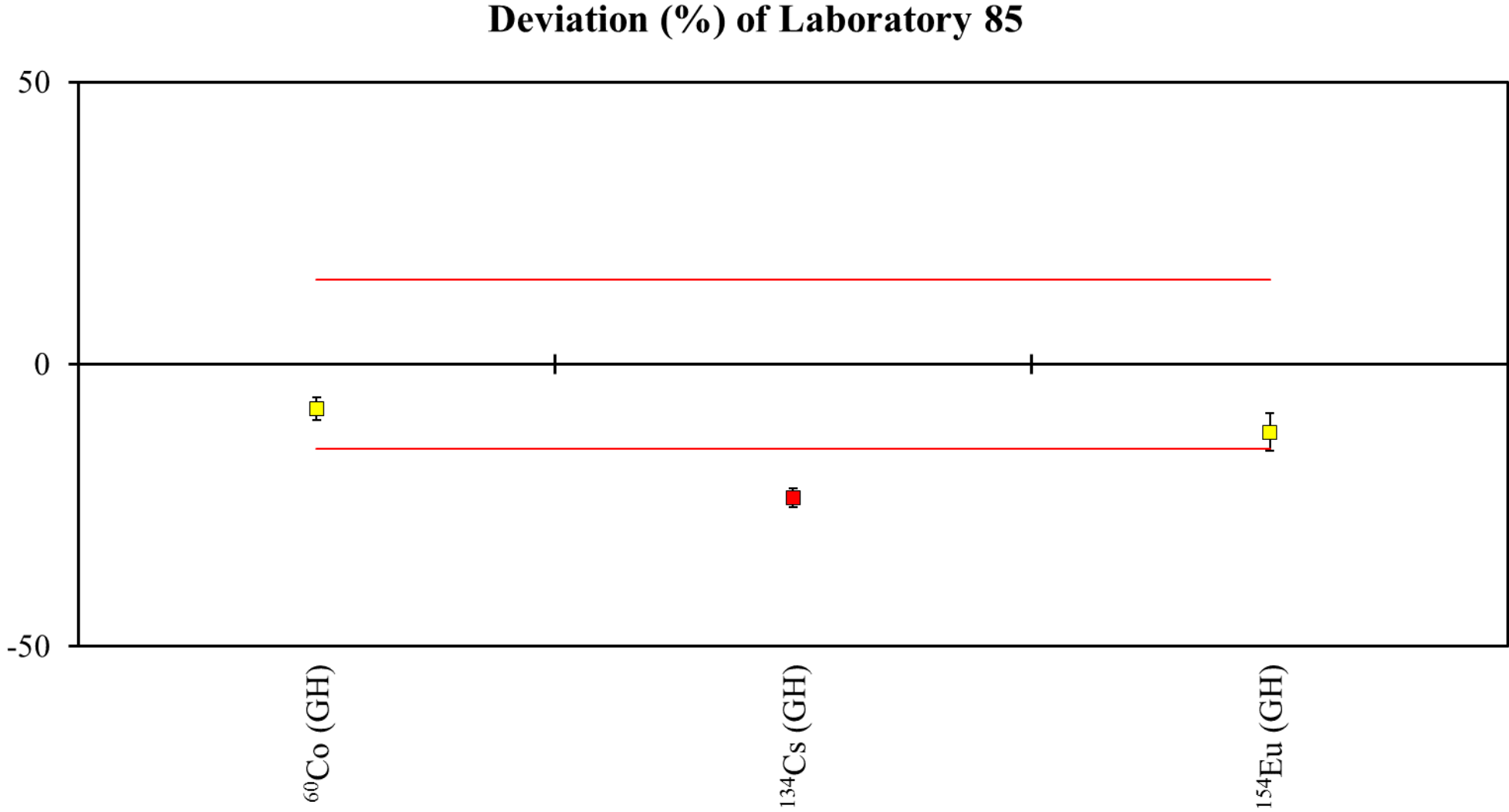


Radionuclide	Laboratory 76	NPL Assigned Value	Deviation /%	Zeta	Z Score
¹³⁷ Cs (GL)	9.20 ± 0.31	9.527 ± 0.086	-3.4	-1.02	-0.59
²¹⁰ Pb (GL)	19.7 ± 3.2	19.39 ± 0.20	1.6	0.10	0.27
²⁴¹ Am (GL)	16.20 ± 0.42	14.825 ± 0.032	9.3	3.26	1.59

Deviation (%) of Laboratory 83

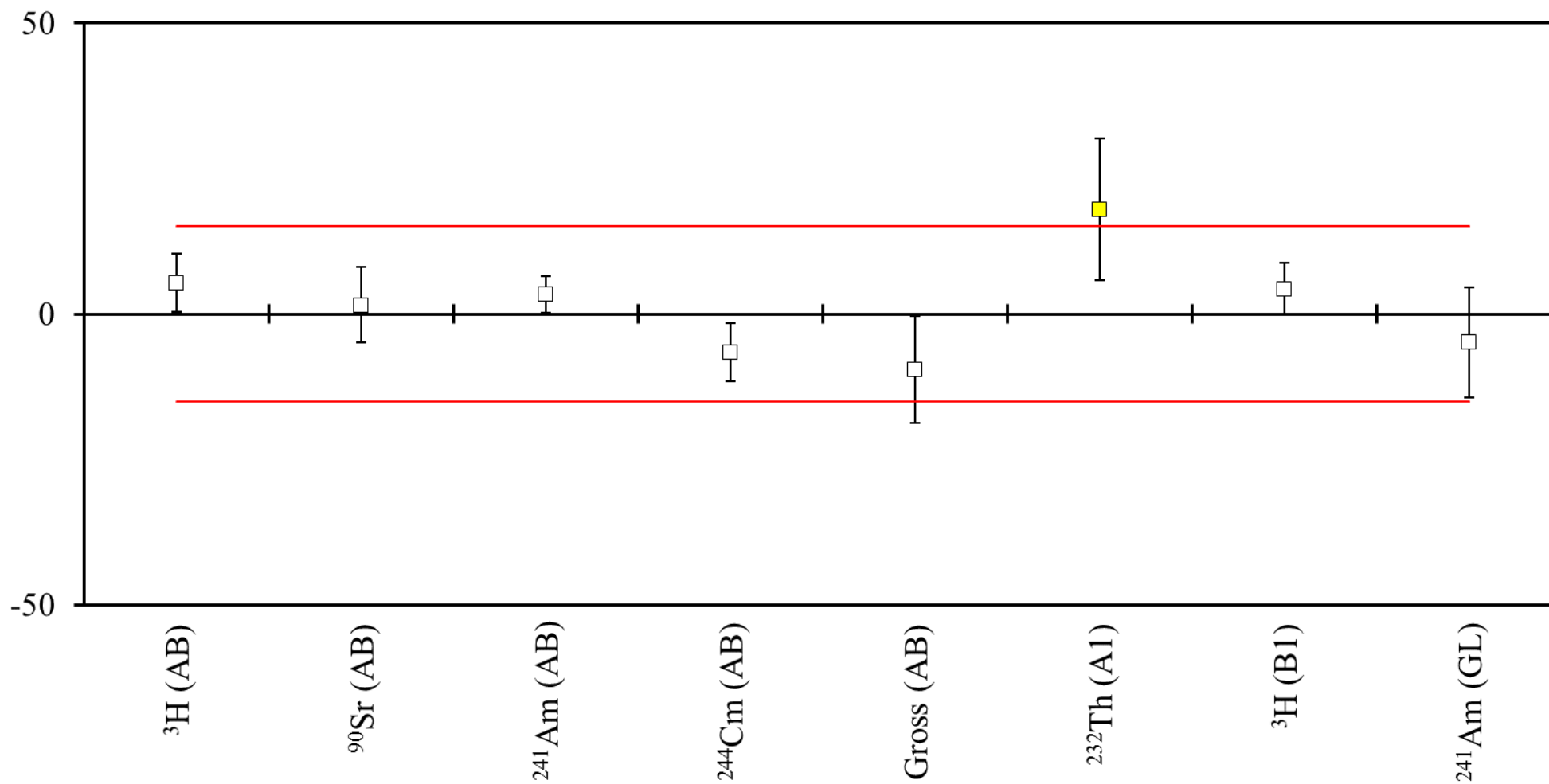


Radionuclide	Laboratory 83	NPL Assigned Value	Deviation /%	Zeta	Z Score
^{60}Co (GH)	12.00 ± 0.20	12.074 ± 0.047	-0.6	-0.36	-0.11
^{134}Cs (GH)	2.46 ± 0.10	2.503 ± 0.018	-1.7	-0.42	-0.30
^{154}Eu (GH)	4.01 ± 0.10	4.015 ± 0.032	-0.1	-0.05	-0.02
^{137}Cs (GL)	9.82 ± 0.50	9.527 ± 0.086	3.1	0.58	0.53
^{210}Pb (GL)	19.0 ± 2.5	19.39 ± 0.20	-2.0	-0.16	-0.35
^{241}Am (GL)	15.2 ± 0.7	14.825 ± 0.032	2.5	0.54	0.43



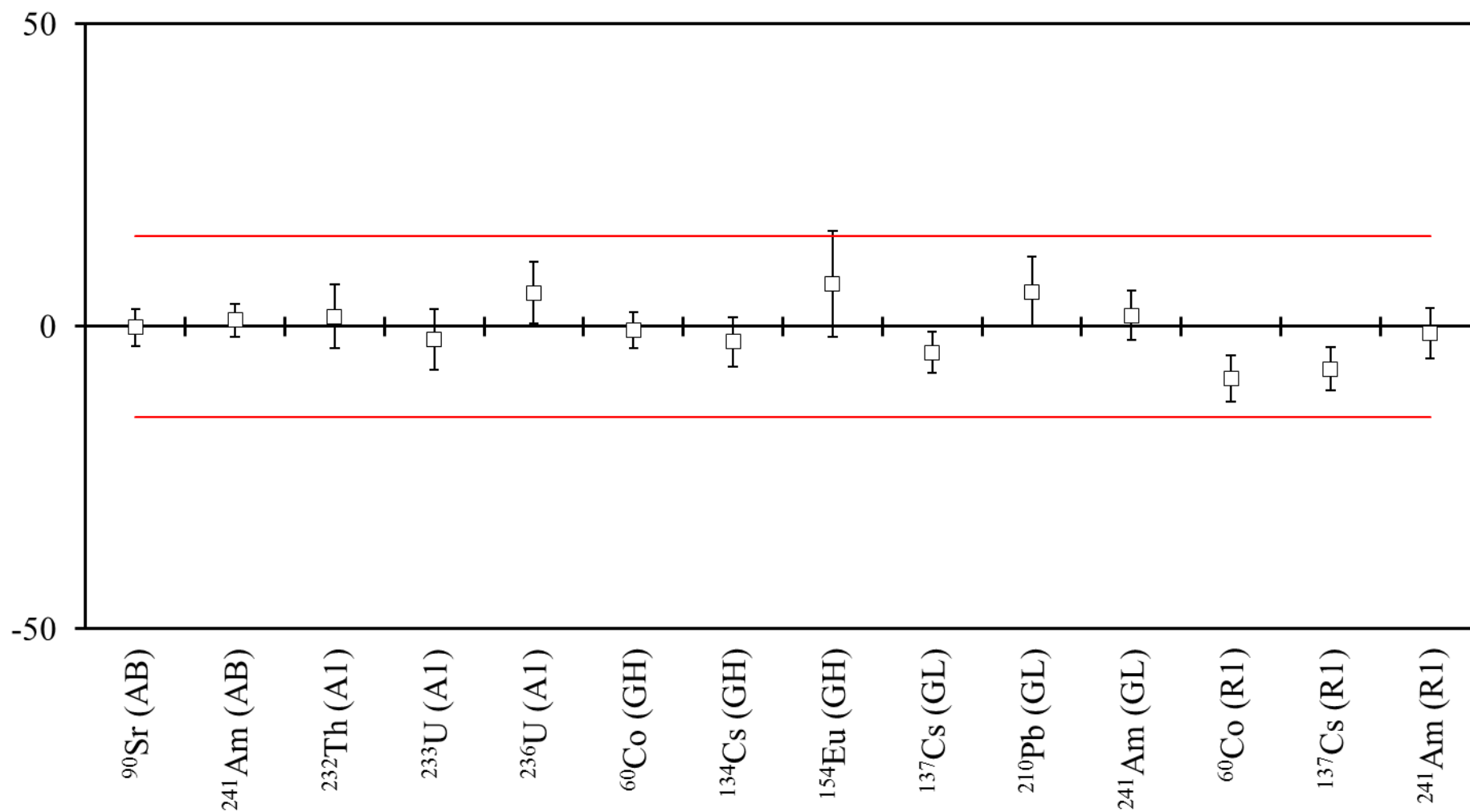
Radionuclide	Laboratory 85	NPL Assigned Value	Deviation /%	Zeta	Z Score
⁶⁰ Co (GH)	11.12 ± 0.24	12.074 ± 0.047	-7.9	-3.90	-1.36
¹³⁴ Cs (GH)	1.911 ± 0.040	2.503 ± 0.018	-23.7	-13.50	-4.06
¹⁵⁴ Eu (GH)	3.53 ± 0.13	4.015 ± 0.032	-12.1	-3.62	-2.07

Deviation (%) of Laboratory 86.1



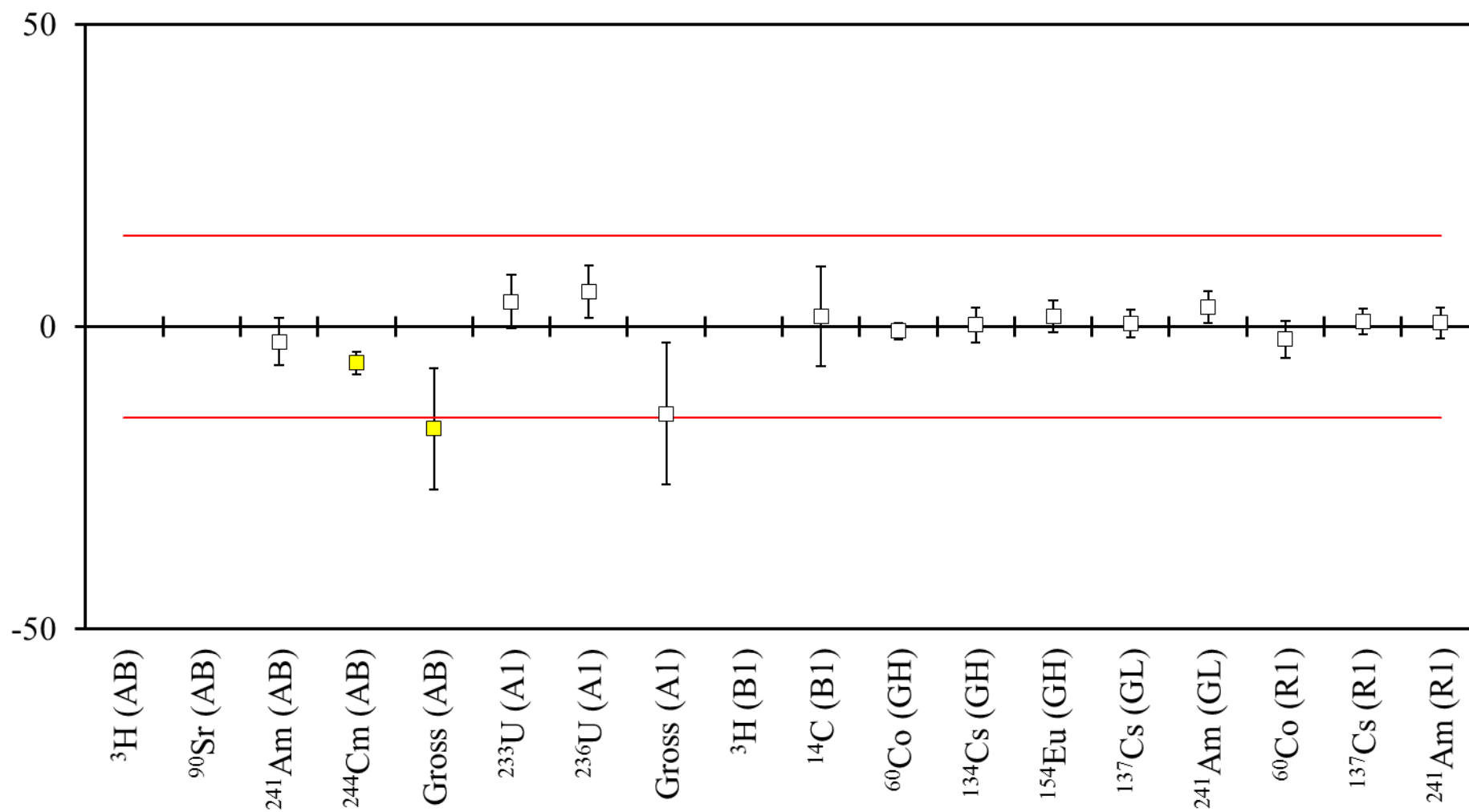
Radionuclide	Laboratory 86.1	NPL Assigned Value	Deviation /%	Zeta	Z Score
^3H (AB)	5.30 ± 0.24	5.031 ± 0.064	5.3	1.08	0.92
^{90}Sr (AB)	4.730 ± 0.3	4.658 ± 0.021	1.5	0.24	0.27
^{241}Am (AB)	2.660 ± 0.080	2.574 ± 0.011	3.3	1.06	0.57
^{244}Cm (AB)	15.00 ± 0.80	16.066 ± 0.054	-6.6	-1.33	-1.14
Gross alpha (AB)	17.7 ± 1.7	19.62 ± 0.61	-9.8	-1.06	-1.68
^{232}Th (A1)	3.90 ± 0.40	3.305 ± 0.032	18.0	1.48	3.09
^3H (B1)	1.000 ± 0.040	0.958 ± 0.012	4.4	1.01	0.75
^{241}Am (GL)	14.1 ± 1.4	14.825 ± 0.032	-4.9	-0.52	-0.84

Deviation (%) of Laboratory 86.2



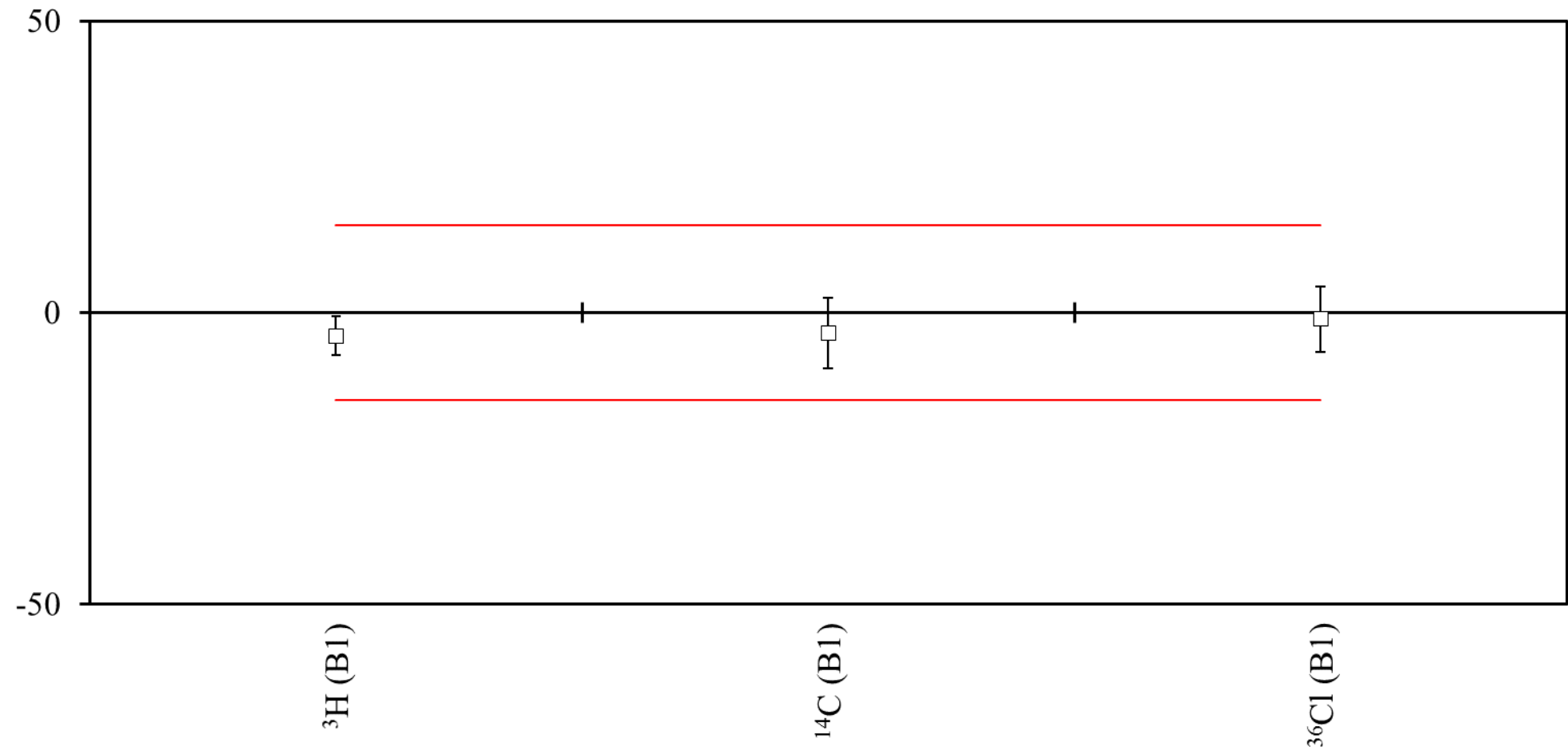
Radionuclide	Laboratory 86.2	NPL Assigned Value	Deviation /%	Zeta	Z Score
⁹⁰ Sr (AB)	4.65 ± 0.14	4.658 ± 0.021	-0.2	-0.06	-0.03
²⁴¹ Am (AB)	2.60 ± 0.07	2.574 ± 0.011	1.0	0.37	0.17
²³² Th (A1)	3.36 ± 0.17	3.305 ± 0.032	1.7	0.32	0.29
²³³ U (A1)	15.70 ± 0.80	16.040 ± 0.049	-2.1	-0.42	-0.36
²³⁶ U (A1)	12.4 ± 0.6	11.748 ± 0.029	5.5	1.09	0.95
⁶⁰ Co (GH)	12.00 ± 0.35	12.074 ± 0.047	-0.6	-0.21	-0.11
¹³⁴ Cs (GH)	2.44 ± 0.10	2.503 ± 0.018	-2.5	-0.62	-0.43
¹⁵⁴ Eu (GH)	4.30 ± 0.35	4.015 ± 0.032	7.1	0.81	1.22
¹³⁷ Cs (GL)	9.12 ± 0.32	9.527 ± 0.086	-4.3	-1.23	-0.73
²¹⁰ Pb (GL)	20.5 ± 1.1	19.39 ± 0.20	5.7	0.99	0.98
²⁴¹ Am (GL)	15.1 ± 0.6	14.825 ± 0.032	1.9	0.46	0.32
⁶⁰ Co (R1)	1.410 ± 0.050	1.543 ± 0.036	-8.6	-2.16	-1.48
¹³⁷ Cs (R1)	1.770 ± 0.063	1.904 ± 0.026	-7.0	-1.97	-1.21
²⁴¹ Am (R1)	5.28 ± 0.21	5.338 ± 0.067	-1.1	-0.26	-0.19

Deviation (%) of Laboratory 91



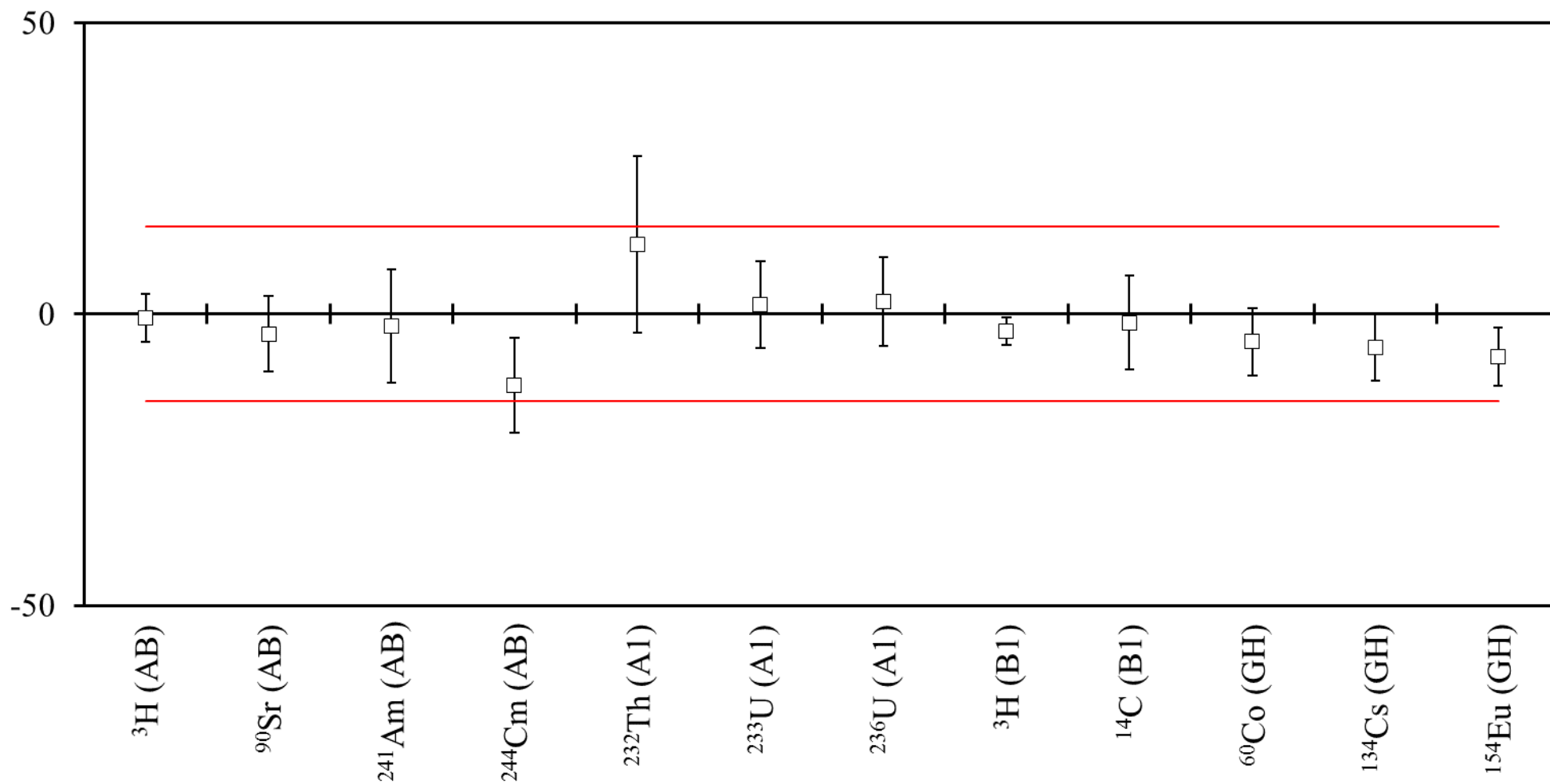
Radionuclide	Laboratory 91	NPL Assigned Value	Deviation /%	Zeta	Z Score
³ H (AB)	0.957 ± 0.016	5.031 ± 0.064	-81.0	-61.76	-13.91
⁹⁰ Sr (AB)	9.71 ± 0.28	4.658 ± 0.021	108.5	17.99	18.63
²⁴¹ Am (AB)	2.51 ± 0.10	2.574 ± 0.011	-2.5	-0.64	-0.43
²⁴⁴ Cm (AB)	15.1 ± 0.3	16.066 ± 0.054	-6.0	-3.17	-1.03
Gross alpha (AB)	16.3 ± 1.9	19.62 ± 0.61	-16.9	-1.66	-2.91
²³³ U (A1)	16.7 ± 0.7	16.040 ± 0.049	4.1	0.94	0.71
²³⁶ U (A1)	12.43 ± 0.51	11.748 ± 0.029	5.8	1.34	1.00
Gross alpha (A1)	32.0 ± 4.0	37.4 ± 2.1	-14.4	-1.20	-2.48
³ H (B1)	5.11 ± 0.11	0.958 ± 0.012	433.4	37.52	74.43
¹⁴ C (B1)	0.506 ± 0.041	0.4974 ± 0.0033	1.7	0.21	0.30
⁶⁰ Co (GH)	11.98 ± 0.15	12.074 ± 0.047	-0.8	-0.60	-0.13
¹³⁴ Cs (GH)	2.51 ± 0.07	2.503 ± 0.018	0.3	0.10	0.05
¹⁵⁴ Eu (GH)	4.08 ± 0.10	4.015 ± 0.032	1.6	0.62	0.28
¹³⁷ Cs (GL)	9.58 ± 0.20	9.527 ± 0.086	0.6	0.24	0.10
²⁴¹ Am (GL)	15.30 ± 0.40	14.825 ± 0.032	3.2	1.18	0.55
⁶⁰ Co (R1)	1.51 ± 0.03	1.543 ± 0.036	-2.1	-0.70	-0.37
¹³⁷ Cs (R1)	1.92 ± 0.03	1.904 ± 0.026	0.8	0.40	0.14
²⁴¹ Am (R1)	5.37 ± 0.12	5.338 ± 0.067	0.6	0.23	0.10

Deviation (%) of Laboratory 103



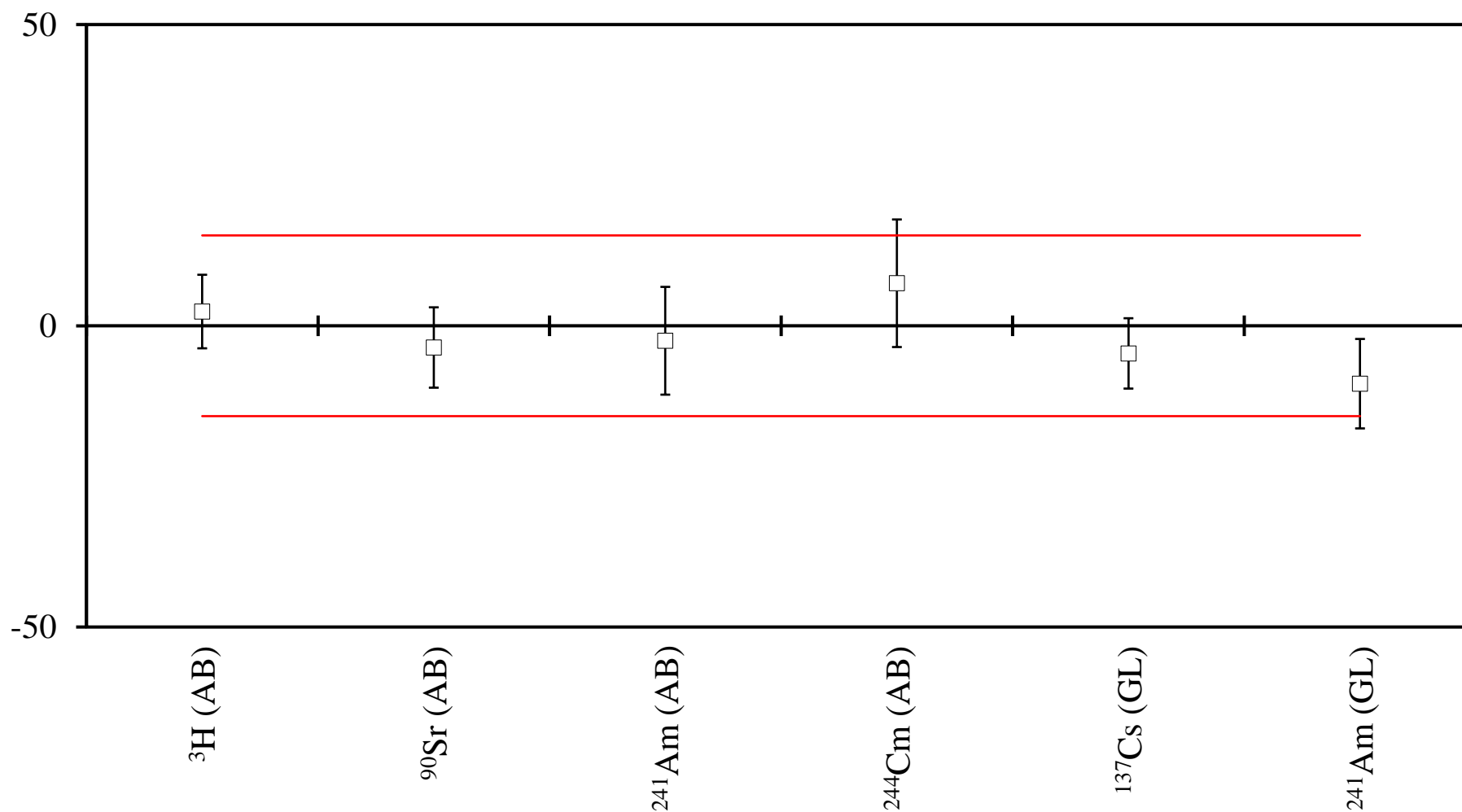
Radionuclide	Laboratory 103	NPL Assigned Value	Deviation /%	Zeta	Z Score
^3H (B1)	0.92 ± 0.03	0.958 ± 0.012	-4.0	-1.18	-0.68
^{14}C (B1)	0.48 ± 0.03	0.4974 ± 0.0033	-3.5	-0.58	-0.60
^{36}Cl (B1)	0.248 ± 0.014	0.2509 ± 0.0010	-1.2	-0.21	-0.20

Deviation (%) of Laboratory 106



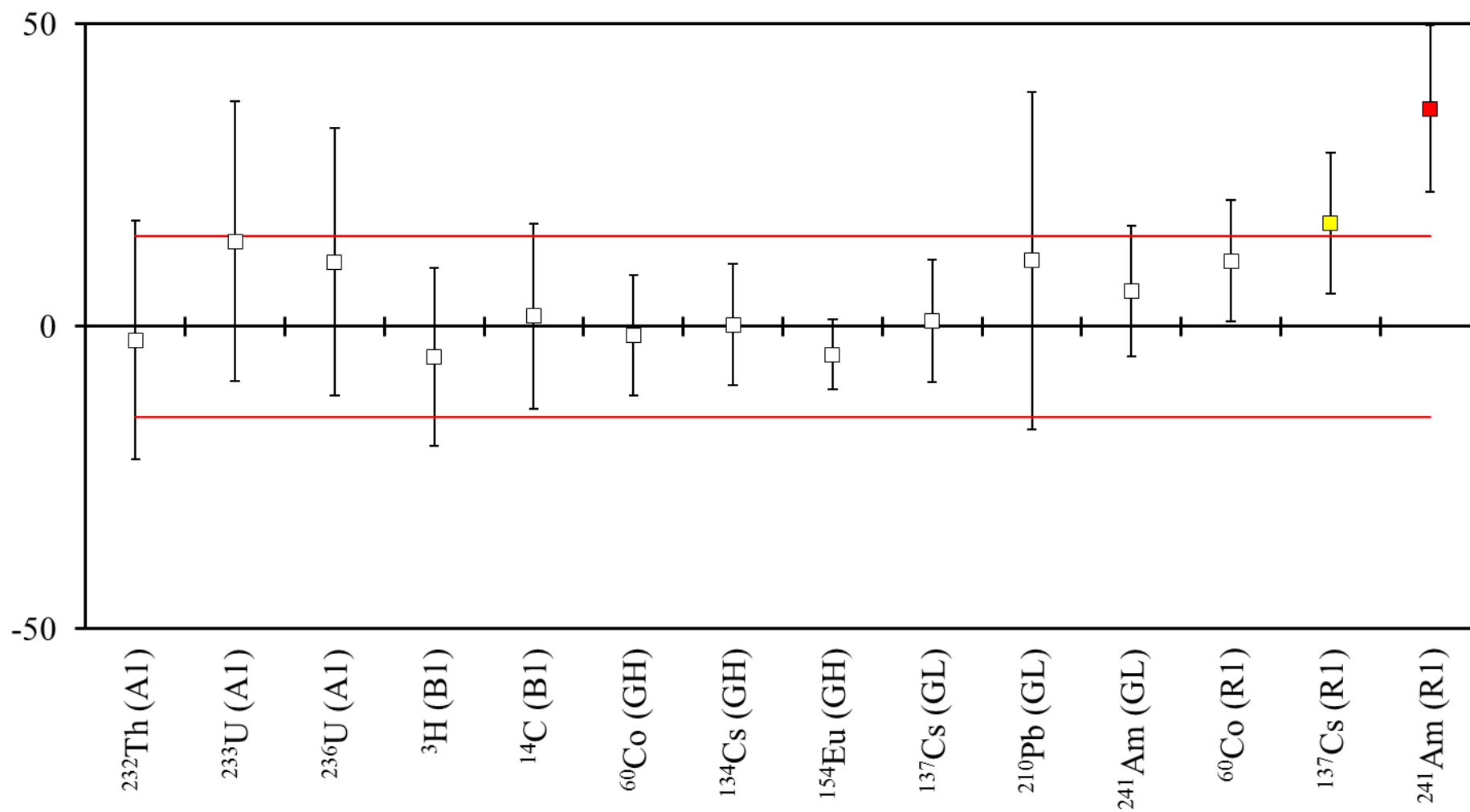
Radionuclide	Laboratory 106	NPL Assigned Value	Deviation /%	Zeta	Z Score
^3H (AB)	5.00 ± 0.20	5.031 ± 0.064	-0.6	-0.15	-0.11
^{90}Sr (AB)	4.5 ± 0.3	4.658 ± 0.021	-3.4	-0.53	-0.58
^{241}Am (AB)	2.52 ± 0.25	2.574 ± 0.011	-2.1	-0.22	-0.36
^{244}Cm (AB)	14.1 ± 1.3	16.066 ± 0.054	-12.2	-1.51	-2.10
^{232}Th (A1)	3.70 ± 0.50	3.305 ± 0.032	12.0	0.79	2.05
^{233}U (A1)	16.3 ± 1.2	16.040 ± 0.049	1.6	0.22	0.28
^{236}U (A1)	12.00 ± 0.90	11.748 ± 0.029	2.1	0.28	0.37
^3H (B1)	0.930 ± 0.020	0.958 ± 0.012	-2.9	-1.20	-0.50
^{14}C (B1)	0.490 ± 0.040	0.4974 ± 0.0033	-1.5	-0.18	-0.26
^{60}Co (GH)	11.5 ± 0.7	12.074 ± 0.047	-4.8	-0.82	-0.82
^{134}Cs (GH)	2.36 ± 0.14	2.503 ± 0.018	-5.7	-1.01	-0.98
^{154}Eu (GH)	3.72 ± 0.20	4.015 ± 0.032	-7.3	-1.46	-1.26

Deviation (%) of Laboratory 107



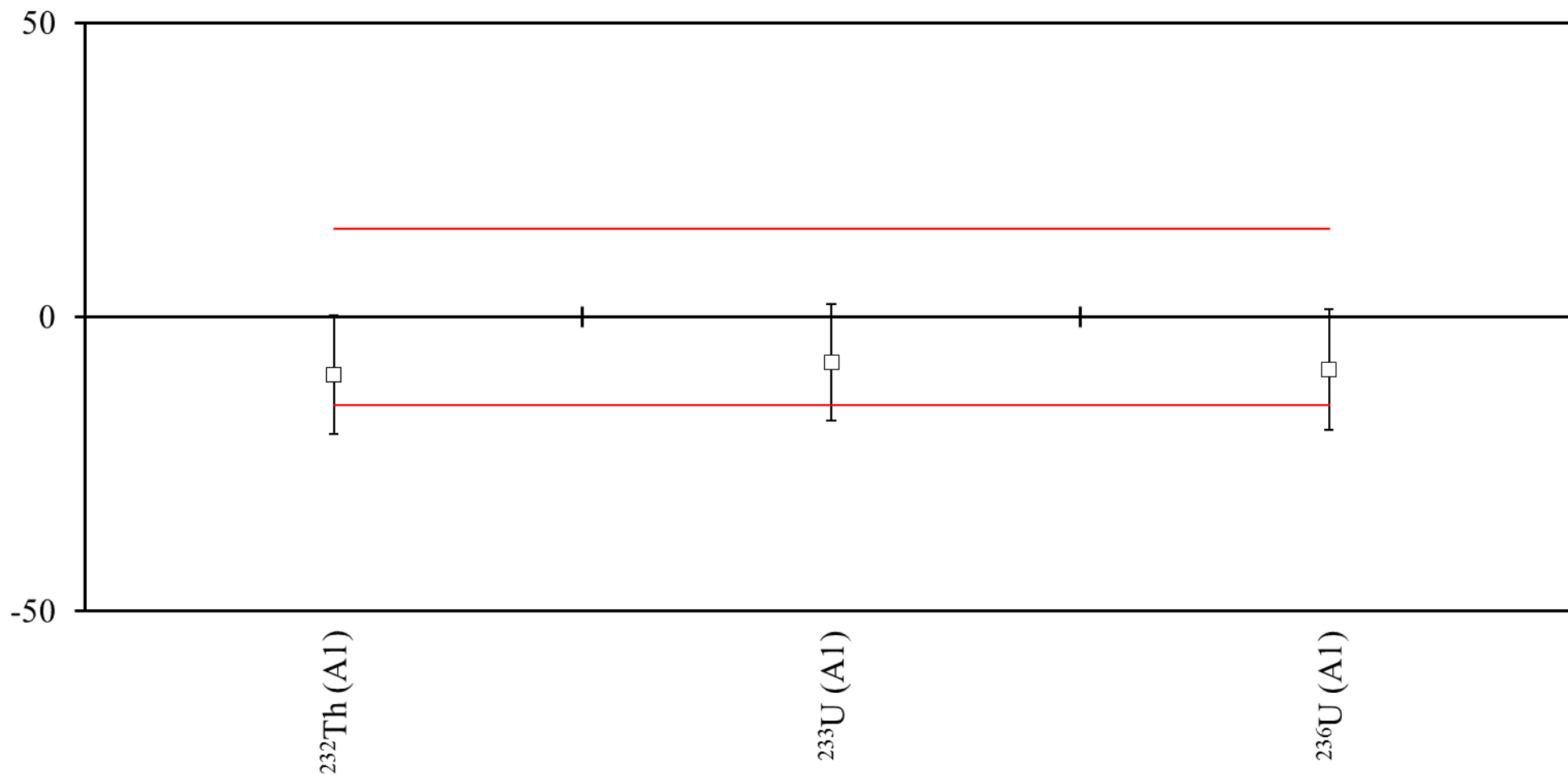
Radionuclide	Laboratory 107	NPL Assigned Value	Deviation /%	Zeta	Z Score
^3H (AB)	5.150 ± 0.3	5.031 ± 0.064	2.4	0.39	0.41
^{90}Sr (AB)	4.49 ± 0.31	4.658 ± 0.021	-3.6	-0.54	-0.62
^{241}Am (AB)	2.51 ± 0.23	2.574 ± 0.011	-2.5	-0.28	-0.43
^{244}Cm (AB)	17.2 ± 1.7	16.066 ± 0.054	7.1	0.67	1.21
^{137}Cs (GL)	9.09 ± 0.55	9.527 ± 0.086	-4.6	-0.79	-0.79
^{241}Am (GL)	13.4 ± 1.1	14.825 ± 0.032	-9.6	-1.29	-1.65

Deviation (%) of Laboratory 109.1



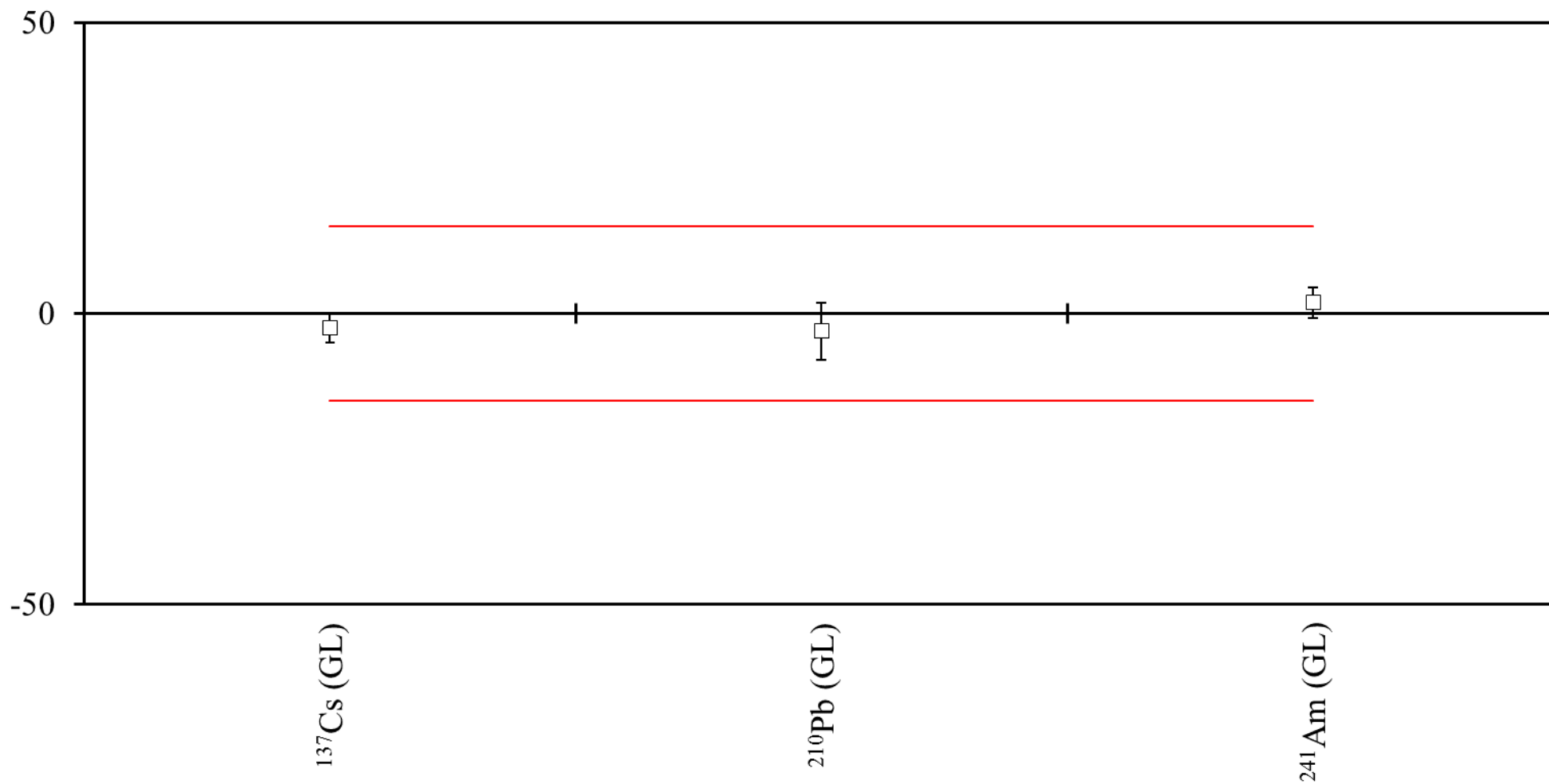
Radionuclide	Laboratory 109.1	NPL Assigned Value	Deviation /%	Zeta	Z Score
²³² Th (A1)	3.23 ± 0.65	3.305 ± 0.032	-2.3	-0.12	-0.39
²³³ U (A1)	18.3 ± 3.7	16.040 ± 0.049	14.1	0.61	2.42
²³⁶ U (A1)	13.0 ± 2.6	11.748 ± 0.029	10.7	0.48	1.83
³ H (B1)	0.91 ± 0.14	0.958 ± 0.012	-5.0	-0.34	-0.86
¹⁴ C (B1)	0.506 ± 0.076	0.4974 ± 0.0033	1.7	0.11	0.30
⁶⁰ Co (GH)	11.9 ± 1.2	12.074 ± 0.047	-1.4	-0.14	-0.25
¹³⁴ Cs (GH)	2.51 ± 0.25	2.503 ± 0.018	0.3	0.03	0.05
¹⁵⁴ Eu (GH)	3.83 ± 0.23	4.015 ± 0.032	-4.6	-0.80	-0.79
¹³⁷ Cs (GL)	9.62 ± 0.96	9.527 ± 0.086	1.0	0.10	0.17
²¹⁰ Pb (GL)	21.5 ± 5.4	19.39 ± 0.20	10.9	0.39	1.87
²⁴¹ Am (GL)	15.7 ± 1.6	14.825 ± 0.032	5.9	0.55	1.01
⁶⁰ Co (R1)	1.71 ± 0.15	1.543 ± 0.036	10.8	1.08	1.86
¹³⁷ Cs (R1)	2.23 ± 0.22	1.904 ± 0.026	17.1	1.47	2.94
²⁴¹ Am (R1)	7.26 ± 0.73	5.338 ± 0.067	36.0	2.62	6.18

Deviation (%) of Laboratory 109.2



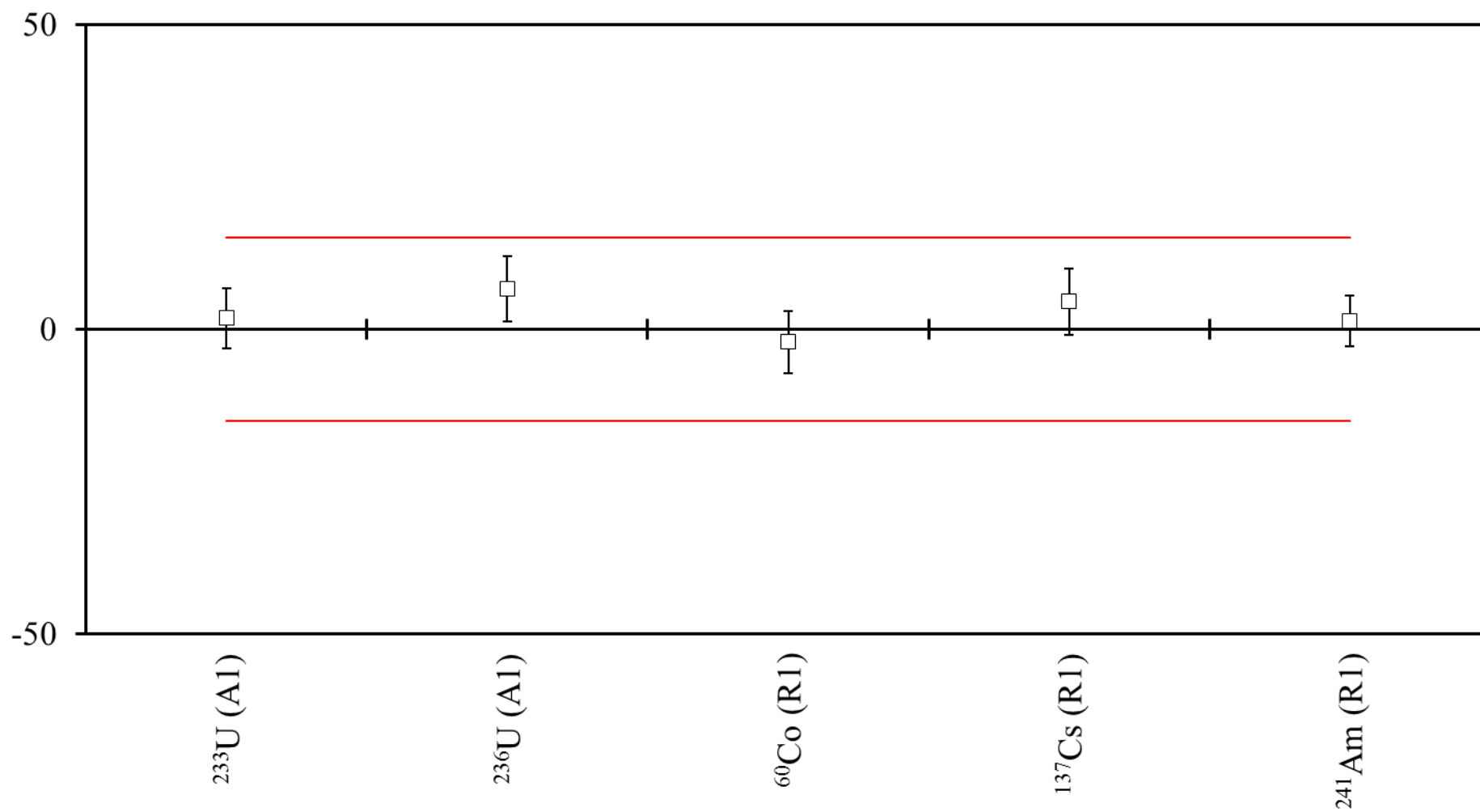
Radionuclide	Laboratory 109.2	NPL Assigned Value	Deviation /%	Zeta	Z Score
²³² Th (A1)	2.98 ± 0.33	3.305 ± 0.032	-9.8	-0.98	-1.69
²³³ U (A1)	14.8 ± 1.6	16.040 ± 0.049	-7.7	-0.77	-1.33
²³⁶ U (A1)	10.7 ± 1.2	11.748 ± 0.029	-8.9	-0.87	-1.53

Deviation (%) of Laboratory 111



Radionuclide	Laboratory 111	NPL Assigned Value	Deviation /%	Zeta	Z Score
¹³⁷ Cs (GL)	9.29 ± 0.22	9.527 ± 0.086	-2.5	-1.00	-0.43
²¹⁰ Pb (GL)	18.80 ± 0.93	19.39 ± 0.20	-3.0	-0.62	-0.52
²⁴¹ Am (GL)	15.10 ± 0.39	14.825 ± 0.032	1.9	0.70	0.32

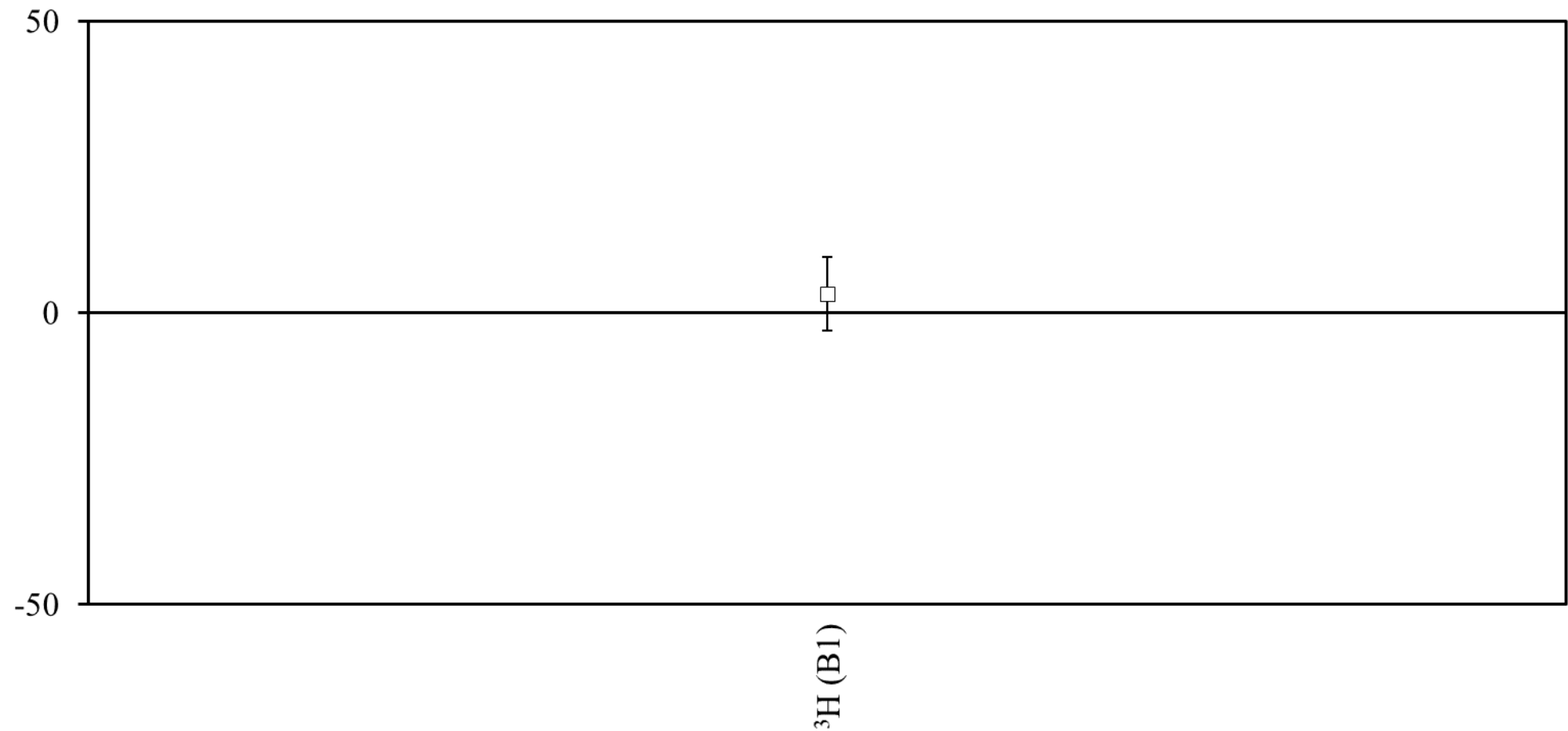
Deviation (%) of Laboratory 120.1



Radionuclide	Laboratory 120.1	NPL Assigned Value	Deviation /%	Zeta	Z Score
²³³ U (A1)	16.33 ± 0.79	16.040 ± 0.049	1.8	0.37	0.31
²³⁶ U (A1)	12.53 ± 0.63	11.748 ± 0.029	6.7	1.24	1.14
⁶⁰ Co (R1)	1.51 ± 0.07	1.543 ± 0.036	-2.1	-0.42	-0.37
¹³⁷ Cs (R1)	1.99 ± 0.10	1.904 ± 0.026	4.5	0.83	0.78
²⁴¹ Am (R1)	5.41 ± 0.21	5.338 ± 0.067	1.3	0.33	0.23

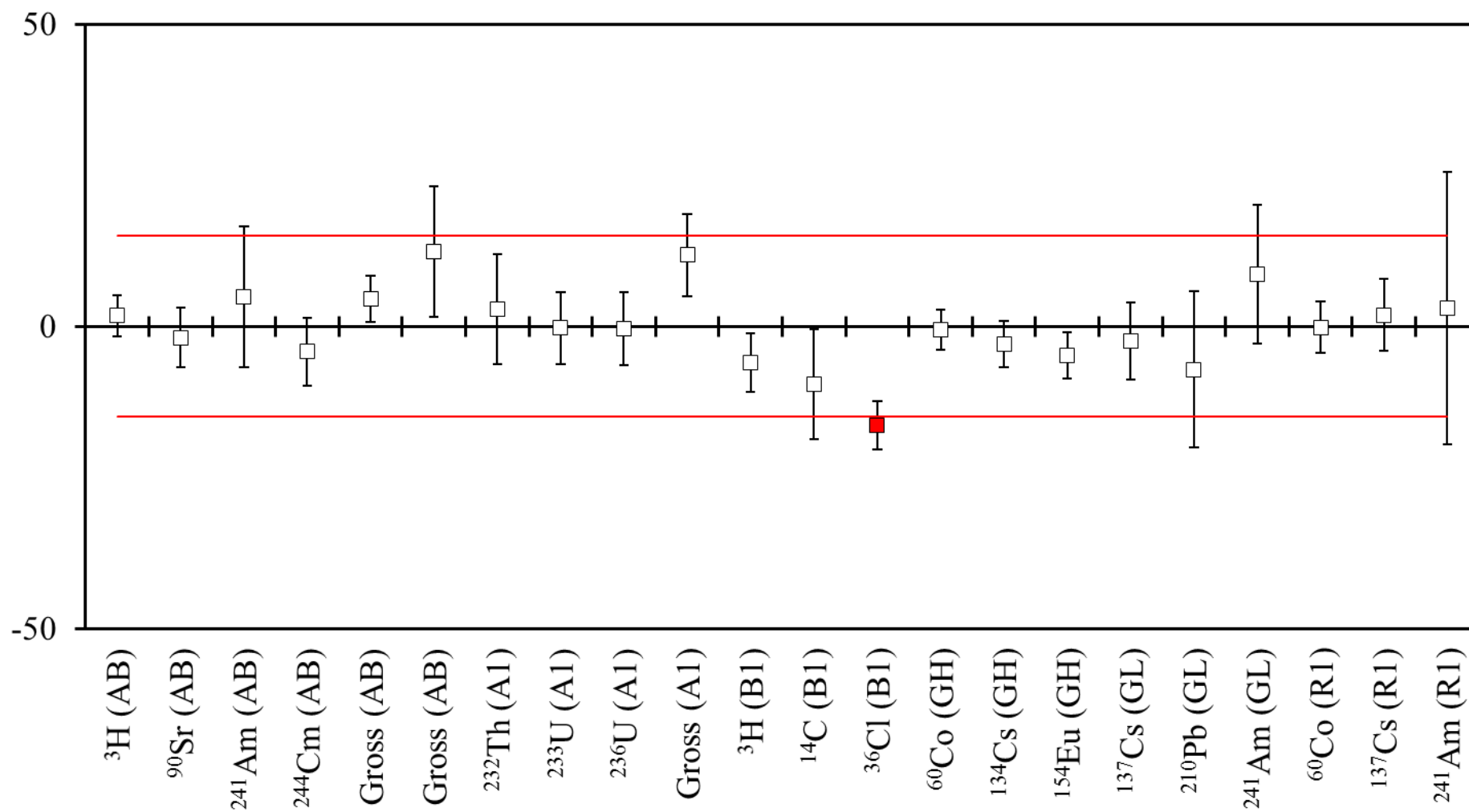
Radionuclide	Laboratory 120.2	NPL Assigned Value	Deviation /%	Zeta	Z Score
²⁴¹ Am (R1)	5.24 ± 0.45	-	-	-	-

Deviation (%) of Laboratory 128



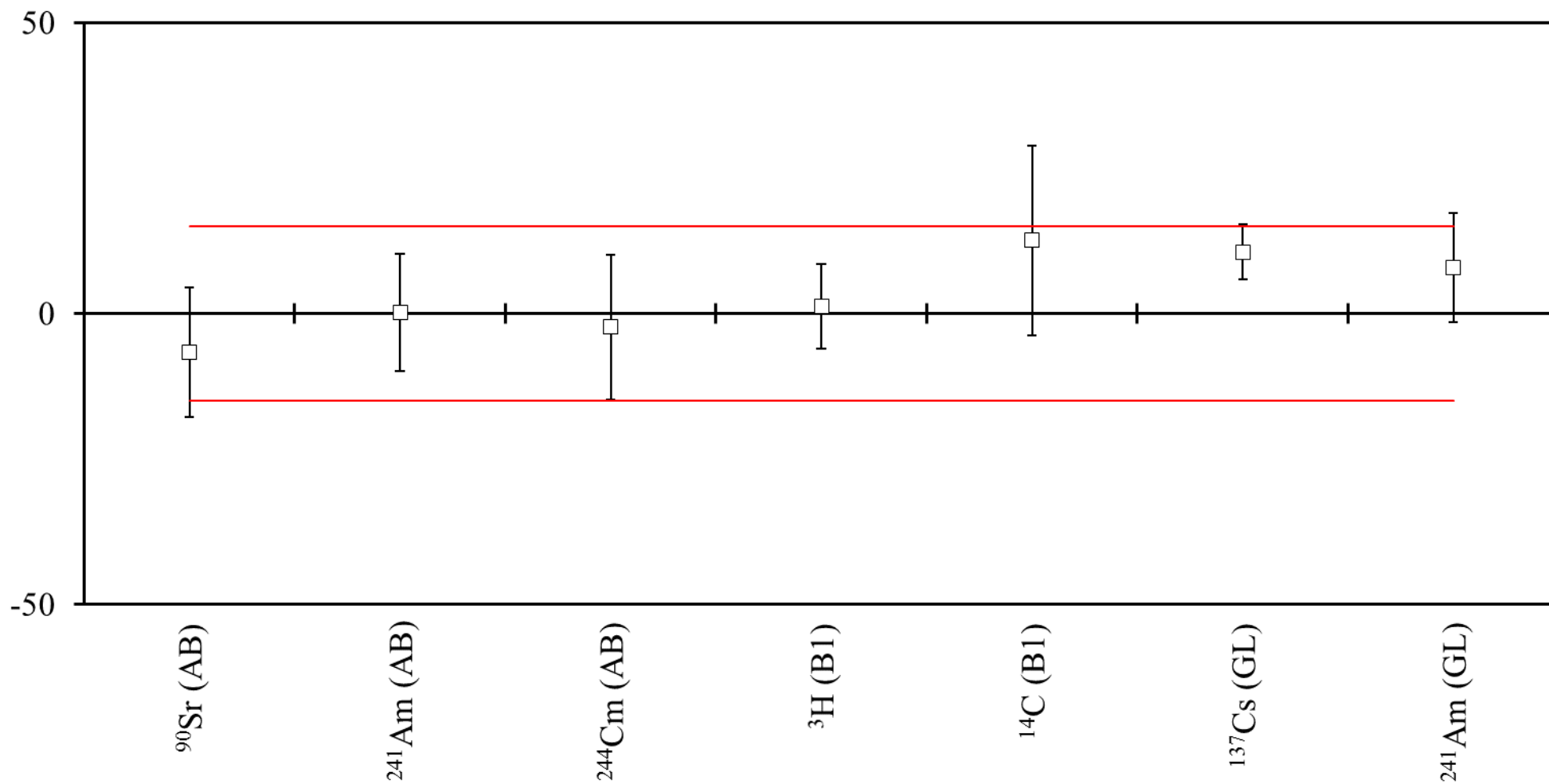
Radionuclide	Laboratory 128	NPL Assigned Value	Deviation /%	Zeta	Z Score
^3H (B1)	0.989 ± 0.059	0.958 ± 0.012	3.2	0.51	0.56

Deviation (%) of Laboratory 135



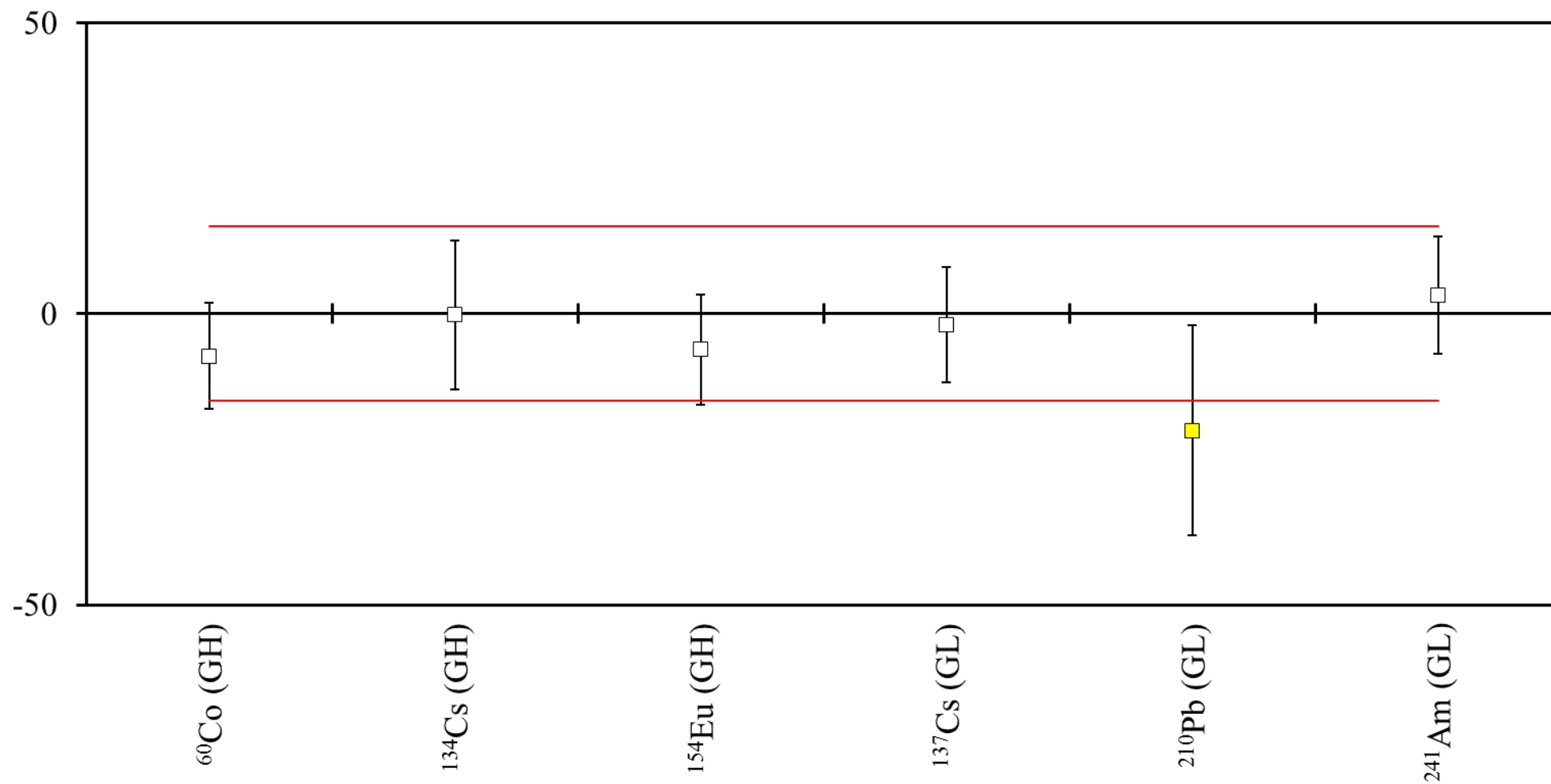
Radionuclide	Laboratory 135	NPL Assigned Value	Deviation /%	Zeta	Z Score
³ H (AB)	5.12 ± 0.16	5.031 ± 0.064	1.8	0.52	0.30
⁹⁰ Sr (AB)	4.57 ± 0.23	4.658 ± 0.021	-1.9	-0.38	-0.32
²⁴¹ Am (AB)	2.7 ± 0.3	2.574 ± 0.011	4.9	0.42	0.84
²⁴⁴ Cm (AB)	15.40 ± 0.90	16.066 ± 0.054	-4.1	-0.74	-0.71
Gross alpha (AB)	20.50 ± 0.40	19.62 ± 0.61	4.5	1.21	0.77
Gross beta (AB)	12.0 ± 0.7	10.68 ± 0.81	12.4	1.23	2.12
²³² Th (A1)	3.4 ± 0.3	3.305 ± 0.032	2.9	0.31	0.49
²³³ U (A1)	16.00 ± 0.95	16.040 ± 0.049	-0.2	-0.04	-0.04
²³⁶ U (A1)	11.7 ± 0.7	11.748 ± 0.029	-0.4	-0.07	-0.07
Gross alpha (A1)	41.80 ± 0.90	37.4 ± 2.1	11.8	1.93	2.02
³ H (B1)	0.900 ± 0.045	0.958 ± 0.012	-6.1	-1.25	-1.04
¹⁴ C (B1)	0.450 ± 0.045	0.4974 ± 0.0033	-9.5	-1.05	-1.64
³⁶ Cl (B1)	0.210 ± 0.010	0.2509 ± 0.0010	-16.3	-4.07	-2.80
Gross beta (B1)	0.44 ± 0.03	-	-	-	-
⁶⁰ Co (GH)	12.00 ± 0.40	12.074 ± 0.047	-0.6	-0.18	-0.11
¹³⁴ Cs (GH)	2.430 ± 0.095	2.503 ± 0.018	-2.9	-0.75	-0.50
¹⁵⁴ Eu (GH)	3.82 ± 0.15	4.015 ± 0.032	-4.9	-1.27	-0.83
¹³⁷ Cs (GL)	9.3 ± 0.6	9.527 ± 0.086	-2.4	-0.37	-0.41
²¹⁰ Pb (GL)	18.0 ± 2.5	19.39 ± 0.20	-7.2	-0.55	-1.23
²⁴¹ Am (GL)	16.1 ± 1.7	14.825 ± 0.032	8.6	0.75	1.48
⁶⁰ Co (R1)	1.540 ± 0.055	1.543 ± 0.036	-0.2	-0.05	-0.03
¹³⁷ Cs (R1)	1.94 ± 0.11	1.904 ± 0.026	1.9	0.32	0.32
²⁴¹ Am (R1)	5.5 ± 1.2	5.338 ± 0.067	3.0	0.13	0.52

Deviation (%) of Laboratory 136



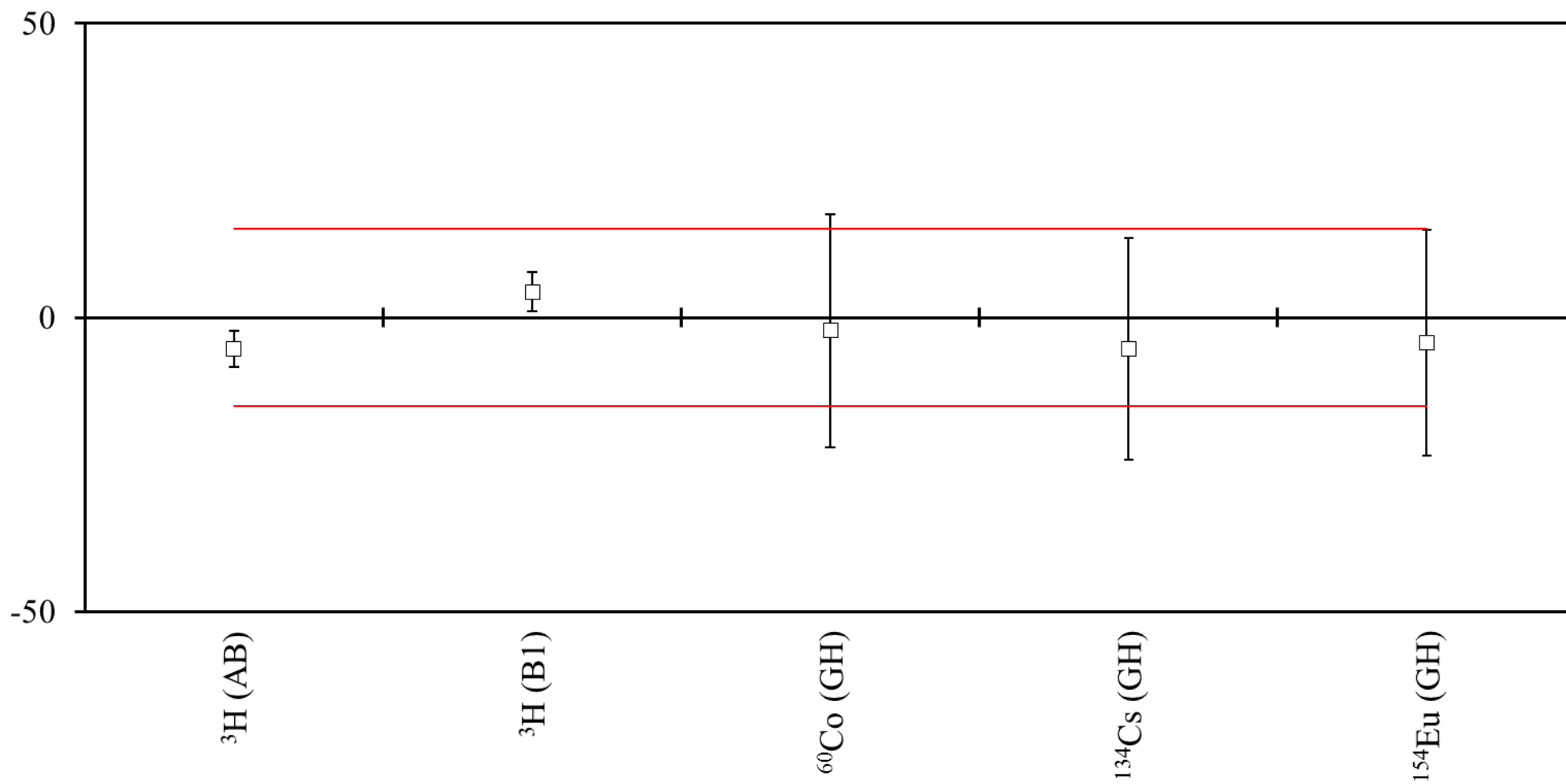
Radionuclide	Laboratory 136	NPL Assigned Value	Deviation /%	Zeta	Z Score
⁹⁰ Sr (AB)	4.35 ± 0.52	4.658 ± 0.021	-6.6	-0.59	-1.14
²⁴¹ Am (AB)	2.58 ± 0.26	2.574 ± 0.011	0.2	0.02	0.04
²⁴⁴ Cm (AB)	15.7 ± 2.0	16.066 ± 0.054	-2.3	-0.18	-0.39
³ H (B1)	0.970 ± 0.069	0.958 ± 0.012	1.3	0.17	0.22
¹⁴ C (B1)	0.560 ± 0.081	0.4974 ± 0.0033	12.6	0.77	2.16
¹³⁷ Cs (GL)	10.54 ± 0.44	9.527 ± 0.086	10.6	2.26	1.83
²⁴¹ Am (GL)	16.0 ± 1.4	14.825 ± 0.032	7.9	0.84	1.36

Deviation (%) of Laboratory 137



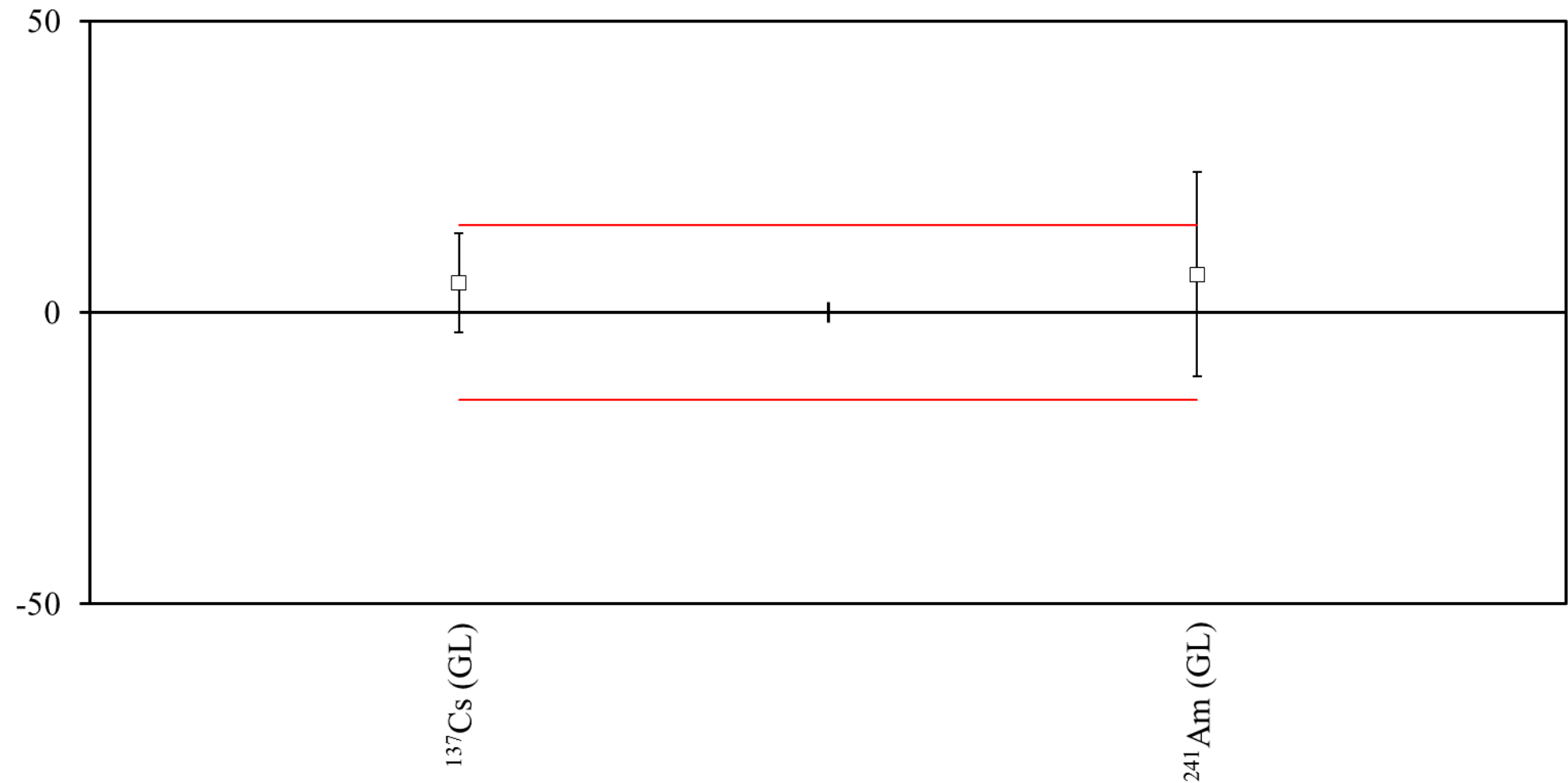
Radionuclide	Laboratory 137	NPL Assigned Value	Deviation /%	Zeta	Z Score
^{60}Co (GH)	11.2 ± 1.1	12.074 ± 0.047	-7.2	-0.79	-1.24
^{134}Cs (GH)	2.50 ± 0.32	2.503 ± 0.018	-0.1	-0.01	-0.02
^{154}Eu (GH)	3.77 ± 0.38	4.015 ± 0.032	-6.1	-0.64	-1.05
^{137}Cs (GL)	9.35 ± 0.94	9.527 ± 0.086	-1.9	-0.19	-0.32
^{210}Pb (GL)	15.5 ± 3.5	19.39 ± 0.20	-20.1	-1.11	-3.45
^{241}Am (GL)	15.3 ± 1.5	14.825 ± 0.032	3.2	0.32	0.55

Deviation (%) of Laboratory 141



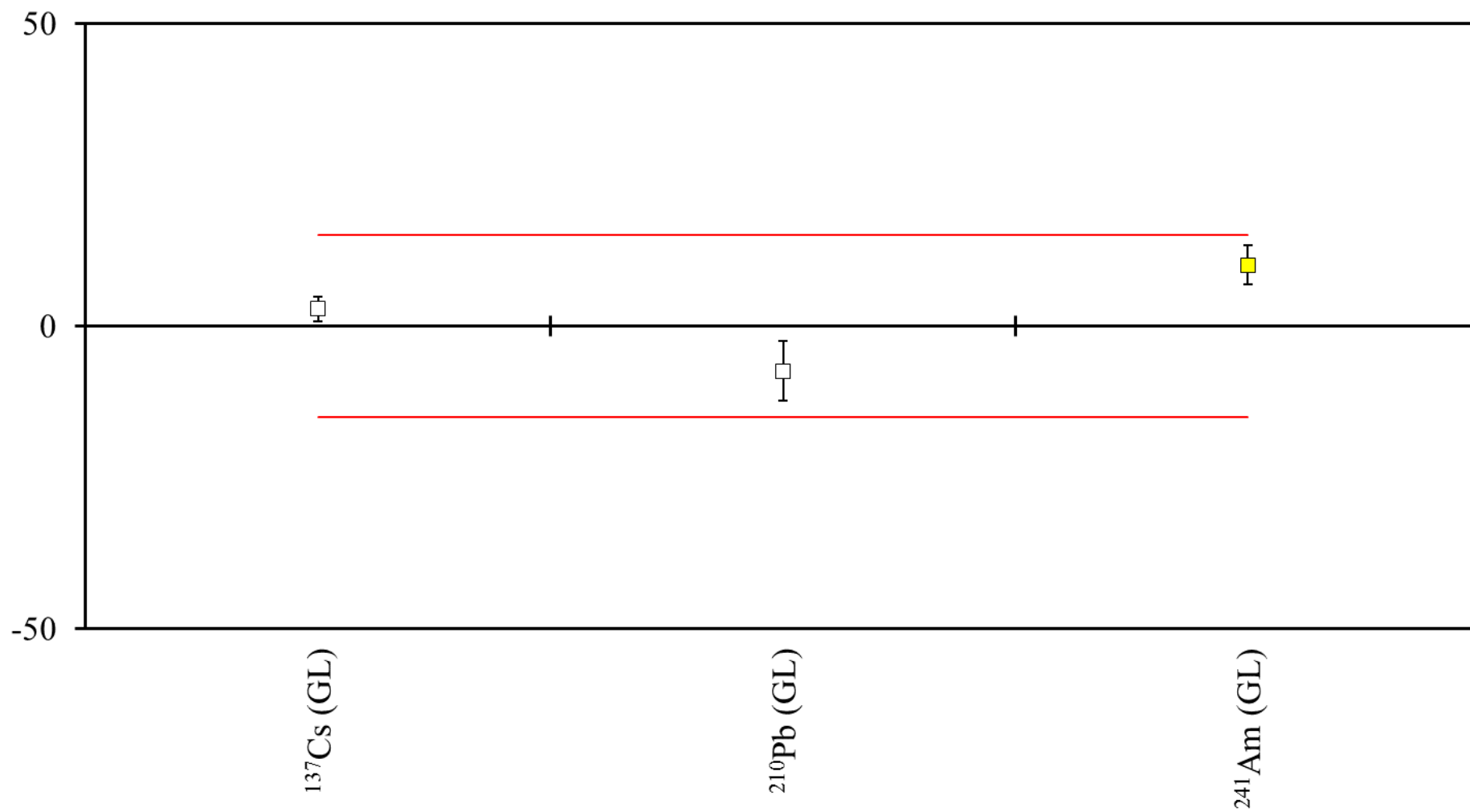
Radionuclide	Laboratory 141	NPL Assigned Value	Deviation /%	Zeta	Z Score
^3H (AB)	4.76 ± 0.14	5.031 ± 0.064	-5.4	-1.76	-0.93
^3H (B1)	1.00 ± 0.03	0.958 ± 0.012	4.4	1.30	0.75
^{60}Co (GH)	11.8 ± 2.4	12.074 ± 0.047	-2.3	-0.11	-0.39
^{134}Cs (GH)	2.37 ± 0.47	2.503 ± 0.018	-5.3	-0.28	-0.91
^{154}Eu (GH)	3.84 ± 0.77	4.015 ± 0.032	-4.4	-0.23	-0.75

Deviation (%) of Laboratory 145



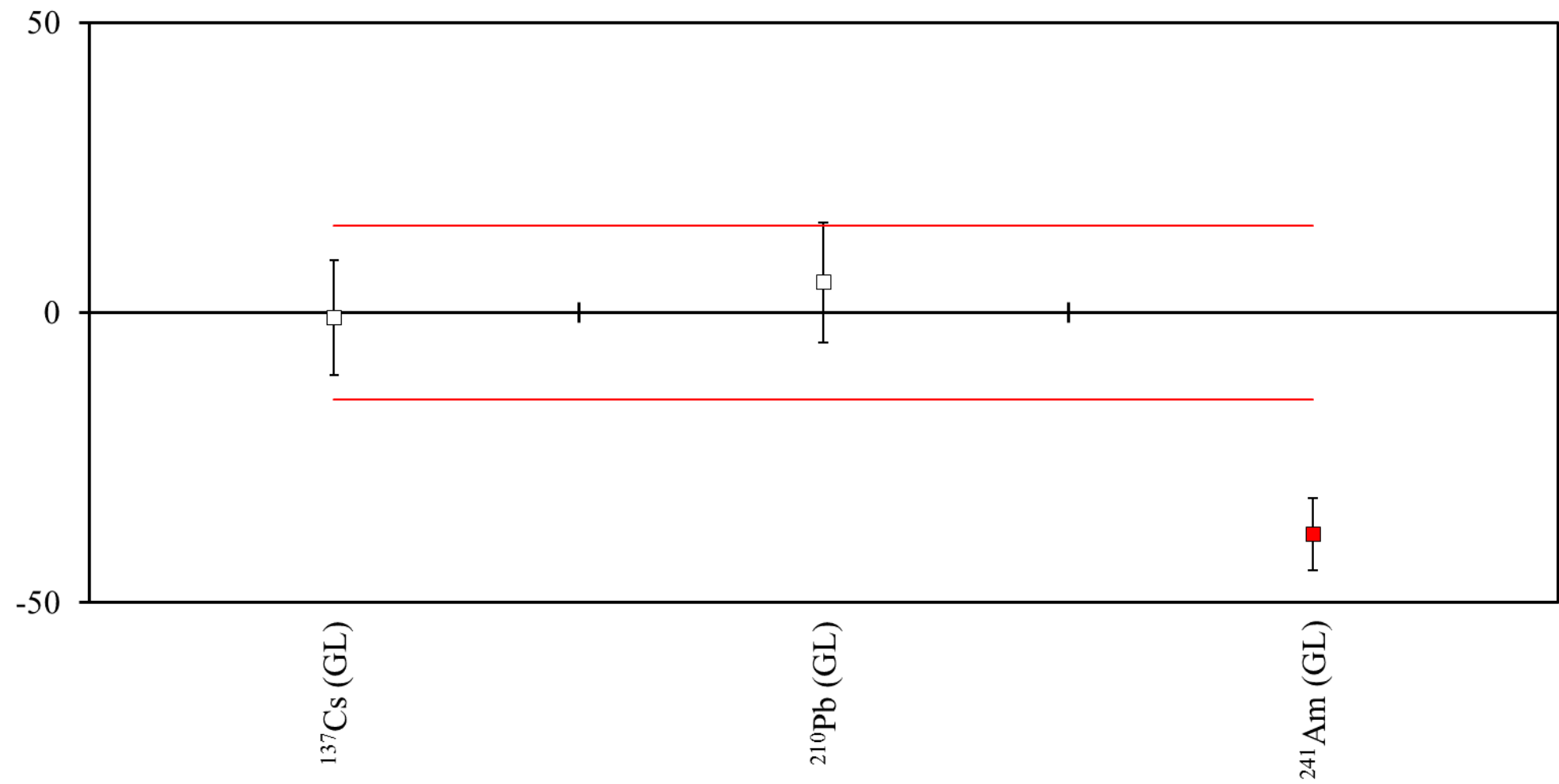
Radionuclide	Laboratory 145	NPL Assigned Value	Deviation /%	Zeta	Z Score
¹³⁷ Cs (GL)	10.01 ± 0.81	9.527 ± 0.086	5.1	0.59	0.87
²⁴¹ Am (GL)	15.8 ± 2.6	14.825 ± 0.032	6.6	0.37	1.13

Deviation (%) of Laboratory 151



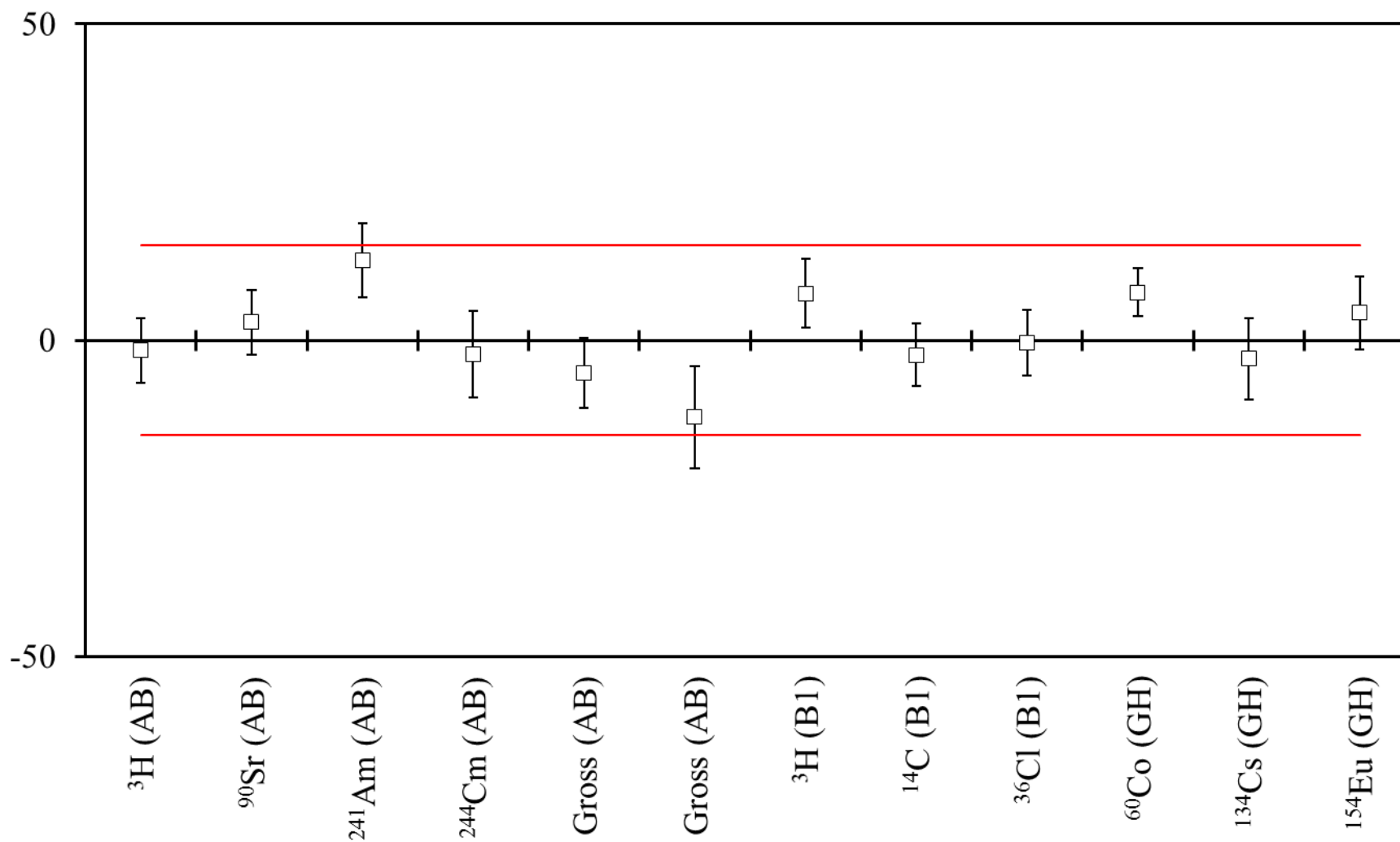
Radionuclide	Laboratory 151	NPL Assigned Value	Deviation /%	Zeta	Z Score
¹³⁷ Cs (GL)	9.80 ± 0.17	9.527 ± 0.086	2.9	1.43	0.49
²¹⁰ Pb (GL)	17.96 ± 0.94	19.39 ± 0.20	-7.4	-1.49	-1.27
²⁴¹ Am (GL)	16.33 ± 0.48	14.825 ± 0.032	10.2	3.13	1.74

Deviation (%) of Laboratory 152



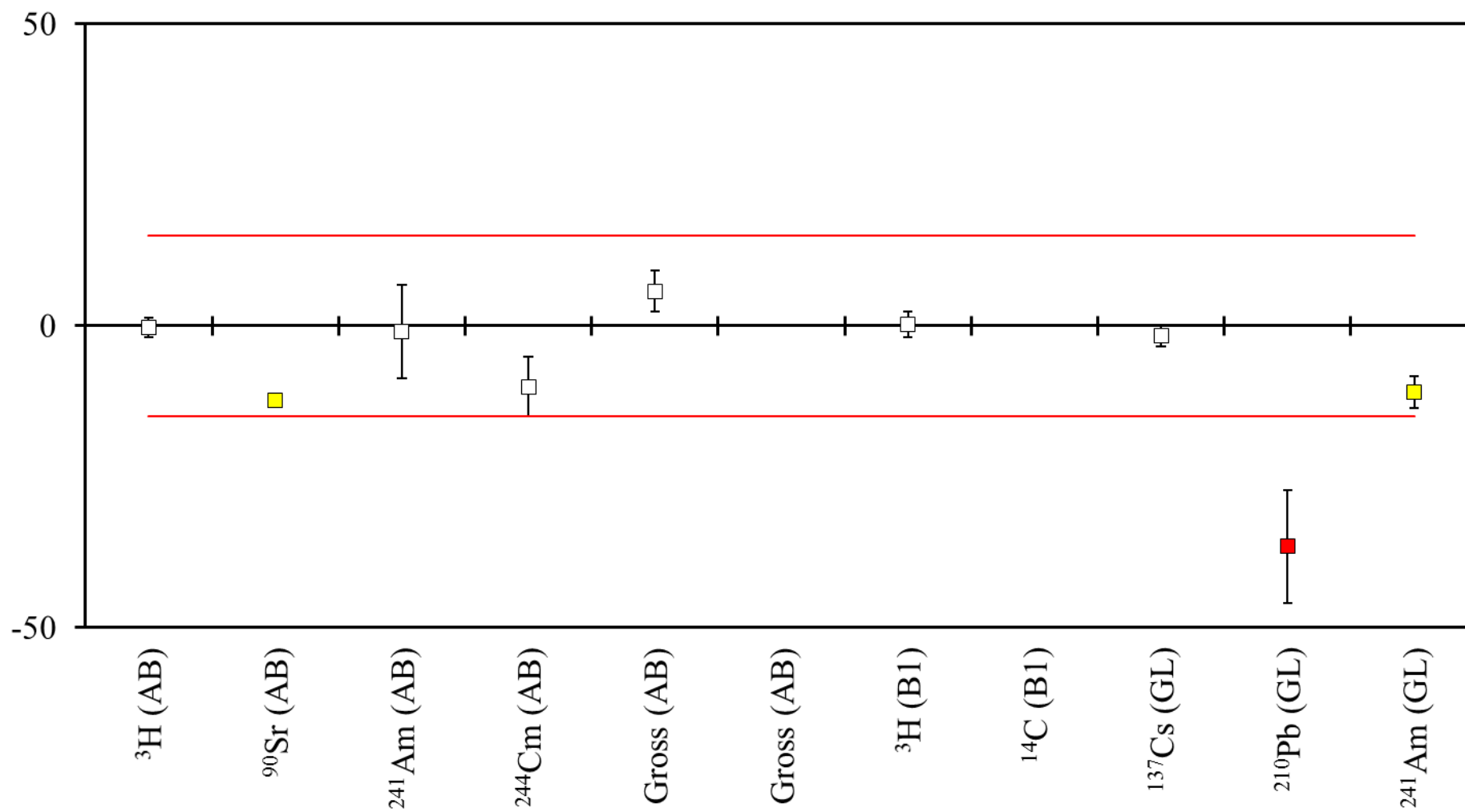
Radionuclide	Laboratory 152	NPL Assigned Value	Deviation /%	Zeta	Z Score
¹³⁷ Cs (GL)	9.44 ± 0.94	9.527 ± 0.086	-0.9	-0.09	-0.16
²¹⁰ Pb (GL)	20.4 ± 2.0	19.39 ± 0.20	5.2	0.50	0.89
²⁴¹ Am (GL)	9.16 ± 0.92	14.825 ± 0.032	-38.2	-6.15	-6.56

Deviation (%) of Laboratory 154



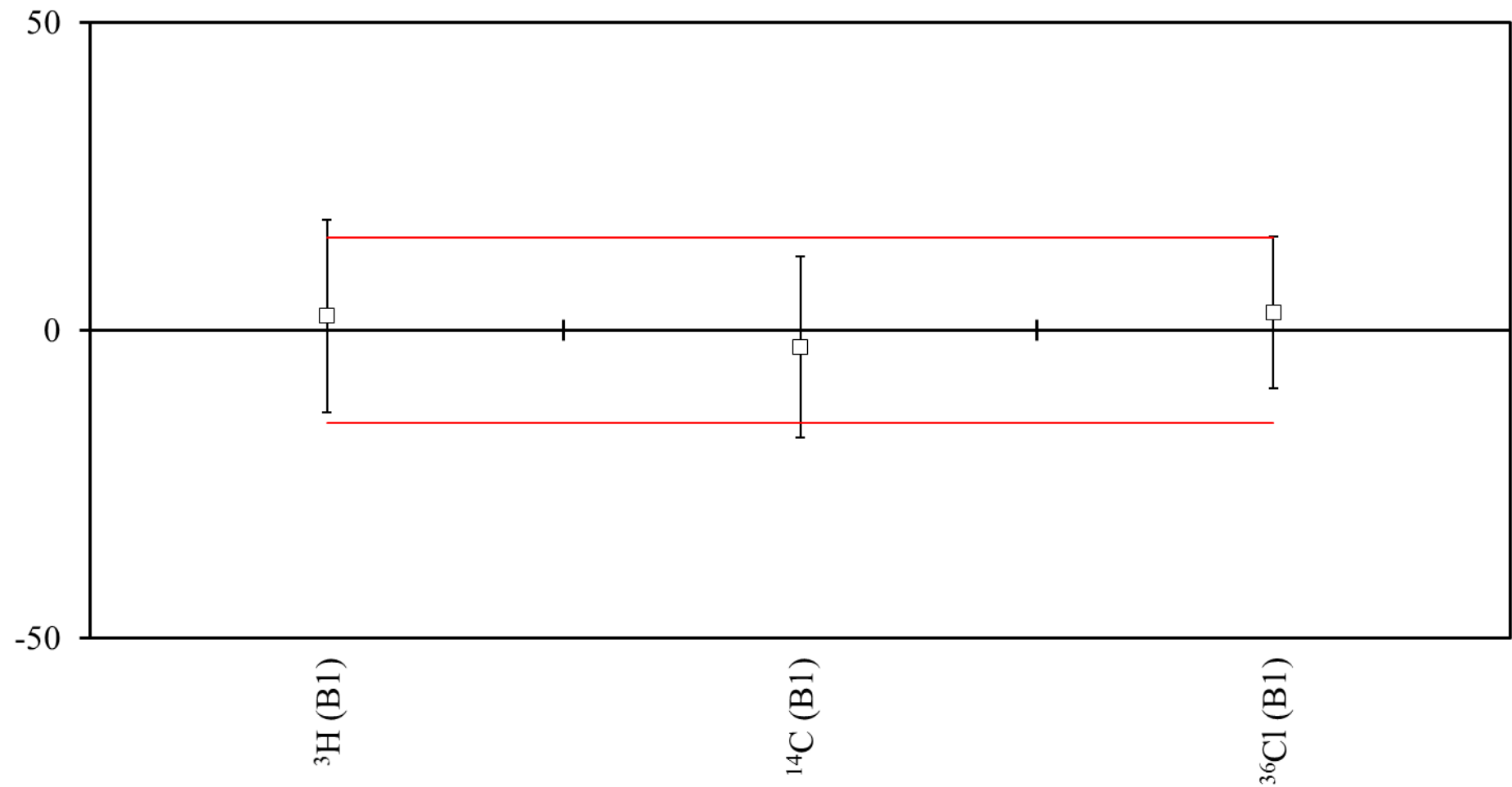
Radionuclide	Laboratory 154	NPL Assigned Value	Deviation /%	Zeta	Z Score
^3H (AB)	4.95 ± 0.25	5.031 ± 0.064	-1.6	-0.31	-0.28
^{90}Sr (AB)	4.79 ± 0.24	4.658 ± 0.021	2.8	0.55	0.49
^{241}Am (AB)	2.90 ± 0.15	2.574 ± 0.011	12.7	2.17	2.18
^{244}Cm (AB)	15.7 ± 1.1	16.066 ± 0.054	-2.3	-0.33	-0.39
Gross alpha (AB)	18.60 ± 0.93	19.62 ± 0.61	-5.2	-0.92	-0.89
Gross beta (AB)	9.38 ± 0.50	10.68 ± 0.81	-12.2	-1.37	-2.09
^3H (B1)	1.029 ± 0.051	0.958 ± 0.012	7.4	1.36	1.27
^{14}C (B1)	0.486 ± 0.024	0.4974 ± 0.0033	-2.3	-0.47	-0.39
^{36}Cl (B1)	0.250 ± 0.013	0.2509 ± 0.0010	-0.4	-0.07	-0.06
^{60}Co (GH)	12.99 ± 0.45	12.074 ± 0.047	7.6	2.02	1.30
^{134}Cs (GH)	2.43 ± 0.16	2.503 ± 0.018	-2.9	-0.45	-0.50
^{154}Eu (GH)	4.19 ± 0.23	4.015 ± 0.032	4.4	0.75	0.75

Deviation (%) of Laboratory 155

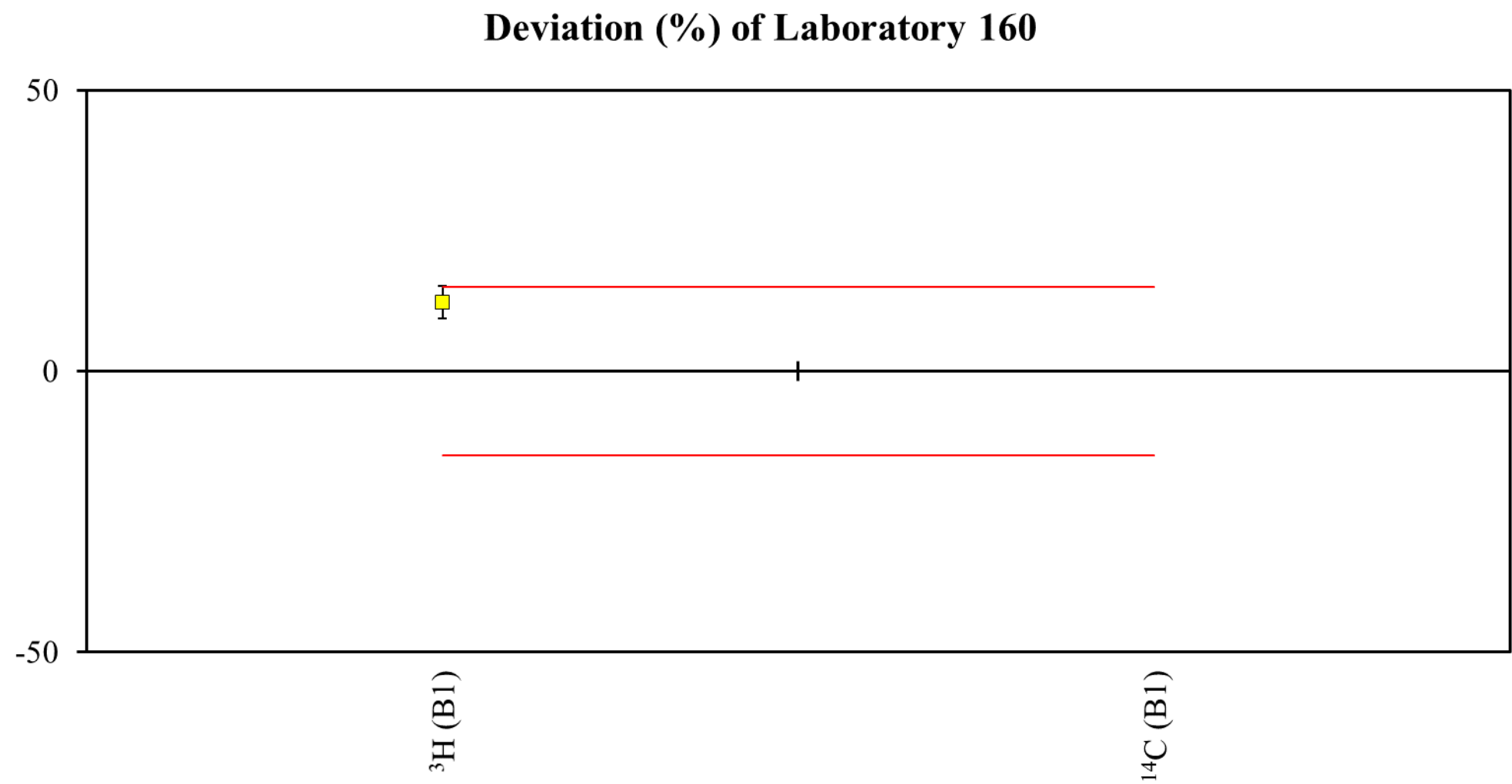


Radionuclide	Laboratory 155	NPL Assigned Value	Deviation /%	Zeta	Z Score
^3H (AB)	5.020 ± 0.048	5.031 ± 0.064	-0.2	-0.14	-0.04
^{90}Sr (AB)	4.080 ± 0.014	4.658 ± 0.021	-12.4	-22.90	-2.13
^{241}Am (AB)	2.55 ± 0.20	2.574 ± 0.011	-0.9	-0.12	-0.16
^{244}Cm (AB)	14.45 ± 0.78	16.066 ± 0.054	-10.1	-2.07	-1.73
Gross alpha (AB)	20.74 ± 0.17	19.62 ± 0.61	5.7	1.77	0.98
Gross beta (AB)	4.191 ± 0.043	10.68 ± 0.81	-60.8	-8.00	-10.43
^3H (B1)	0.960 ± 0.016	0.958 ± 0.012	0.2	0.10	0.04
^{14}C (B1)	0.8427 ± 0.0085	0.4974 ± 0.0033	69.4	37.87	11.92
Gross beta (B1)	0.00111 ± 0.00027	-	-	-	-
^{137}Cs (GL)	9.37 ± 0.14	9.527 ± 0.086	-1.6	-0.96	-0.28
^{210}Pb (GL)	12.3 ± 1.8	19.39 ± 0.20	-36.6	-3.91	-6.28
^{241}Am (GL)	13.19 ± 0.39	14.825 ± 0.032	-11.0	-4.18	-1.89

Deviation (%) of Laboratory 159

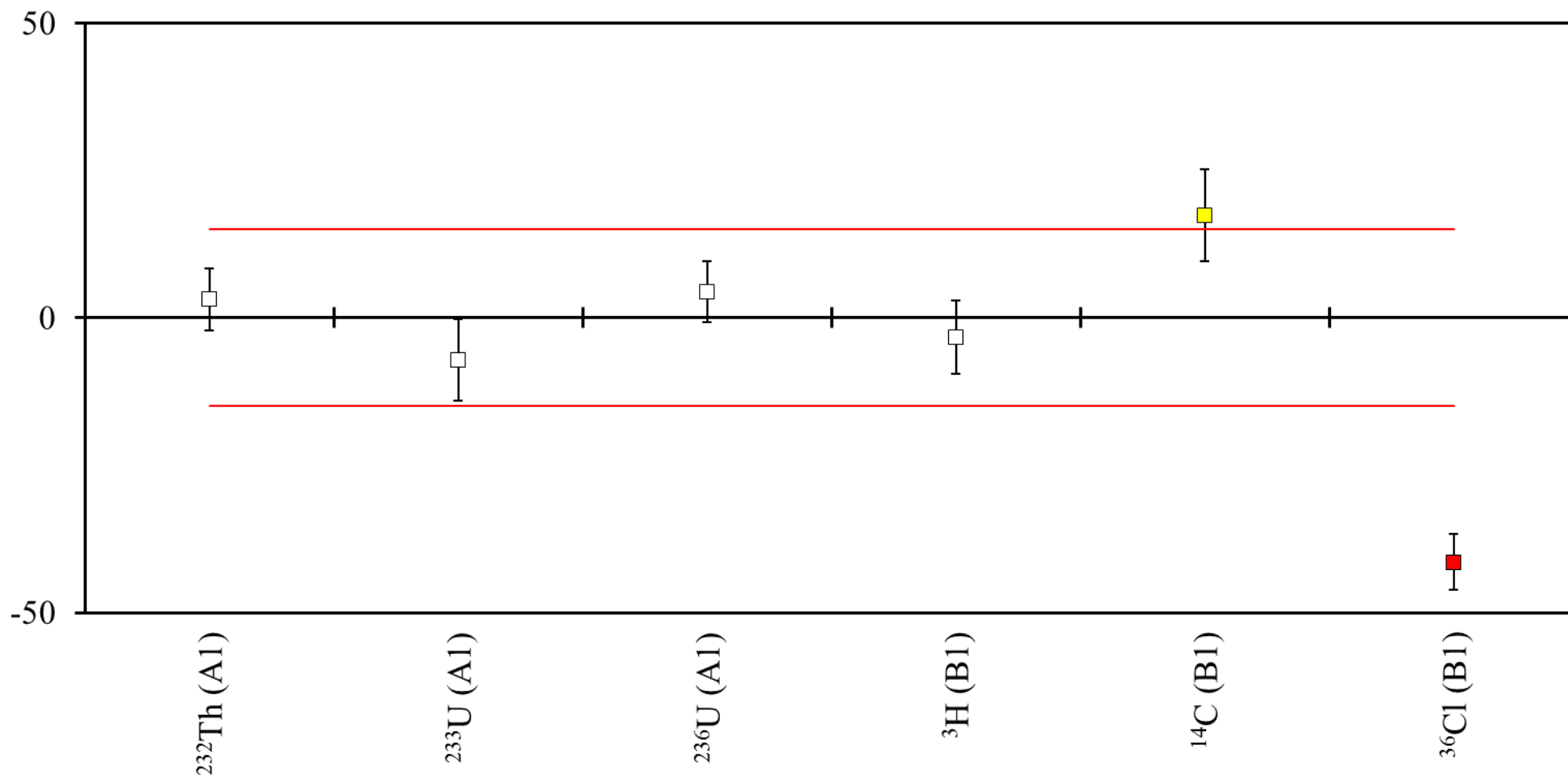


Radionuclide	Laboratory 159	NPL Assigned Value	Deviation /%	Zeta	Z Score
^3H (B1)	0.98 ± 0.15	0.958 ± 0.012	2.3	0.15	0.39
^{14}C (B1)	0.484 ± 0.073	0.4974 ± 0.0033	-2.7	-0.18	-0.46
^{36}Cl (B1)	0.258 ± 0.031	0.2509 ± 0.0010	2.8	0.23	0.49
Gross beta (B1)	0.620 ± 0.087	-	-	-	-



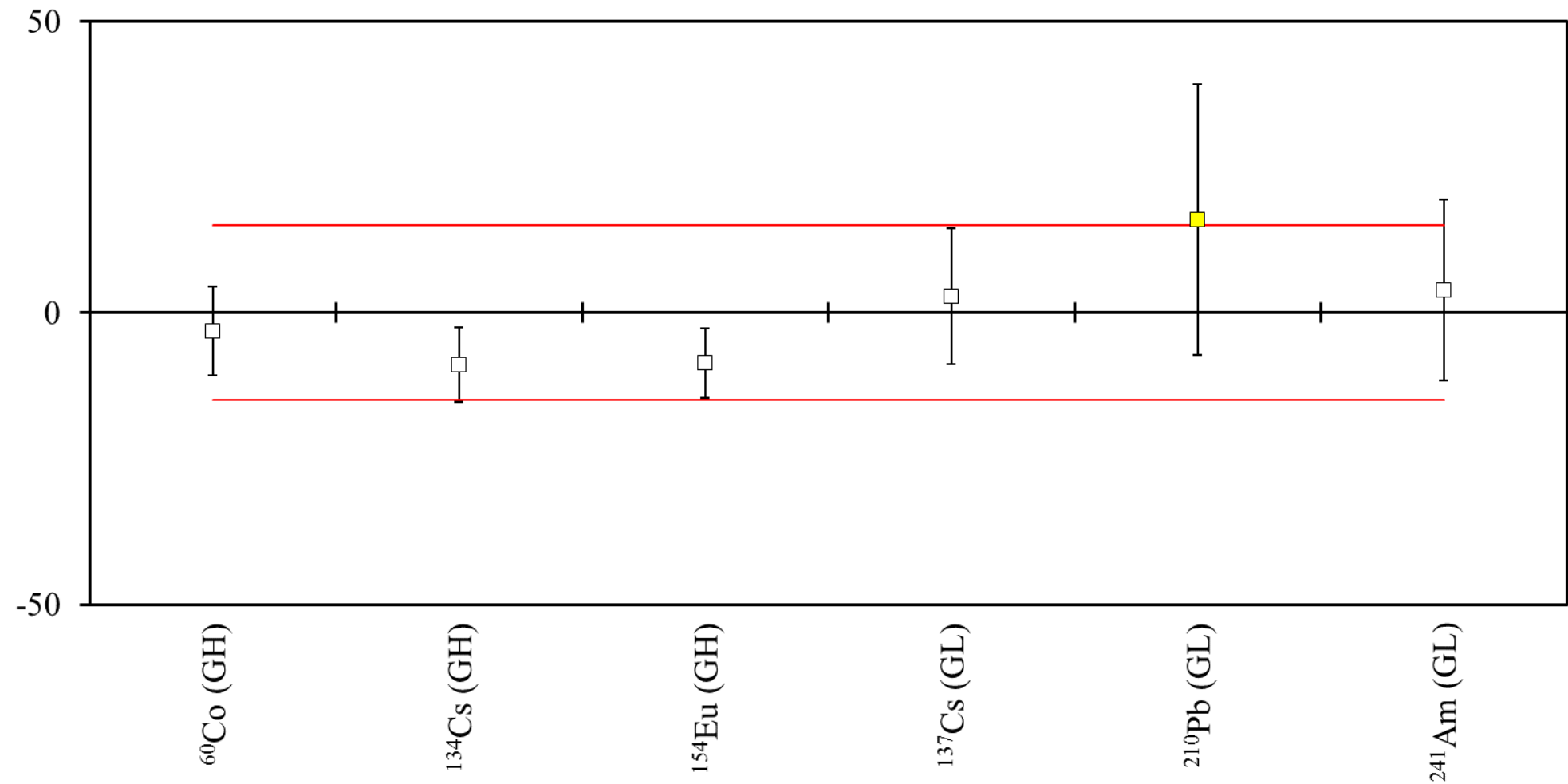
Radionuclide	Laboratory 160	NPL Assigned Value	Deviation /%	Zeta	Z Score
³ H (B1)	1.076 ± 0.024	0.958 ± 0.012	12.3	4.40	2.12
¹⁴ C (B1)	1.254 ± 0.036	0.4974 ± 0.0033	152.1	20.93	26.12

Deviation (%) of Laboratory 162



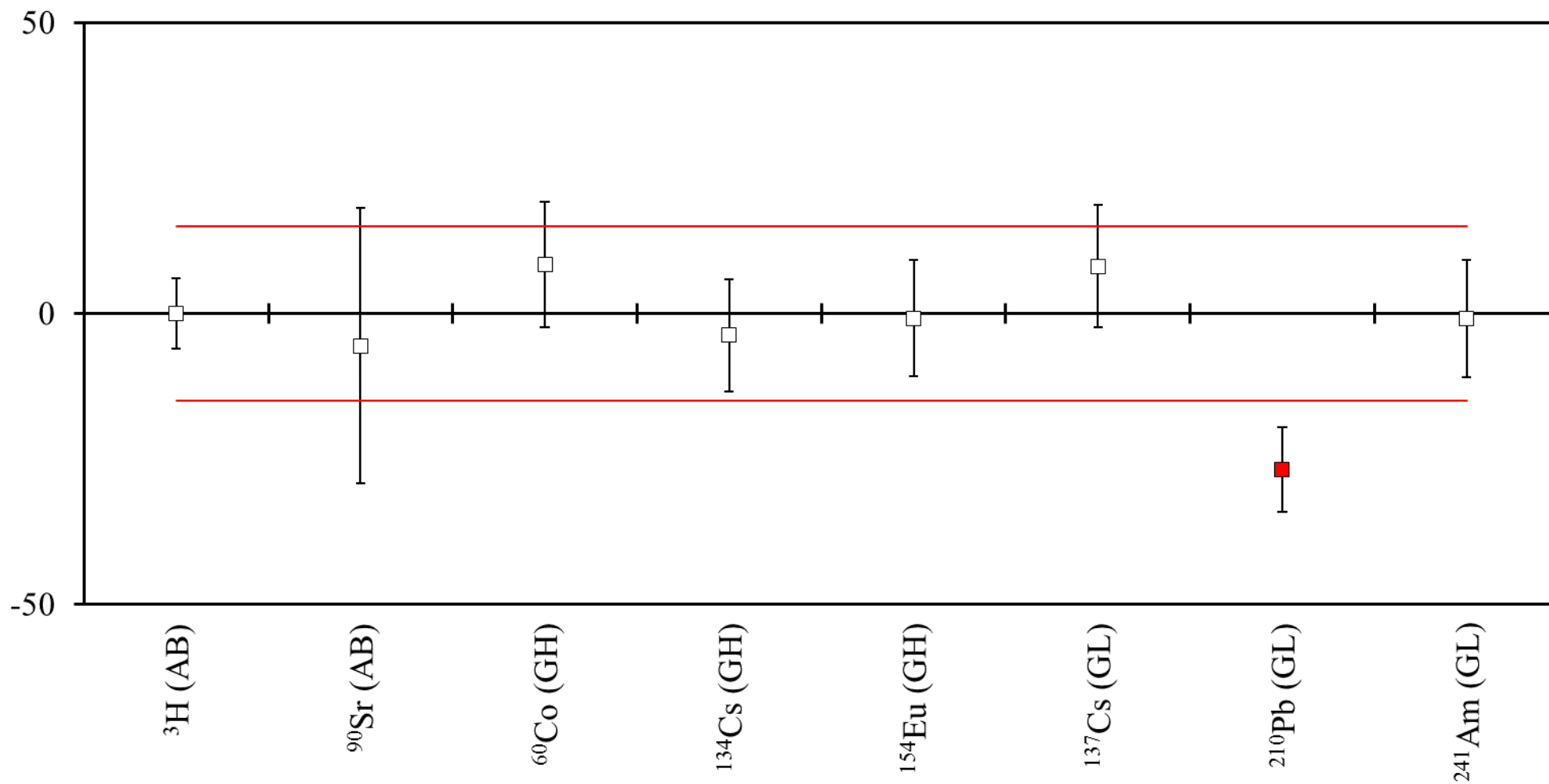
Radionuclide	Laboratory 162	NPL Assigned Value	Deviation /%	Zeta	Z Score
^{232}Th (A1)	3.41 ± 0.17	3.305 ± 0.032	3.2	0.61	0.55
^{233}U (A1)	14.9 ± 1.1	16.040 ± 0.049	-7.1	-1.04	-1.22
^{236}U (A1)	12.27 ± 0.61	11.748 ± 0.029	4.4	0.85	0.76
^3H (B1)	0.927 ± 0.058	0.958 ± 0.012	-3.2	-0.52	-0.56
^{14}C (B1)	0.584 ± 0.039	0.4974 ± 0.0033	17.4	2.21	2.99
^{36}Cl (B1)	0.147 ± 0.012	0.2509 ± 0.0010	-41.4	-8.63	-7.11

Deviation (%) of Laboratory 164



Radionuclide	Laboratory 164	NPL Assigned Value	Deviation /%	Zeta	Z Score
⁶⁰ Co (GH)	11.70 ± 0.91	12.074 ± 0.047	-3.1	-0.41	-0.53
¹³⁴ Cs (GH)	2.28 ± 0.16	2.503 ± 0.018	-8.9	-1.39	-1.53
¹⁵⁴ Eu (GH)	3.67 ± 0.24	4.015 ± 0.032	-8.6	-1.42	-1.48
¹³⁷ Cs (GL)	9.8 ± 1.1	9.527 ± 0.086	2.9	0.25	0.49
²¹⁰ Pb (GL)	22.5 ± 4.5	19.39 ± 0.20	16.0	0.69	2.75
²⁴¹ Am (GL)	15.4 ± 2.3	14.825 ± 0.032	3.9	0.25	0.67

Deviation (%) of Laboratory 165



Radionuclide	Laboratory 165	NPL Assigned Value	Deviation /%	Zeta	Z Score
^3H (AB)	5.030 ± 0.3	5.031 ± 0.064	0.0	0.00	0.00
^{90}Sr (AB)	4.4 ± 1.1	4.658 ± 0.021	-5.5	-0.23	-0.95
^{60}Co (GH)	13.1 ± 1.3	12.074 ± 0.047	8.5	0.79	1.46
^{134}Cs (GH)	2.41 ± 0.24	2.503 ± 0.018	-3.7	-0.39	-0.64
^{154}Eu (GH)	3.98 ± 0.40	4.015 ± 0.032	-0.9	-0.09	-0.15
^{137}Cs (GL)	10.3 ± 1.0	9.527 ± 0.086	8.1	0.77	1.39
^{210}Pb (GL)	14.2 ± 1.4	19.39 ± 0.20	-26.8	-3.67	-4.60
^{241}Am (GL)	14.7 ± 1.5	14.825 ± 0.032	-0.8	-0.08	-0.14

11. DISCUSSION

Please note that in some cases the participants did not report methods and / or standards and tracers used. The comments on methods and standards below refer, therefore, to the subset of participants (for each nuclide) who did report such information.

11.1 ^3H in AB and B1

The overall performance level for ^3H in B1 was significantly better than in the 2015 PTE, with 29 out of the 33 results submitted being in agreement with the Assigned Value. In most cases, the nuclide was separated from the mixture by distillation and was subsequently assayed using LSC. Five participants used combustion methods to pre-treat the sample. Many participants reported having used a 'standard', but in most cases its provenance was not clear.

The dataset for ^3H in AB was smaller (17), with 13 being in agreement with NPL, and the comments on methods and standards above apply. Two of the discrepant results were from participants who had submitted questionable or discrepant data for ^3H in B1. There was no obvious reason for the questionable and discrepant ^3H data for either AB or B1.

11.2 ^{90}Sr in AB

Twenty results were submitted for this nuclide, with 15 being in agreement with NPL, a similar performance level to 2015. Various separation methods were used, including precipitation, ion-exchange chromatography and extraction chromatography. LSC, gas-flow proportional counting and Cerenkov counting were cited as methods. Various ^{90}Sr standards were cited (e.g. Eckert and Ziegler, G E Healthcare, NPL, or were not named) and 2 participants used a ^{85}Sr yield tracer. Very little information was provided with the questionable / discrepant data so the reasons for the discrepancies are not clear.

11.3 ^{241}Am in AB

Nineteen of the 20 results submitted agreed with the Assigned Value. Eleven participants used alpha spectrometry and 4 used gamma spectrometry. Eleven participants reported using ^{243}Am as a yield tracer.

11.4 ^{244}Cm in AB

The level of performance was similar to ^{241}Am , with 15 out of 17 results being in agreement with NPL. Alpha spectrometry was used by most participants; one carried out a gross alpha measurement with a correction for ^{241}Am by gamma measurement. Again, eleven participants cited ^{243}Am as a tracer.

11.5 ^{232}Th in A1

Thirteen of the 15 reported results for ^{232}Th agreed with the Assigned Value. Seven participants used alpha spectrometry and four used ICPMS. Four participants used a ^{229}Th tracer.

11.6 ^{233}U and ^{236}U in A1

The overall level of performance for both nuclides was high; for ^{233}U , 16 out of 18 agreed with NPL, and for ^{236}U , 16 out of 17 agreed. A range of separation methods were cited, including ion-exchange chromatography and extraction chromatography. Twelve participants used alpha spectrometry to measure the separated nuclide, and 2 used ICPMS. Eight reported using ^{232}U standards.

11.7 ^{14}C in B1

In total, 23 results were submitted for this nuclide, with 20 agreeing with NPL. Combustion methods were often cited for sample pre-treatment. All participants used LSC, often citing the use of a standard but not stating its provenance.

11.8 ^{36}Cl in B1

The dataset for this nuclide was smaller, with 9 out of an 11 reported results being in agreement with NPL. Five participants used LSC and one used gas-flow proportional counting of precipitated silver chloride. The discrepant participants did not provide information on methods or standards used.

11.9 Gross alpha and gross beta results for AB, A1 and B1

In each case, the PMWM of the submitted results was calculated. The gross beta results reported for B1 exhibited a very large spread (the range in terms of order of magnitude was $0.001 - 1 \text{ Bq g}^{-1}$) and it was decided not to declare an Assigned Value in this case. For the other quantities (gross alpha and gross beta in AB and gross alpha in A1), the PMWM was adopted as the Assigned Value.

For AB gross alpha, 20 results were submitted and 8 were in agreement with the Assigned Value. The figures for AB gross beta were: 10 submitted, 5 in agreement; those for A1 gross alpha were: 6 submitted, 5 in agreement.

11.10 Sample Types GH and GL

Almost all measurements were carried out using high-resolution gamma spectrometry (alpha spectrometry was used in a very few cases for ^{210}Pb and ^{241}Am in GL) without pre-treatment of the sample. Laboratories used mixed radionuclide standards from CERCA LEA, Eckert and Ziegler, NPL, or from unspecified suppliers.

Thirty-one datasets were submitted for GH. The numbers of results in agreement with NPL by nuclide were: ^{60}Co (27), ^{134}Cs (28) and ^{154}Eu (29).

The number of results submitted for GL nuclides varied; the numbers of results in agreement by nuclide were: ^{137}Cs (30 out of 31 results submitted), ^{210}Pb (15 out of 26) and ^{241}Am (29 out of 33). Of interest was the increase in the number of ^{210}Pb results submitted compared with 2015 (when only 13 were submitted) and the improvement in the overall level of performance for this nuclide; the bias of the results was -5.3% (c.f. $+44.3\%$ in 2015) and many of the quoted uncertainties were lower. This may be due to the higher activity per unit mass in the 2016 samples (19 Bq kg^{-1} compared with 3 Bq kg^{-1} in 2015). ^{210}Pb is difficult to measure at low energies due to the high presence in background, the need to extrapolate from ^{241}Am in most cases and the matrix/density corrections compared with the standard.

11.11 Sample Type R1

For each nuclide present, the PMWM of the submitted results was adopted as the Assigned Value.

Fourteen datasets derived from gamma spectrometric measurements were submitted for R1. For each of the three nuclides present (^{60}Co , ^{137}Cs and ^{241}Am), 12 results were in agreement with the Assigned Value. Eight participants reported measuring the solid material as supplied,

one reported dissolving the solid and two did not specify any sample pre-treatment. Six participants used a multi-nuclide gamma solution standard and one used LABSOCS.

One dataset was for ^{241}Am only and was based on alpha spectrometry of ^{241}Am extracted from the solid matrix and electrodeposited onto a steel disk. This result was not analysed as analysis of participants' data for alpha measurements of this Sample Type does not fall under the scope of NPL's current accreditation to ISO17043.

12. REFERENCES

Dean, J. C. J. et al., 2015. Environmental Radioactivity Proficiency Test Exercise 2014. NPL Report IR 34. Available at www.npl.co.uk/pte.

Harms, A. and Gilligan, C., 2011. Environmental Radioactivity Proficiency Test Exercise 2010. NPL Report IR 26. Available at www.npl.co.uk/pte.

Pommé, S., 2012. Determination of a reference value, associated standard uncertainty and degrees of equivalence. European Commission Scientific and Technical Research series. ISSN 1831-9424 (online), ISBN 978-92-79-25104-7 (pdf).

BS ISO 13528:2005. Statistical methods for use in proficiency testing by interlaboratory comparisons.

13. ACKNOWLEDGEMENTS

The authors wish to thank the participating organisations for the time and effort they have put into analysing the samples. They also thank colleagues Daniel Ainsworth, Arzu Arinc, Kelley Ferreira, Peter Ivanov, Lynsey Keightley, Andy Pearce and Jane Taylor for their help with preparing the samples, checking the dilution factors, dispatching the samples and reviewing this report.