National Physical Laboratory

NPL REPORT IR 34

Environmental Radioactivity Proficiency Test Exercise 2014

JULIAN DEAN, SEAN COLLINS AND SELINA WOODS

JUNE 2015

UKAS PROFICIENCY TESTING 0016

National Measurement System

Environmental Radioactivity Proficiency Test Exercise† 2014

Julian Dean‡, Sean Collins and Selina Woods
Acoustics and Ionising Radiation Division

ABSTRACT

The results of NPL's twentieth 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 four alpha emitters ('A1'), an aqueous mixture of three beta emitters ('B1'), an aqueous mixture of four gamma emitters ('GH'), a second aqueous mixture of four gamma emitters ('GL') and a vitreous sample containing three gamma emitters ('GS'). A total of 506 results were submitted; 82 % of the results were in agreement with the Assigned Values.

† NPL is accredited to ISO/CASCO 17043:2010 (Conformity Assessment – General Requirements for Proficiency Testing) for this PTE scheme
‡ PTE scheme Co-ordinator

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ISSN 1754-2952

Issued June 2015

National Physical Laboratory
Hampton Road, Teddington, Middlesex, TW11 0LW

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Approved on behalf of NPLML by Dr Steven Judge, Radioactivity Group Leader, Acoustics and Ionising Radiation Division

Assigned Values

Nuclide (AB)	Assigned Value (Bq g^{-1})
^{3}H	6.037 ± 0.086
^{90}Sr	2.418 ± 0.022
^{237}Np	7.43 ± 0.15
^{238}Pu	8.666 ± 0.040
Gross alpha / beta	27 ± 11
Nuclide (A1)	**Assigned Value (Bq kg^{-1})**
^{234}U	16.50 ± 0.56
^{235}U	0.788 ± 0.026
^{238}U	16.50 ± 0.56
^{239}Pu	20.879 ± 0.078
Gross alpha	46.8 ± 8.4
Nuclide (B1)	**Assigned Value (Bq g^{-1})**
^{3}H	0.740 ± 0.010
^{14}C	0.4254 ± 0.0056
^{36}Cl	0.4978 ± 0.0040
Gross beta	0.94 ± 0.56
Nuclide (GH)	**Assigned Value (Bq g^{-1})**
^{60}Co	5.394 ± 0.024
^{134}Cs	4.973 ± 0.068
^{137}Cs	4.125 ± 0.062
^{154}Eu	4.600 ± 0.074
Nuclide (GL)	**Assigned Value (Bq kg^{-1})**
^{60}Co	12.49 ± 0.12
^{137}Cs	2.259 ± 0.040
^{152}Eu	20.00 ± 0.30
^{241}Am	1.8124 ± 0.0078
Nuclide (GS)	**Assigned Value (Bq g^{-1})**
^{60}Co	1.470 ± 0.034
^{152}Eu	0.769 ± 0.024
^{241}Am	2.40 ± 0.40

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.

CONTENTS

1. SUMMARY	1
2. TREATMENT OF DATA	2
3. SUMMARY OF PARTICIPANTS' RESULTS	4
4. ALPHA BETA (AB) DEVIATION PLOTS	6
5. ALPHA ONE (A1) DEVIATION PLOTS	12
6. BETA ONE (B1) DEVIATION PLOTS	18
7. GAMMA HIGH (GH) DEVIATION PLOTS	23
8. GAMMA LOW (GL) DEVIATION PLOTS	28
9. GLASS (GS) DEVIATION PLOTS	33
10. DEVIATION PLOTS AND TABULATED RESULTS ARRANGED BY LAB NUMBER	37
11. DISCUSSION	150
12. POST-EXERCISE WORKSHOP OUTCOMES	151
13. REFERENCES	152
14. ACKNOWLEDGEMENTS	152

1. SUMMARY

This environmental radioactivity Proficiency Test Exercise (PTE) was the twentieth in a series of such exercises run by NPL over the last 26 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 2014 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 (0.5 – 25 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 four γ-emitting radionuclides
100 g of dilute nitric acid (1 – 20 Bq g^{-1} per radionuclide)

(v) **GL**: a 'low-level' mixture of four γ-emitting radionuclides
500 g of dilute nitric acid (1 – 20 Bq kg^{-1} per radionuclide)

(vi) **GS**: a vitreous sample containing three γ-emitting radionuclides
100 g (0.5 – 10 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 concentrations 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.

The activity concentrations of the radionuclides in the aqueous sample types were traceable to national standards of radioactivity, which in turn provide traceability at an international level to the ultimate reference point of all measurements (the SI reference value maintained by the Bureau International des Poids et Mesures (BIPM)).

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 concentrations. 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 concentration 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 method can provide an efficient and robust mean from any data set. 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 vitreous sample type was prepared by adding a weighed mass of a solution of ^{60}Co, ^{152}Eu and ^{241}Am to a mixture of SiO_3, Fe_2O_3, CaO, CaF2, Al_2O_3, $AlPO_4$, MgO, K_2O and MnO and drying slowly on a hotplate. The spiked compound mixture was added to a larger volume of inactive compound mixture of identical composition and the whole was homogenised prior to being transferred to crucibles (in batches), heated to approximately 1500K, poured into cold water, dried, ground and sieved. The spiked material was then transferred to 100 ml plastic bottles before being measured by gamma spectrometry to check the homogeneity of the batch.

After receipt of the results from the participants, the PMWM was calculated for each nuclide and was used as the Assigned Value.

The Assigned Values for gross alpha, gross beta and combined gross alpha / beta activities in sample types A1, B1 and AB respectively were also calculated from the PMWM of the participants' results.

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 2012 exercise (Dean et al., 2013). 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:

$$u_{\mathrm{D}} = \frac{L}{N} \sqrt{\left(\frac{u_{\mathrm{L}}}{L} \right)^2 + \left(\frac{u_{\mathrm{N}}}{N} \right)^2} \quad [2]$$

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

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

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

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

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.

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

Table 2 AB summary

Nuclide (AB)	NPL Assigned Values (Bq g^{-1})	PMWM (Bq g^{-1})	Deviation %	Zeta	Critical Value
^{3}H	6.037 ± 0.043	6.138 ± 0.074	1.7	1.18	2.77
^{90}Sr	2.418 ± 0.011	2.498 ± 0.062	3.3	1.27	2.82
^{237}Np	7.432 ± 0.074	7.54 ± 0.24	1.4	0.42	2.92
^{238}Pu	8.666 ± 0.020	8.616 ± 0.093	-0.6	-0.53	2.88

Table 3 A1 summary

Nuclide (AL)	NPL Assigned Values (Bq kg^{-1})	PMWM (Bq kg^{-1})	Deviation %	Zeta	Critical Value
^{234}U	16.50 ± 0.28	16.43 ± 0.21	-0.4	-0.19	2.58
^{235}U	0.788 ± 0.013	0.772 ± 0.015	-2.1	-0.83	2.68
^{238}U	16.50 ± 0.28	16.44 ± 0.20	-0.4	-0.18	2.58
^{239}Pu	20.879 ± 0.039	20.47 ± 0.48	-1.9	-0.83	2.92

Table 4 B1 summary

Nuclide (B1)	NPL Assigned Values (Bq g^{-1})	PMWM (Bq g^{-1})	Deviation %	Zeta	Critical Value
^{3}H	0.7400 ± 0.0052	0.7269 ± 0.0068	-1.8	-1.53	2.66
^{14}C	0.4254 ± 0.0028	0.4231 ± 0.0084	-0.5	-0.26	2.86
^{36}Cl	0.4978 ± 0.0020	0.450 ± 0.021	-9.5	-2.24	4.03

Table 5 GH summary

Nuclide (GH)	NPL Assigned Values (Bq g^{-1})	PMWM (Bq g^{-1})	Deviation %	Zeta	Critical Value
^{60}Co	5.394 ± 0.012	5.281 ± 0.018	-2.1	-5.24	2.66
^{134}Cs	4.973 ± 0.034	4.632 ± 0.049	-6.9	-5.69	2.66
^{137}Cs	4.125 ± 0.031	4.137 ± 0.019	0.3	0.34	2.58
^{154}Eu	4.600 ± 0.037	4.312 ± 0.039	-6.3	-5.36	2.58

Table 6 GL summary

Nuclide (GL)	NPL Assigned Values (Bq kg^{-1})	PMWM (Bq kg^{-1})	Deviation %	Zeta	Critical Value
^{60}Co	12.490 ± 0.062	12.367 ± 0.086	-1.0	-1.16	2.65
^{137}Cs	2.259 ± 0.020	2.2940 ± 0.03	1.5	0.95	2.66
^{152}Eu	20.00 ± 0.15	19.36 ± 0.26	-3.2	-2.13	2.68
^{241}Am	1.8124 ± 0.0039	1.942 ± 0.039	7.1	3.29	2.80

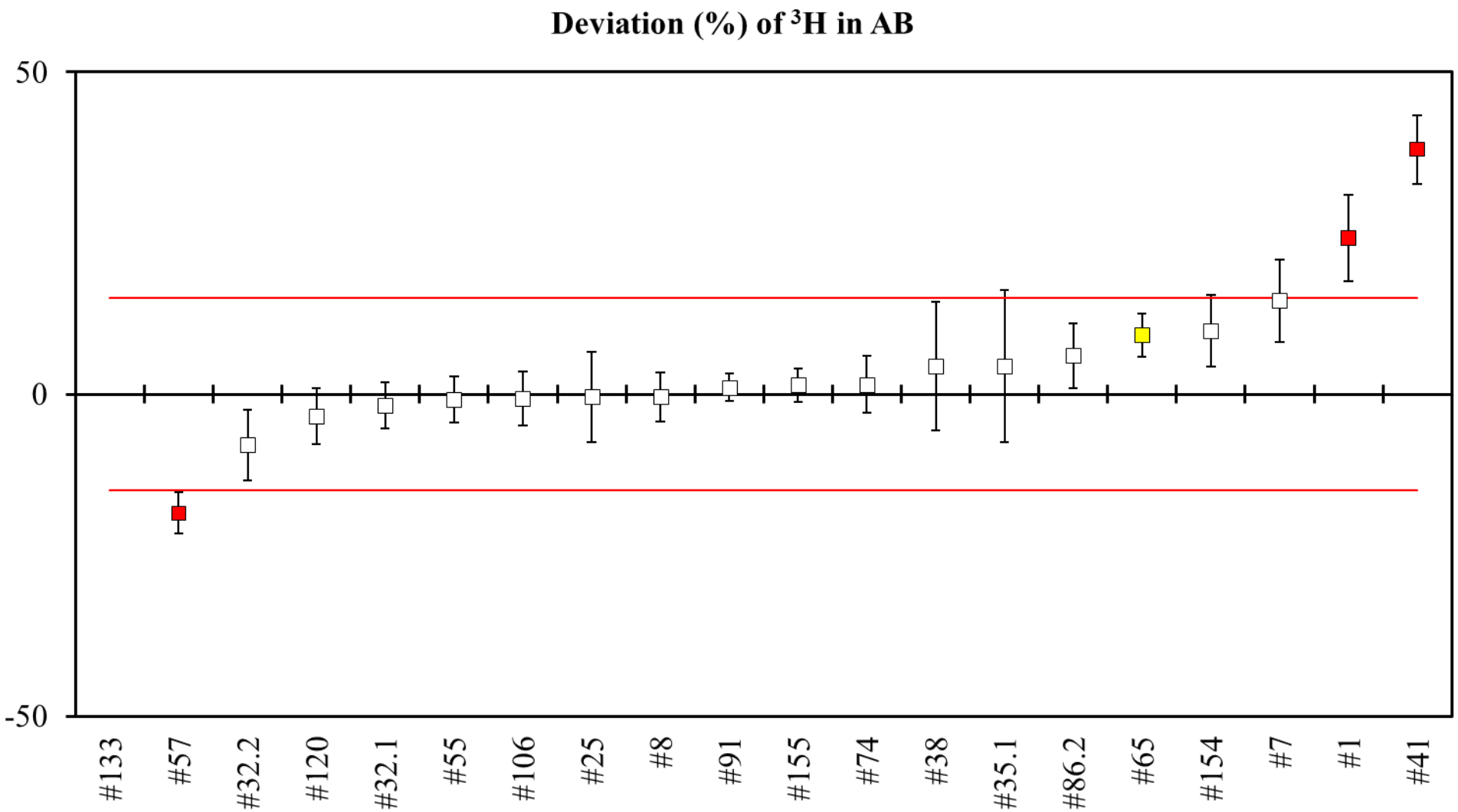
Table 7 GS summary

Nuclide (GS)	PMWM (Bq g^{-1})
^{60}Co	1.470 ± 0.017
^{152}Eu	0.769 ± 0.012
^{241}Am	2.40 ± 0.20

Table 8 Gross nuclides summary

Nuclides	PMWM
Gross alpha / beta (AB)	(27.1 ± 5.3) Bq g^{-1}
Gross alpha (A1)	(46.8 ± 4.2) Bq kg^{-1}
Gross beta (B1)	(0.94 ± 0.28) Bq g^{-1}

4. Alpha Beta (AB) Deviation Plots


Deviation (%) of ³H in AB
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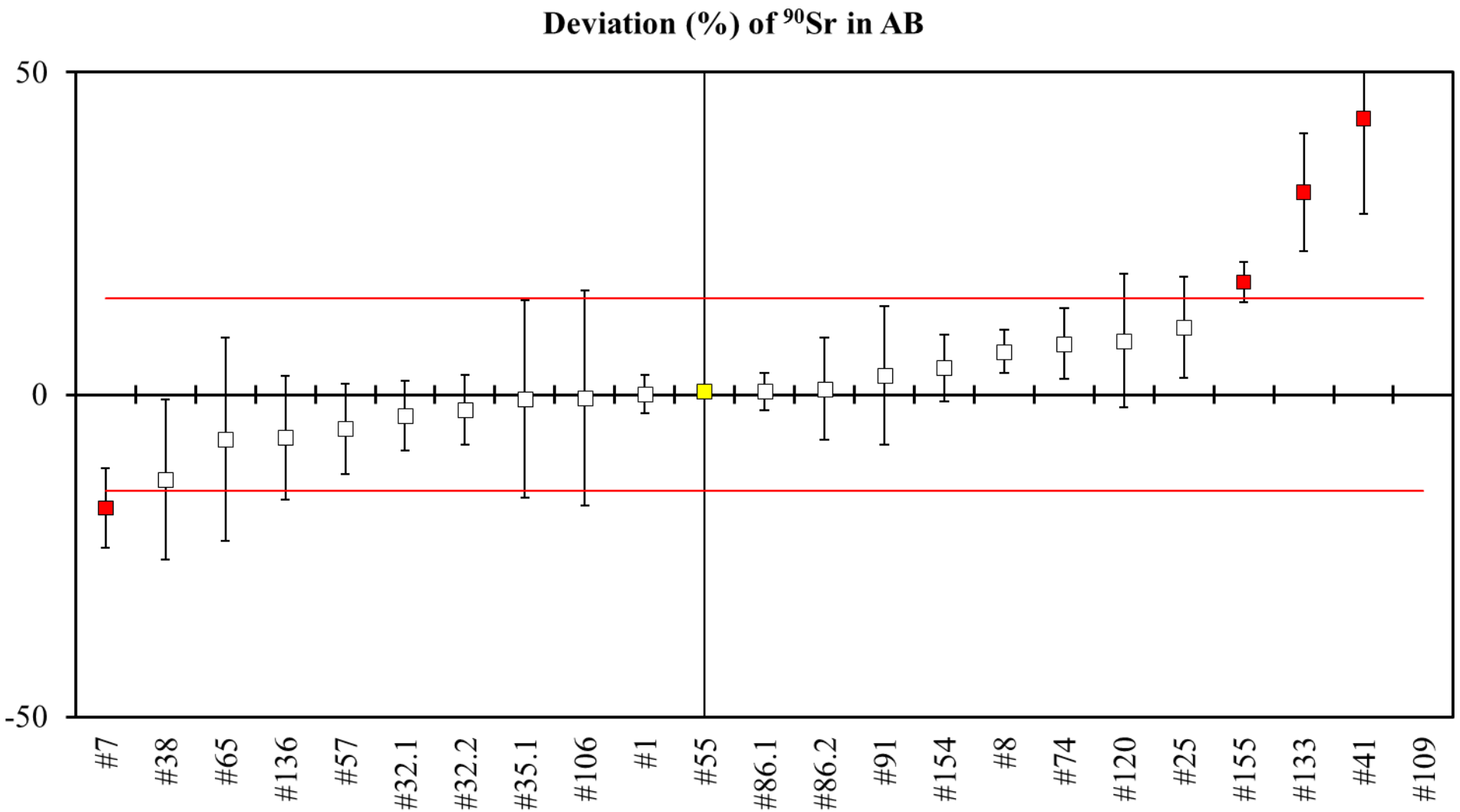
0
-50
#133
#57
#32.2
#120
#32.1
#55
#106
#25
#8
#91
#155
#74
#38
#35.1
#86.2
#65
#154
#7
#1
#41


Deviation (%) of 90Sr in AB
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#7
#38
#65
#136
#57
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#32.2
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#106
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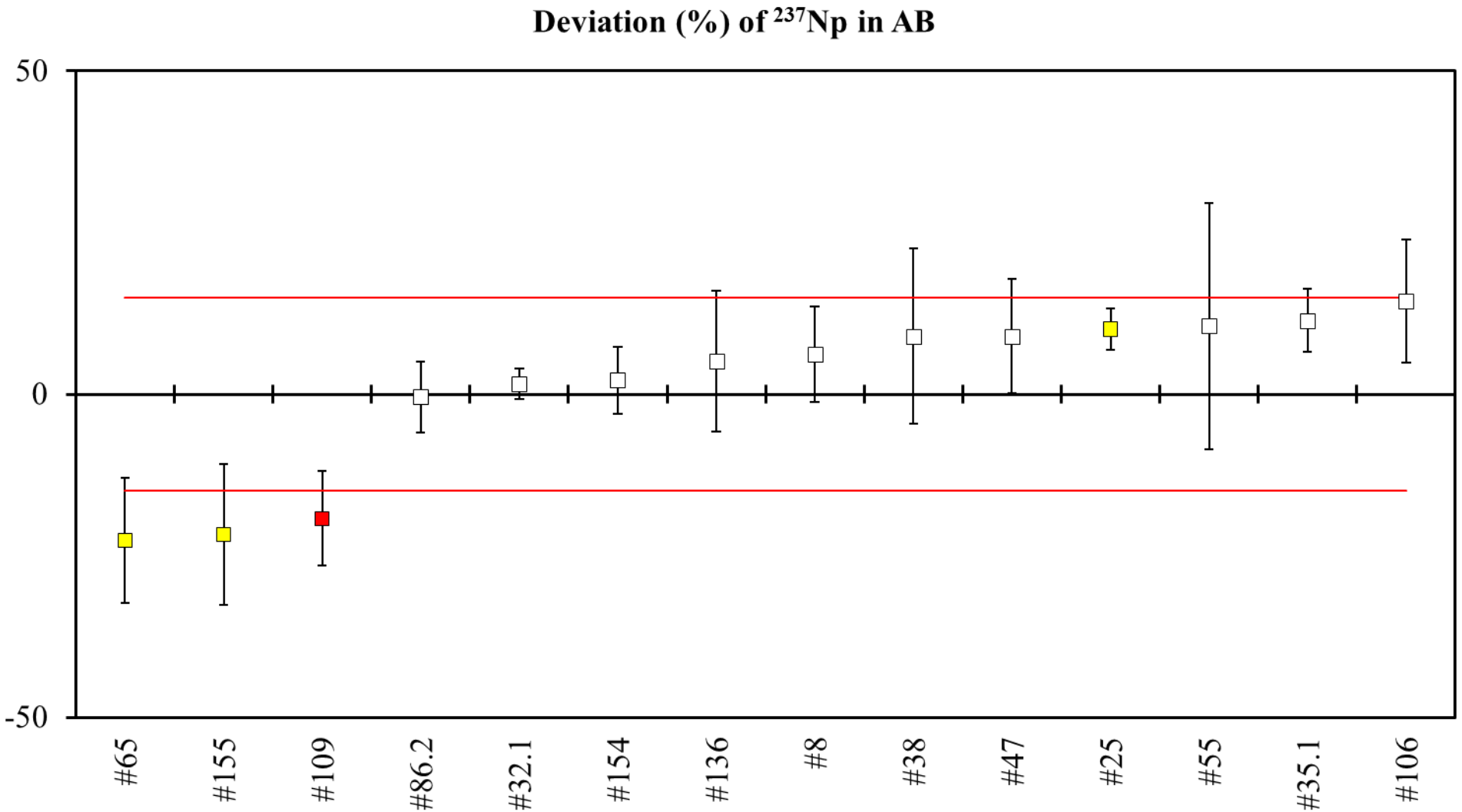
#154
#8
#74
#120
#25
#155
#133
#41
#109


Deviation (%) of 237Np in AB
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#32.1
#154
#136
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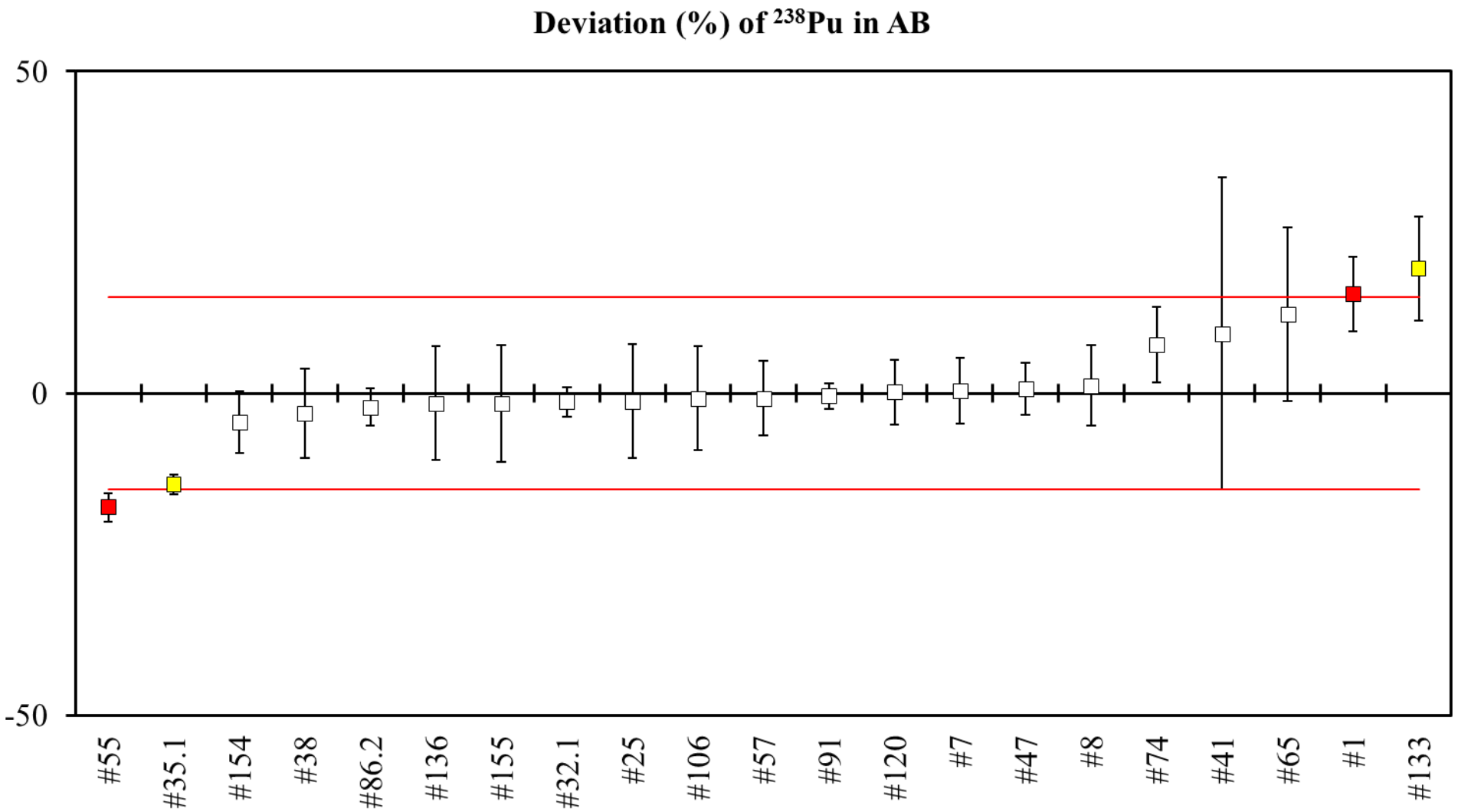
#38
#47
#25
#55
#35.1
#106


Deviation (%) of 238Pu in AB
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#38
#86.2
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#120
#7
#47
#8
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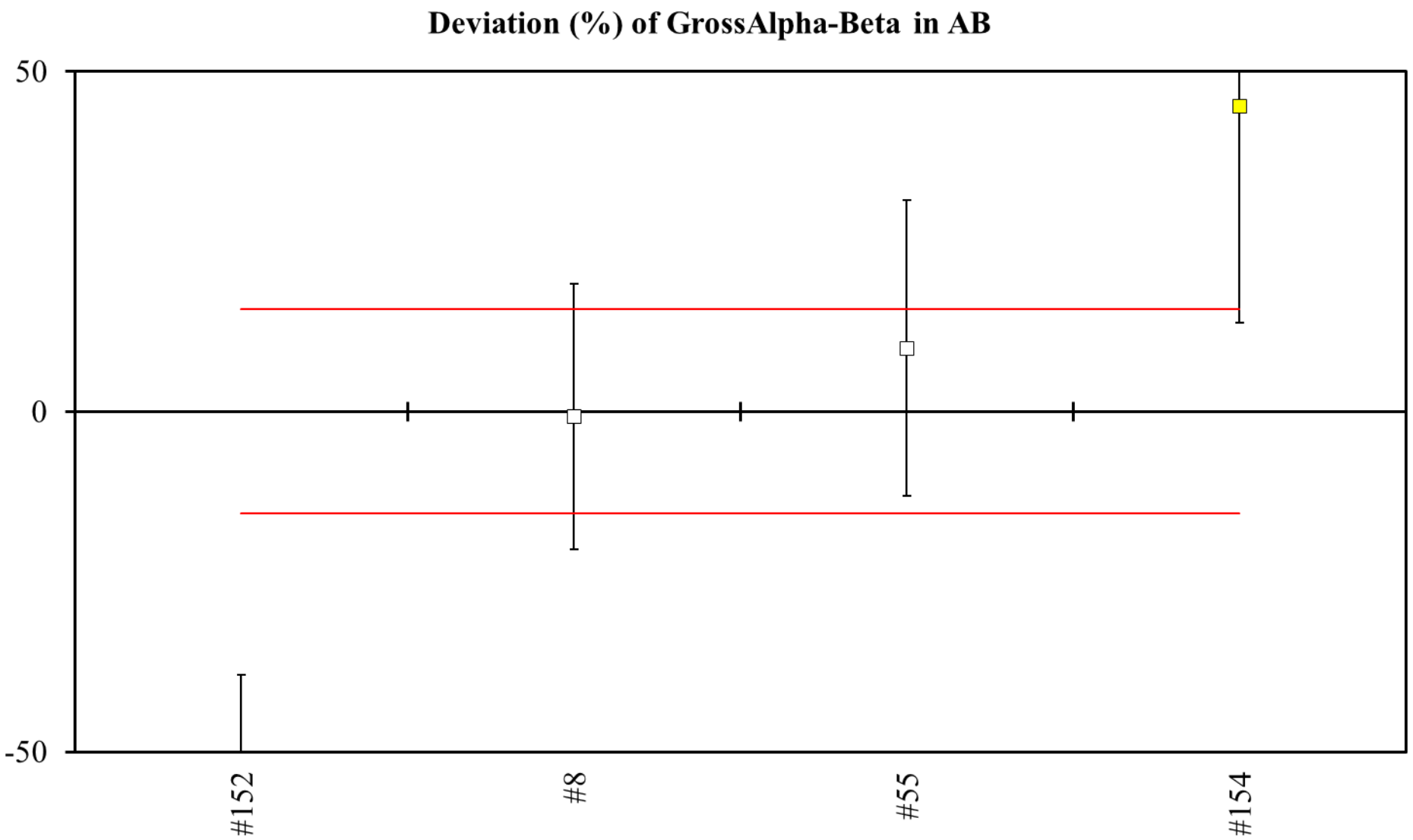
#41
#65
#1
#133


Deviation (%) of GrossAlpha-Beta in AB
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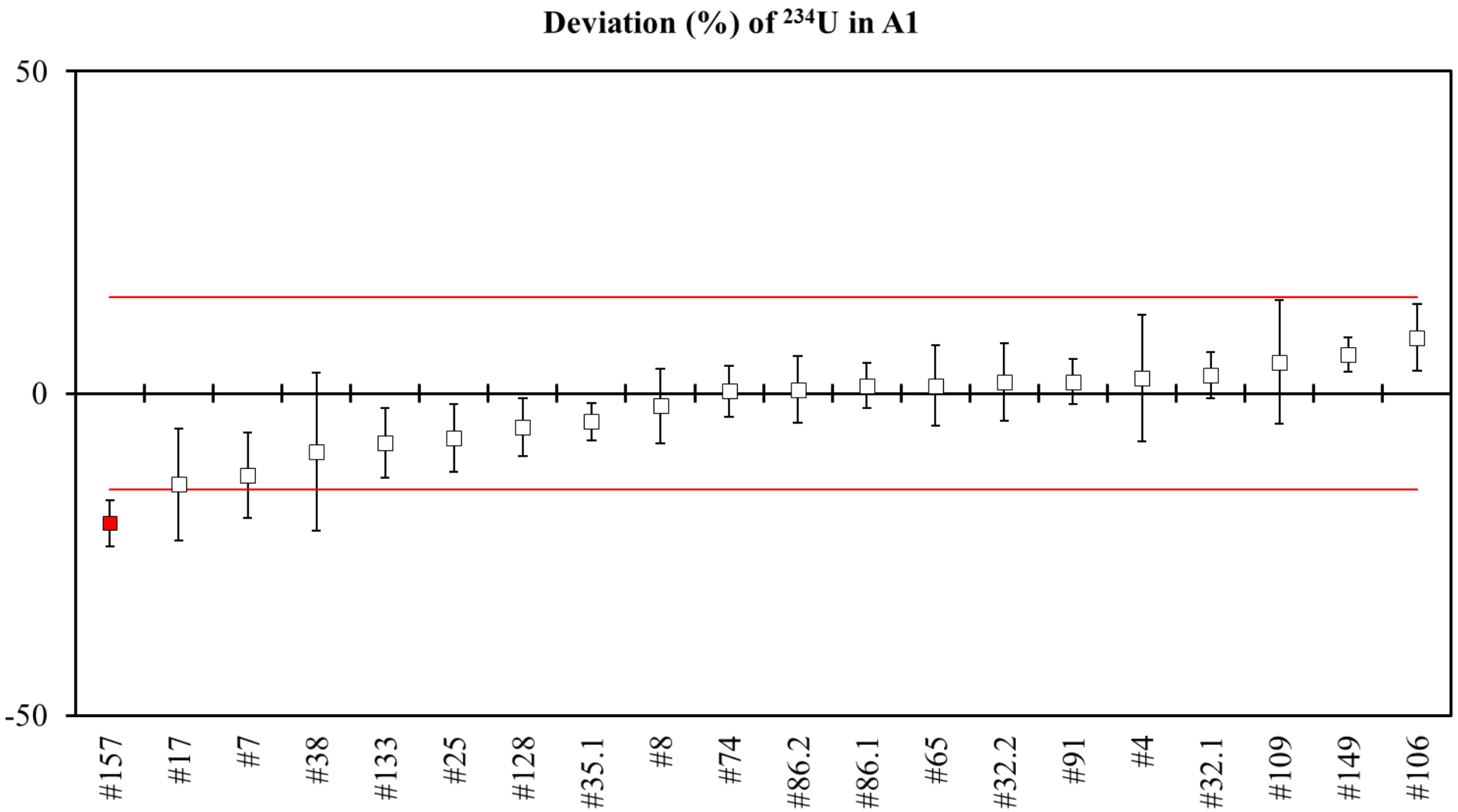
#152
#8
#55
#154

5. Alpha One (A1) Deviation Plots


Deviation (%) of 234U in A1
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-50
#157
#17
#7
#38
#133
#25
#128
#35.1
#8
#74
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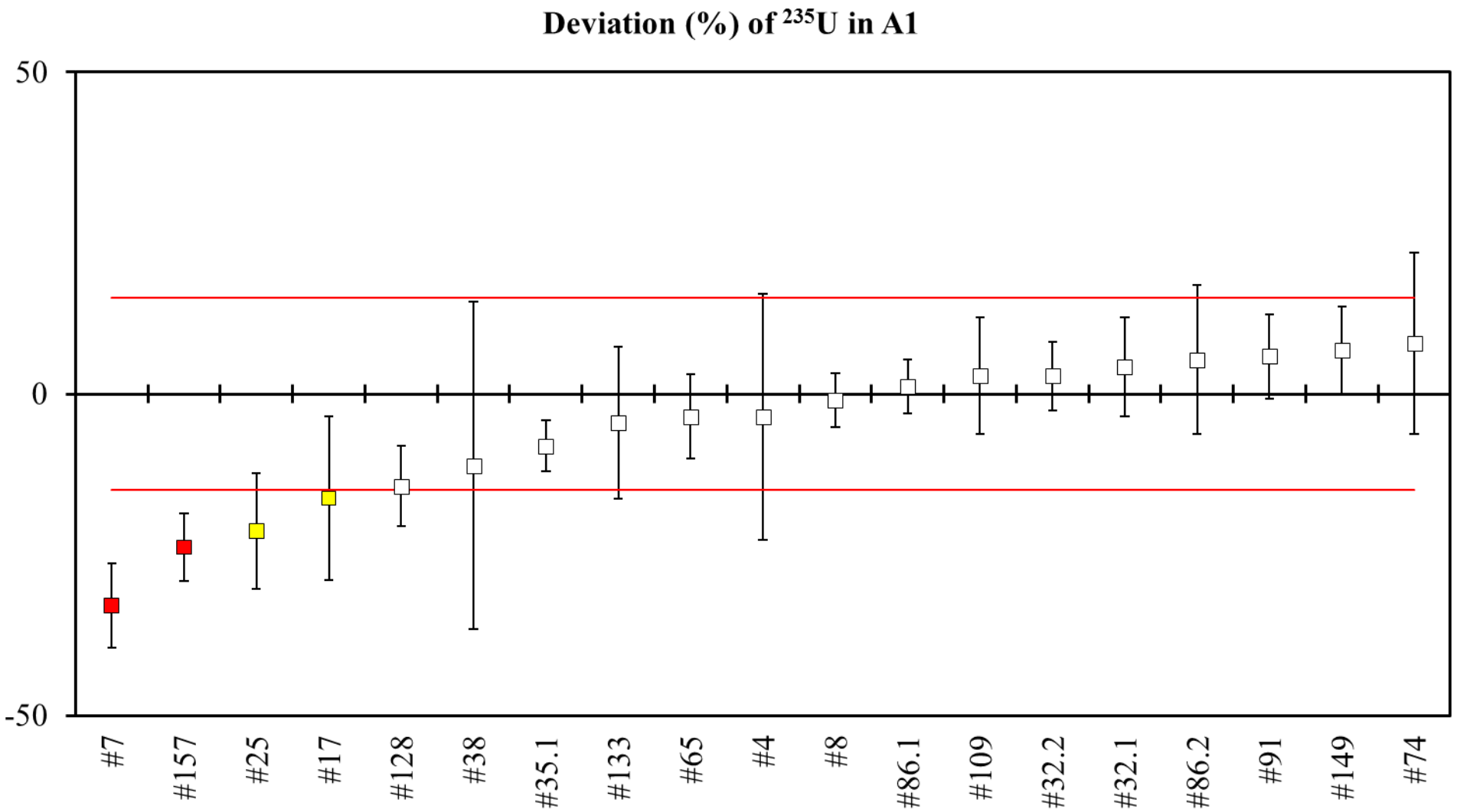
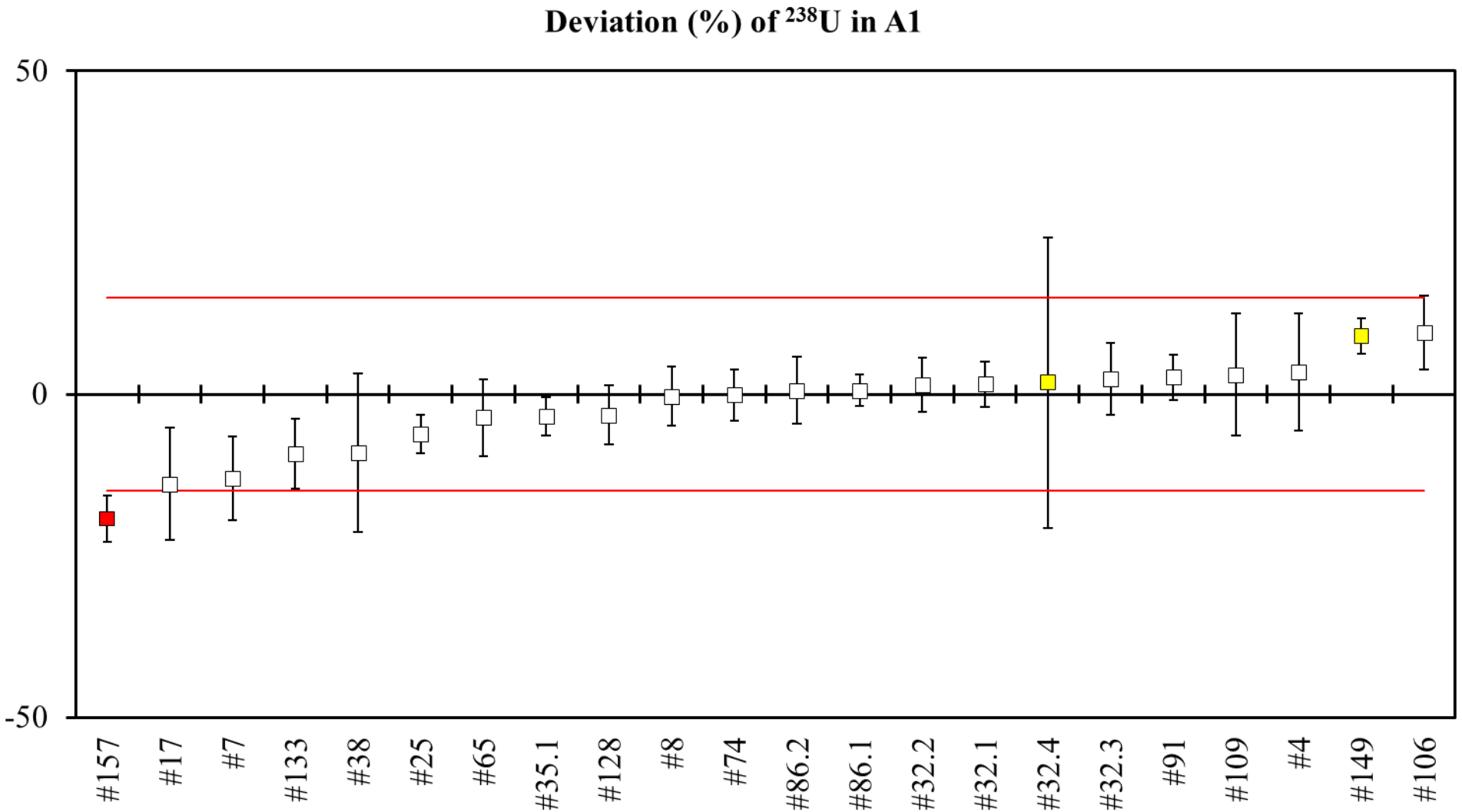
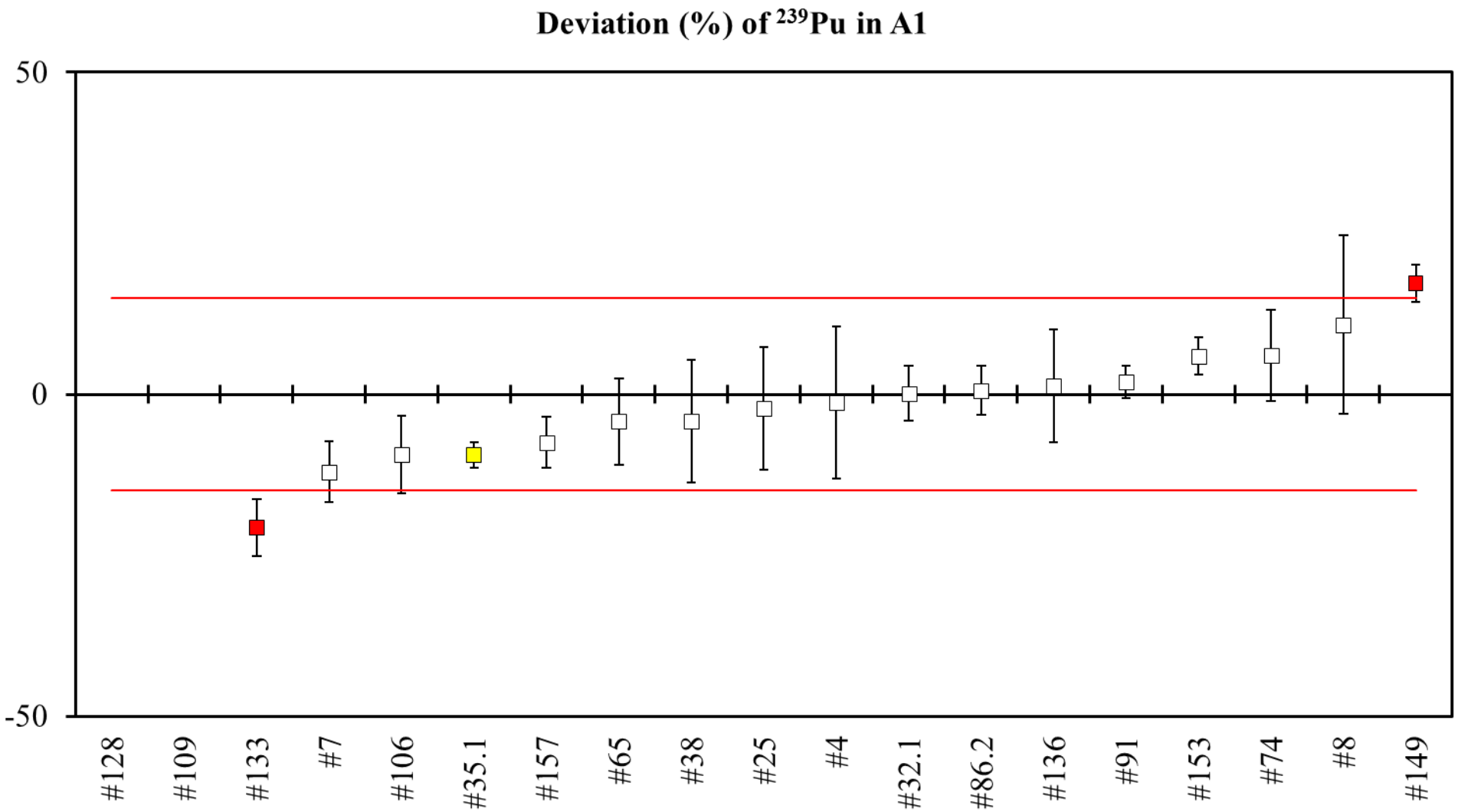
#32.2
#91
#4
#32.1
#109
#149
#106


Deviation (%) of 235U in A1
50
0
-50
#7
#157
#25
#17
#128
#38
#35.1
#133
#65
#4
#8
#86.1
#109
#32.2
#32.1
#86.2
#91
#149
#74


Deviation (%) of 238U in A1
50
0
-50
#157
#17
#7
#133
#38
#25
#65
#35.1
#128
#8
#74
#86.2
#86.1
#32.2
#32.1
#32.4
#32.3
#91
#109
#4
#149
#106


Deviation (%) of 239Pu in A1
50
0
-50
#128
#109
#133
#7
#106
#35.1
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#65
#38
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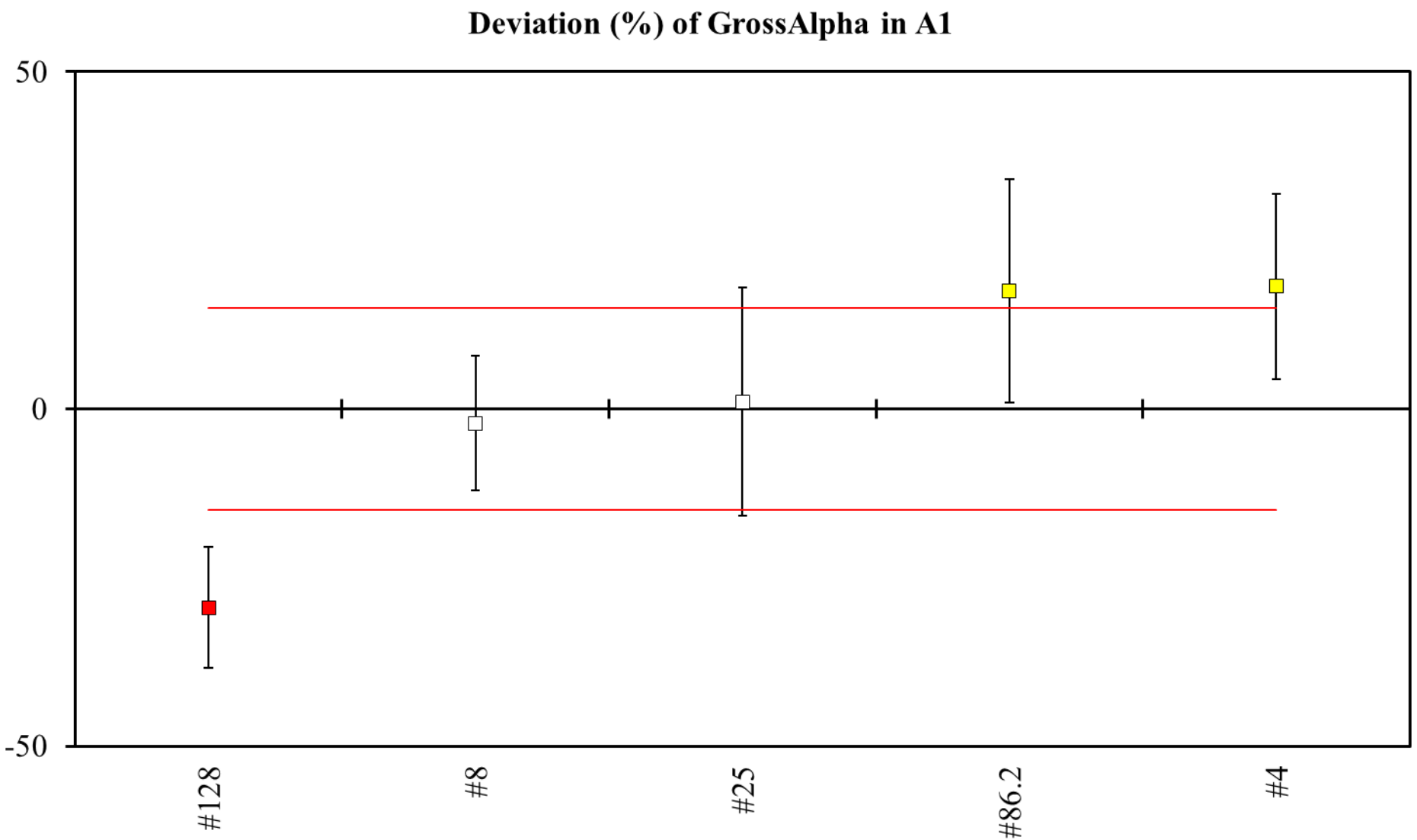
#86.2
#136
#91
#153
#74
#8
#149


Deviation (%) of GrossAlpha in A1
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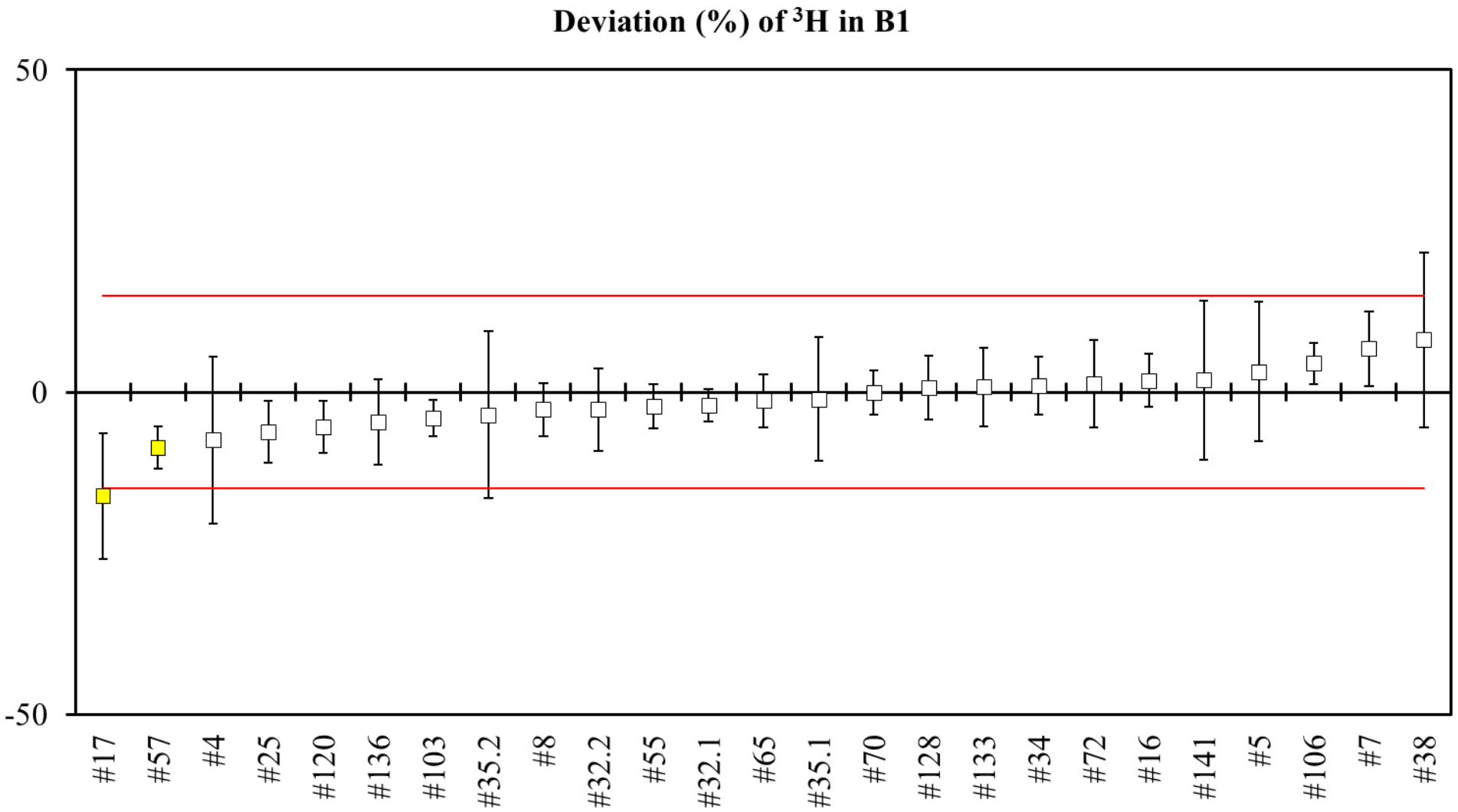
#8
#25
#86.2
#4

6. Beta One (B1) Deviation Plots


Deviation (%) of ³H in B1
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-50
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#57
#4
#25
#120
#136
#103
#35.2
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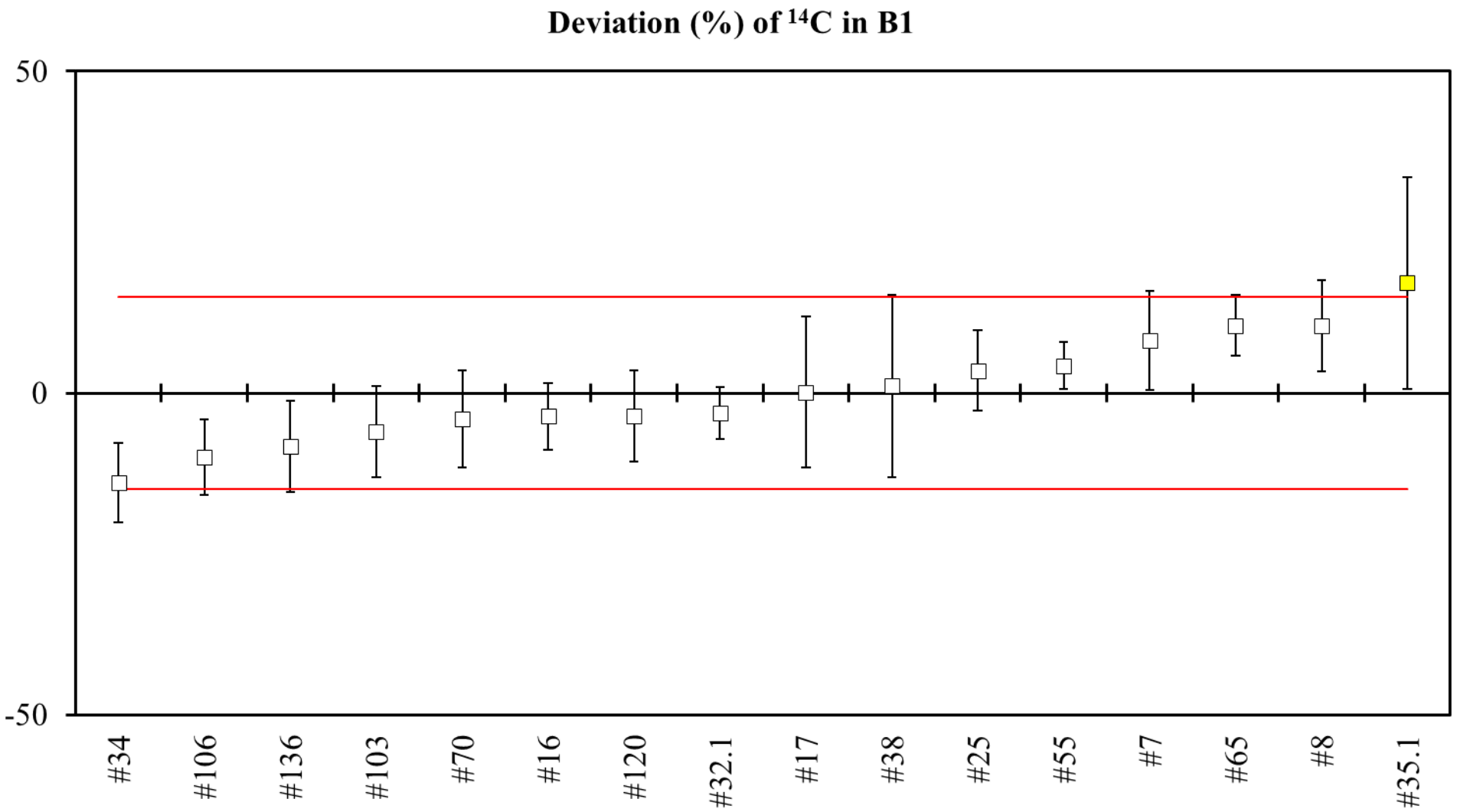
#72
#16
#141
#5
#106
#7
#38


Deviation (%) of 14C in B1
50
0
-50
#34
#106
#136
#103
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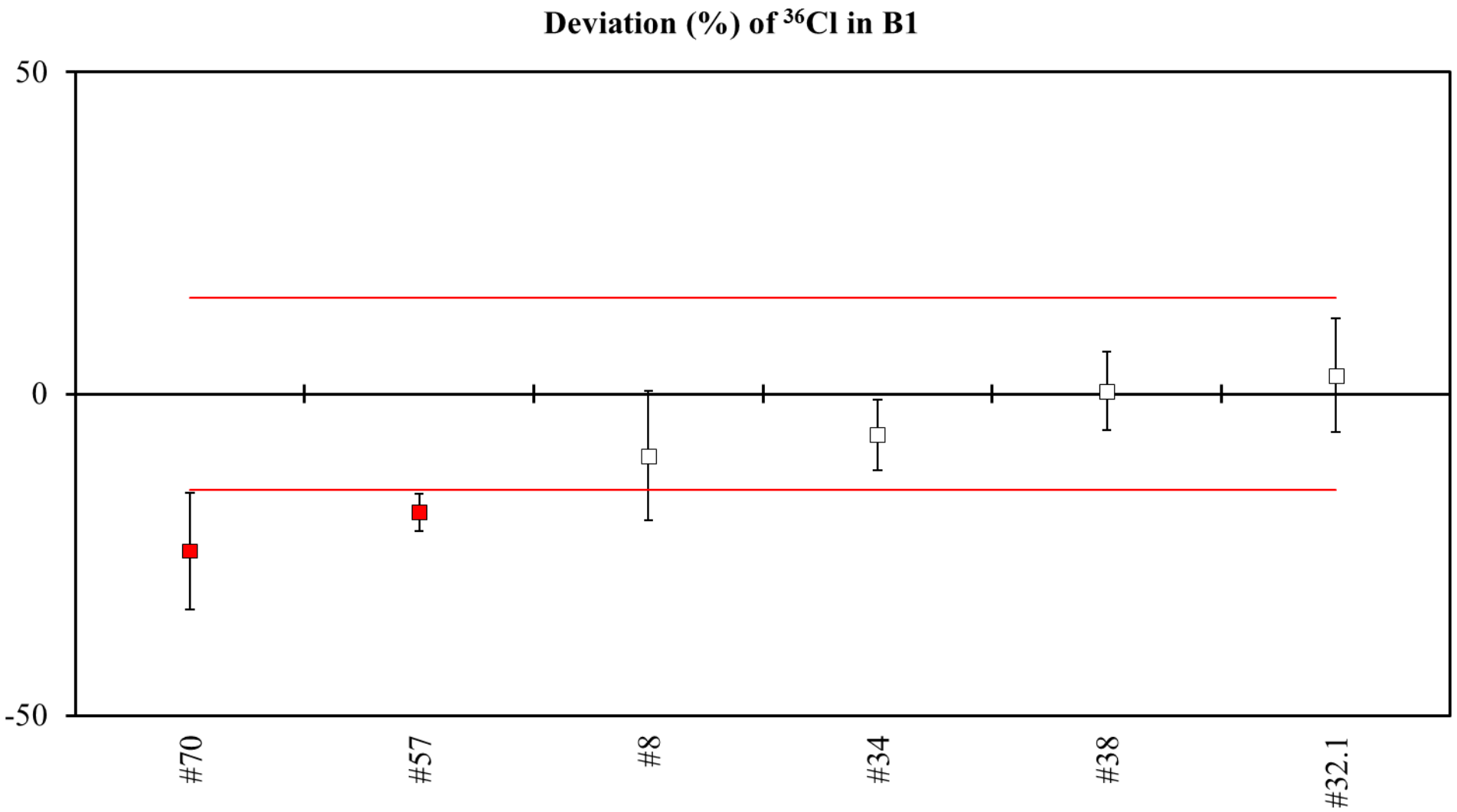
#16
#120
#32.1
#17
#38
#25
#55
#7
#65
#8
#35.1


Deviation (%) of ^{36}Cl in B1
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0
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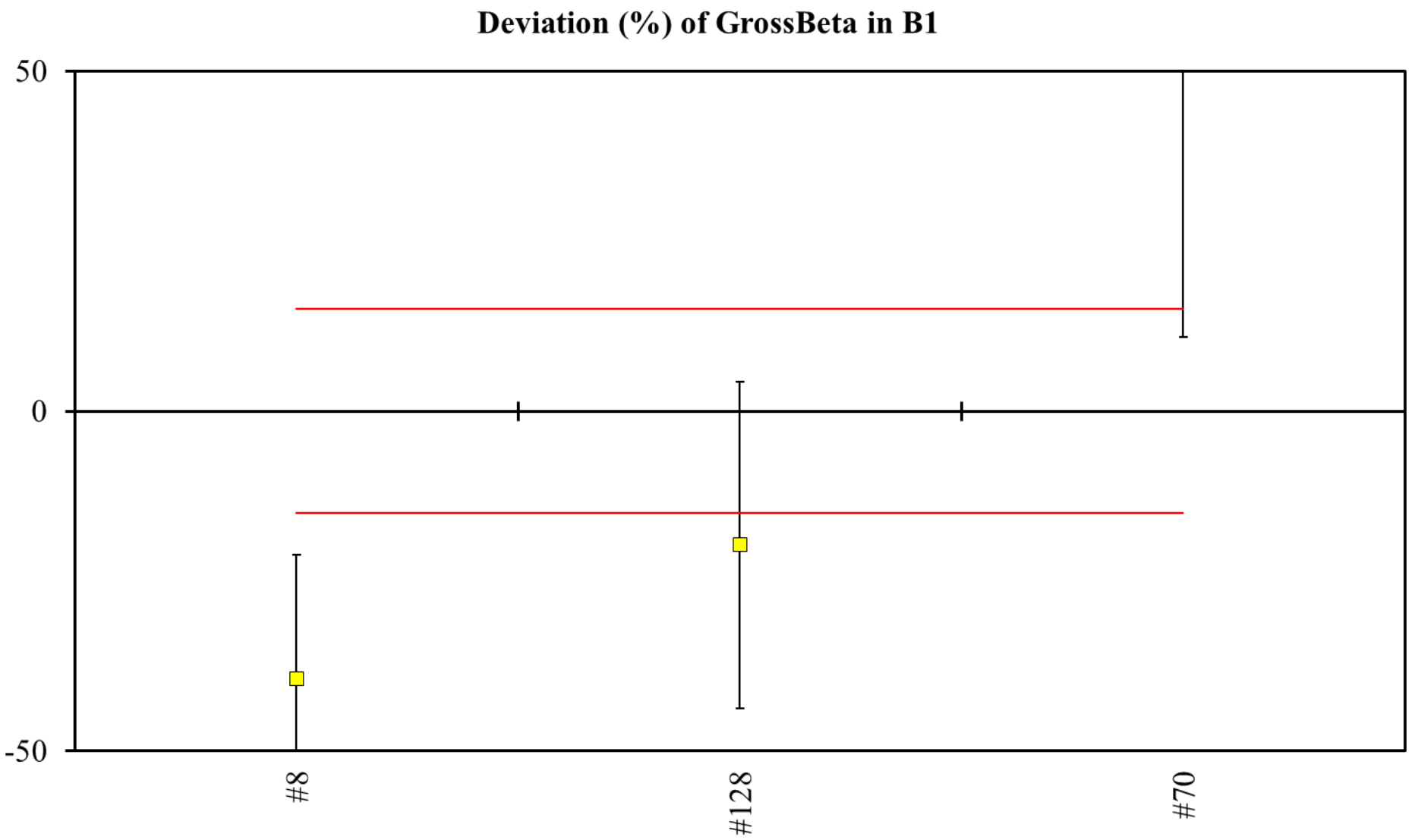
#70
#57
#8
#34
#38
#32.1


Deviation (%) of GrossBeta in B1
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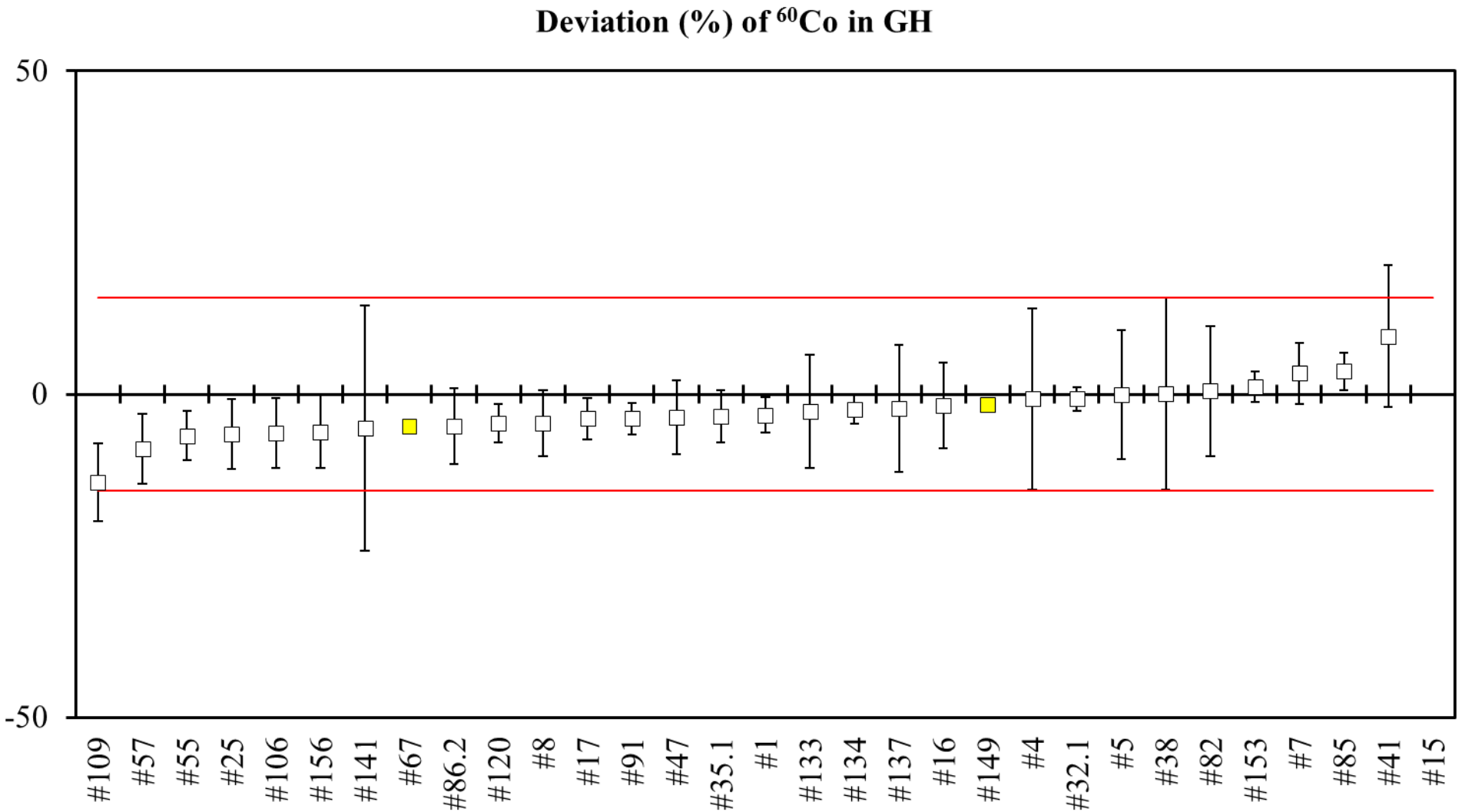
#8
#128
#70

7. Gamma High (GH) Deviation Plots


Deviation (%) of 60Co in GH
50
0
-50
#109
#57
#55
#25
#106
#156
#141
#67
#86.2
#120
#8
#17
#91
#47
#35.1
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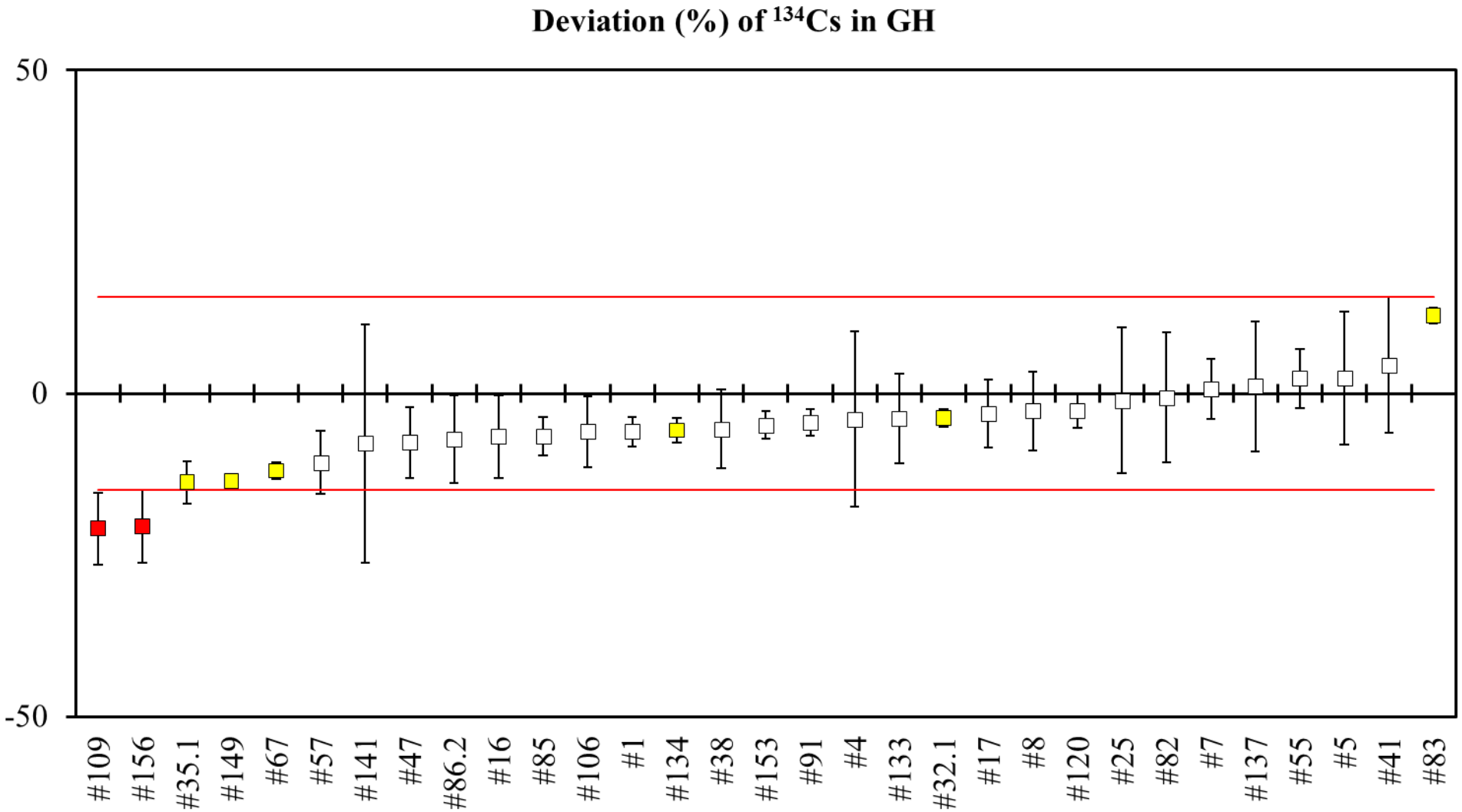
#85
#41
#15


Deviation (%) of 134Cs in GH
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-50
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#156
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#57
#141
#47
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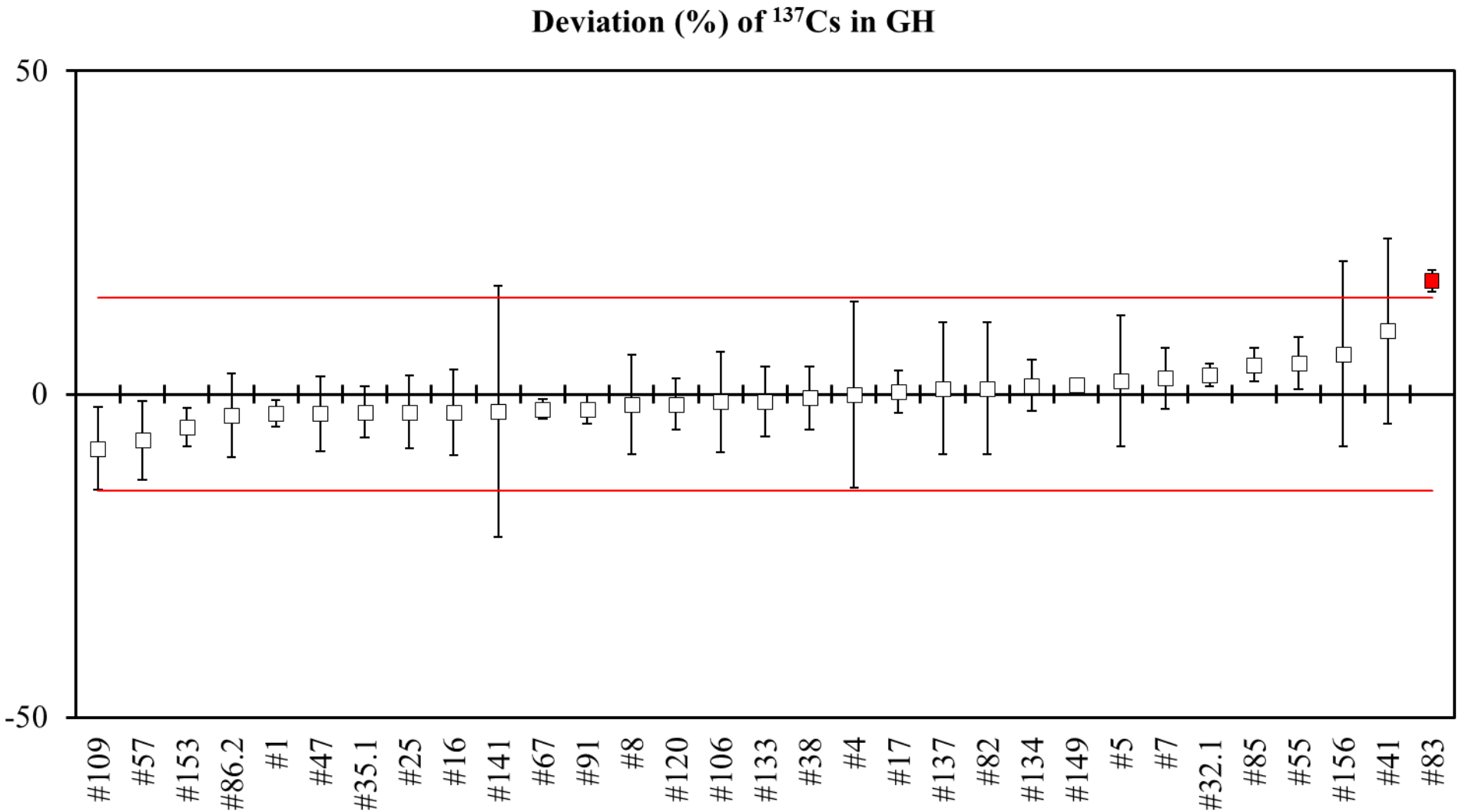
Deviation (%) of 137Cs in GH
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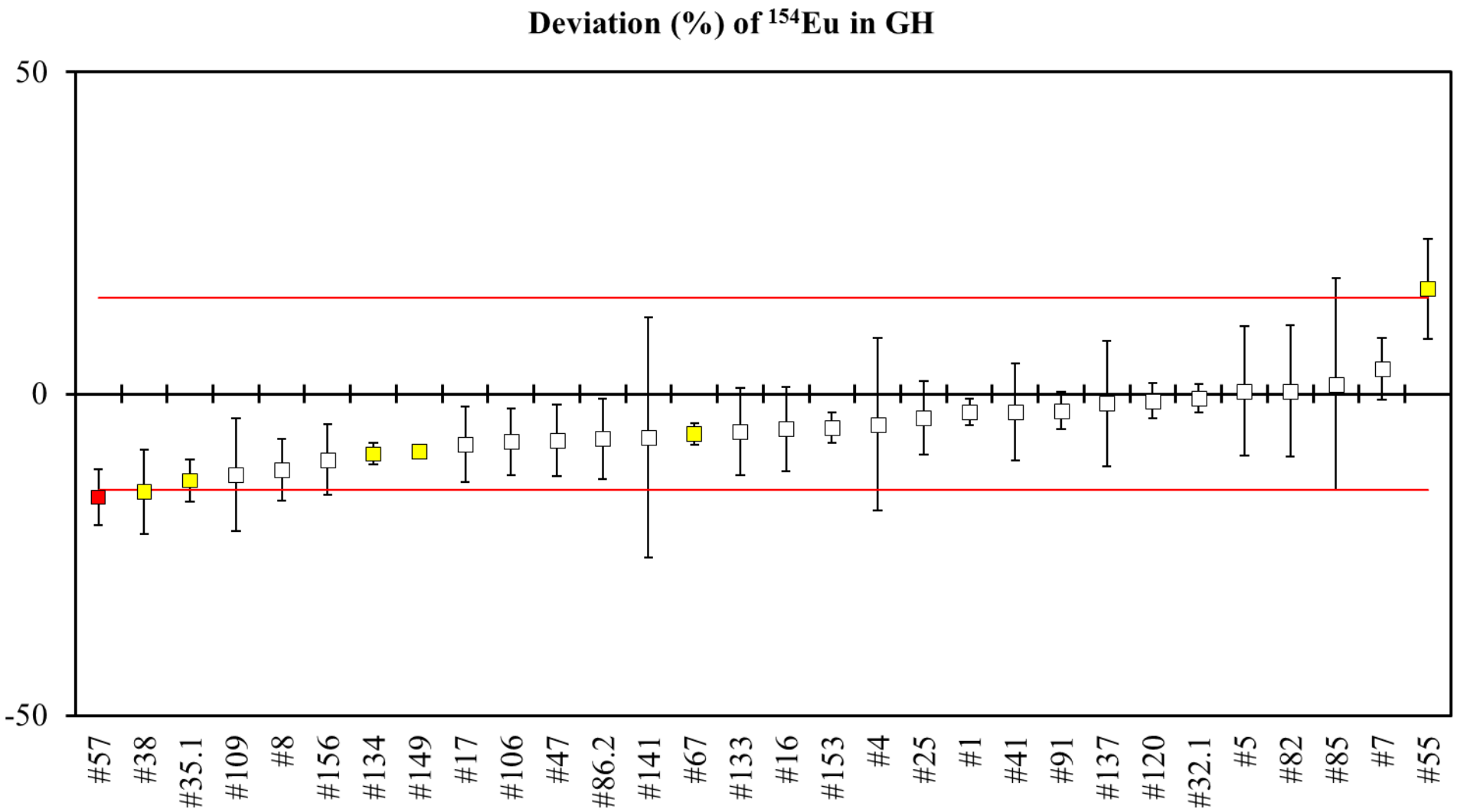
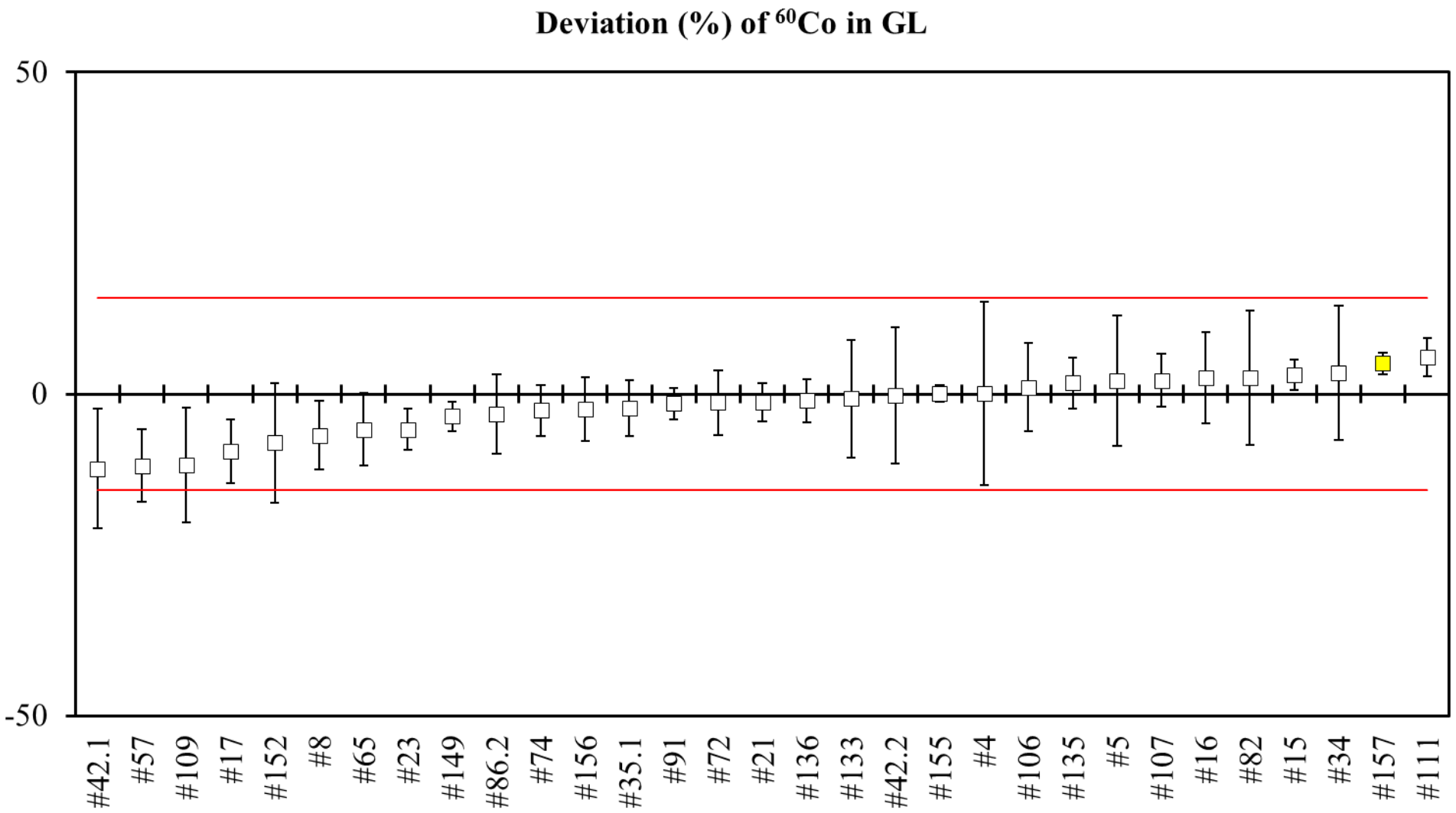
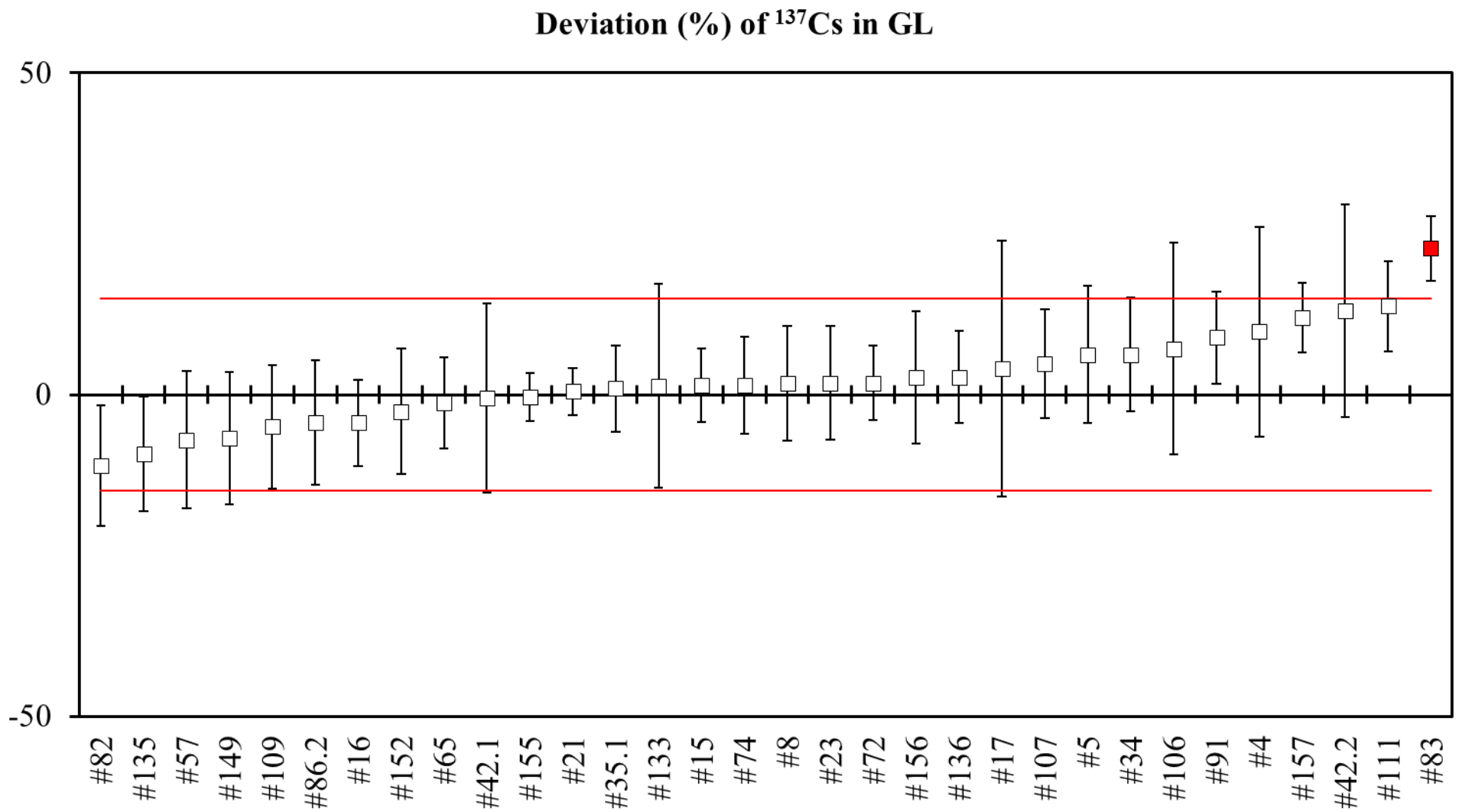
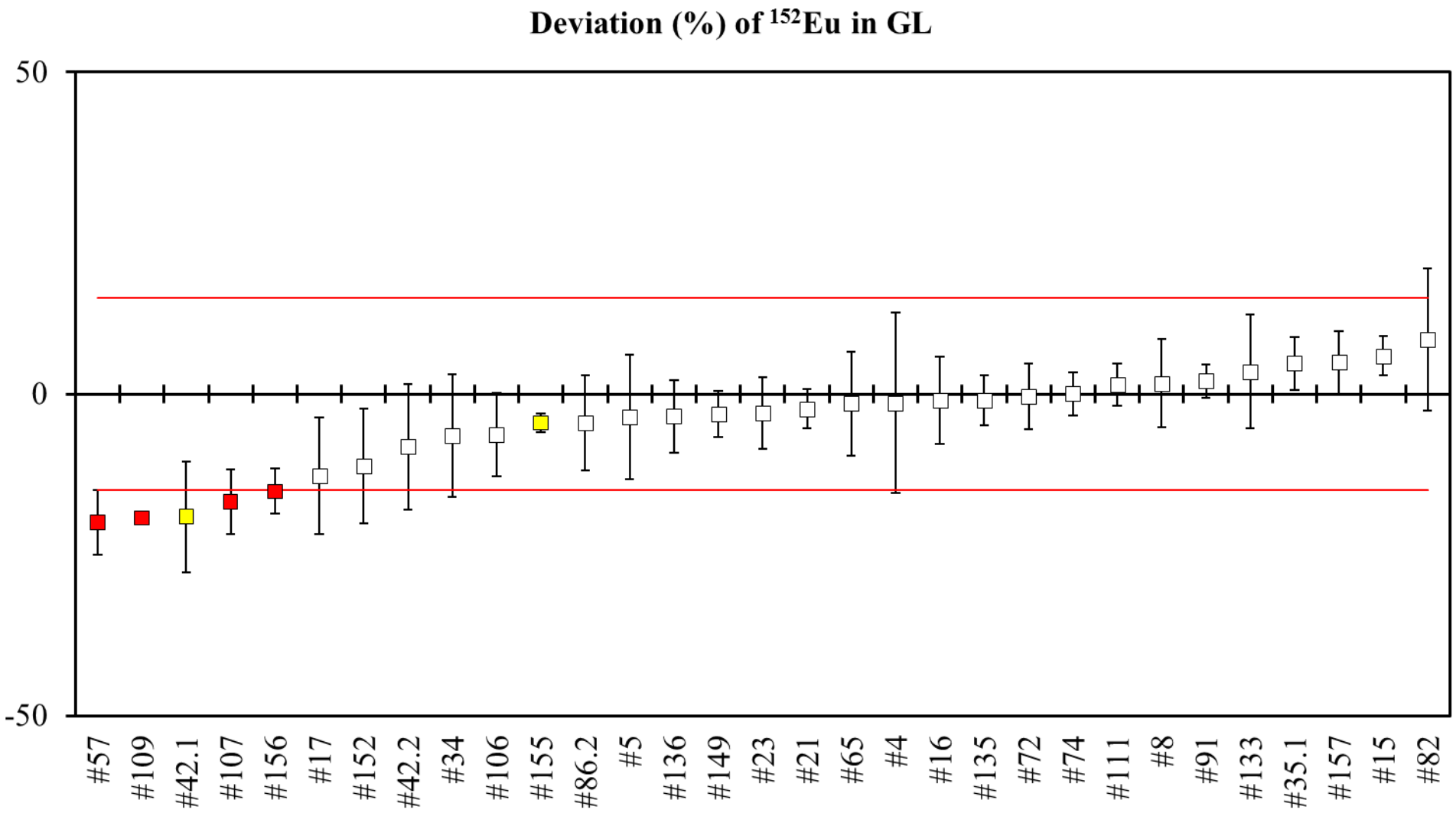
0
-50
#109
#57
#153
#86.2
#1
#47
#35.1
#25
#16
#141
#67
#91
#8
#120
#106
#133
#38
#4
#17
#137
#82
#134
#149
#5
#7
#32.1
#85
#55
#156
#41
#83

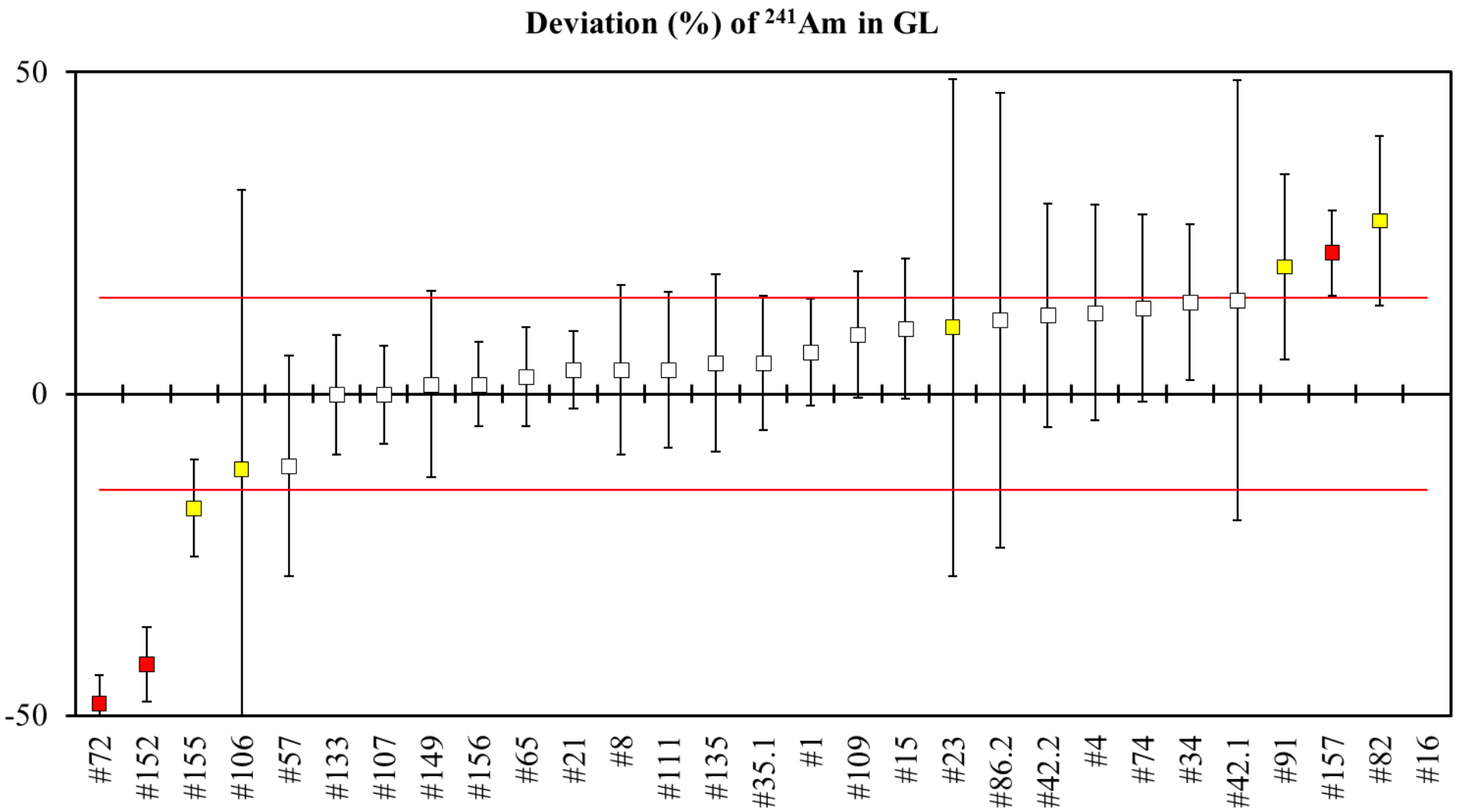

Deviation (%) of 154Eu in GH
50
0
-50
#57
#38
#35.1
#109
#8
#156
#134
#149
#17
#106
#47
#86.2
#141
#67
#133
#16
#153
#4
#25
#1
#41
#91
#137
#120
#32.1
#5
#82
#85
#7
#55

8. Gamma Low (GL) Deviation Plots

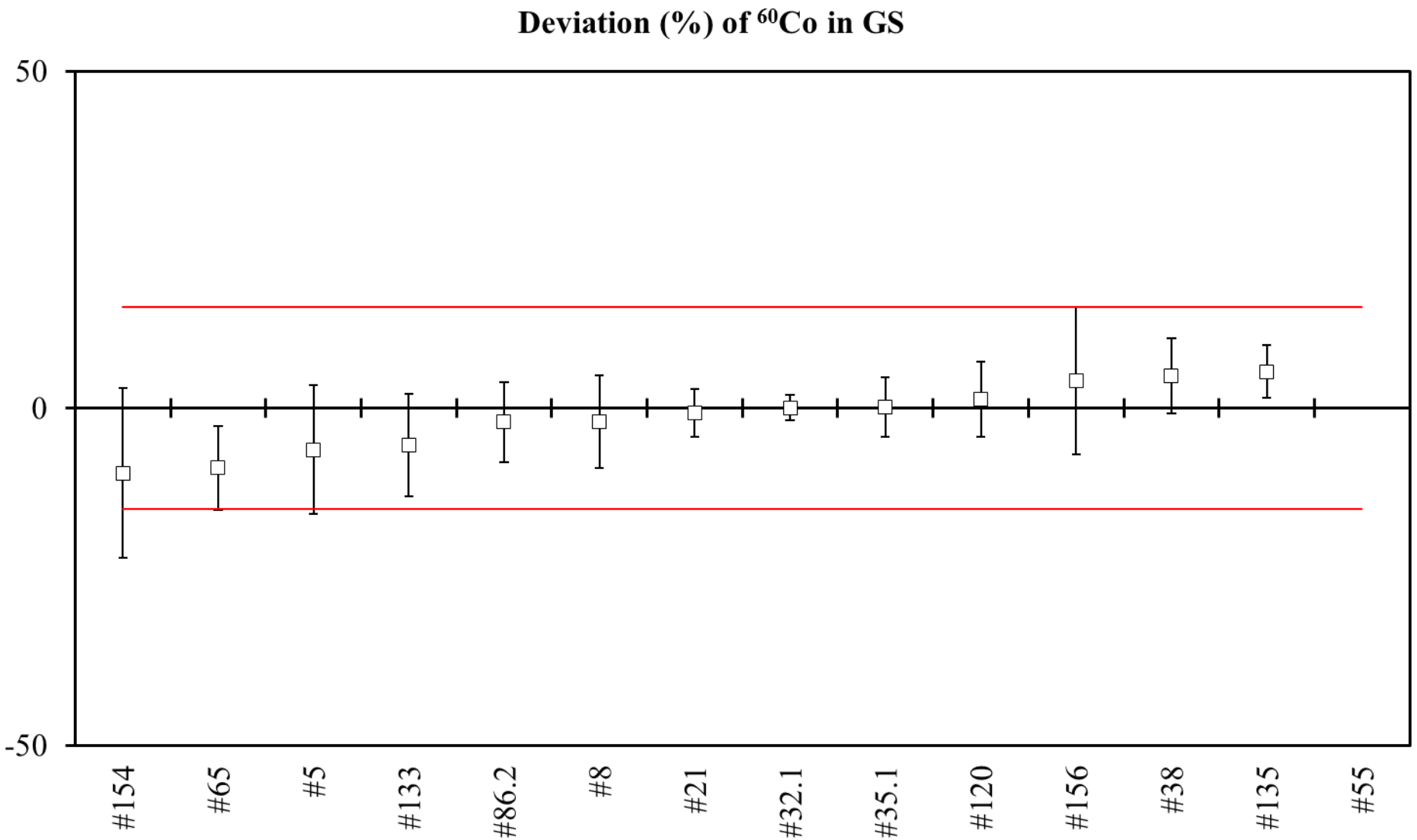

Deviation (%) of 60Co in GL
50
0
-50
#42.1
#57
#109
#17
#152
#8
#65
#23
#149
#86.2
#74
#156
#35.1
#91
#72
#21
#136
#133
#42.2
#155
#4
#106
#135
#5
#107
#16
#82
#15
#34
#157
#111

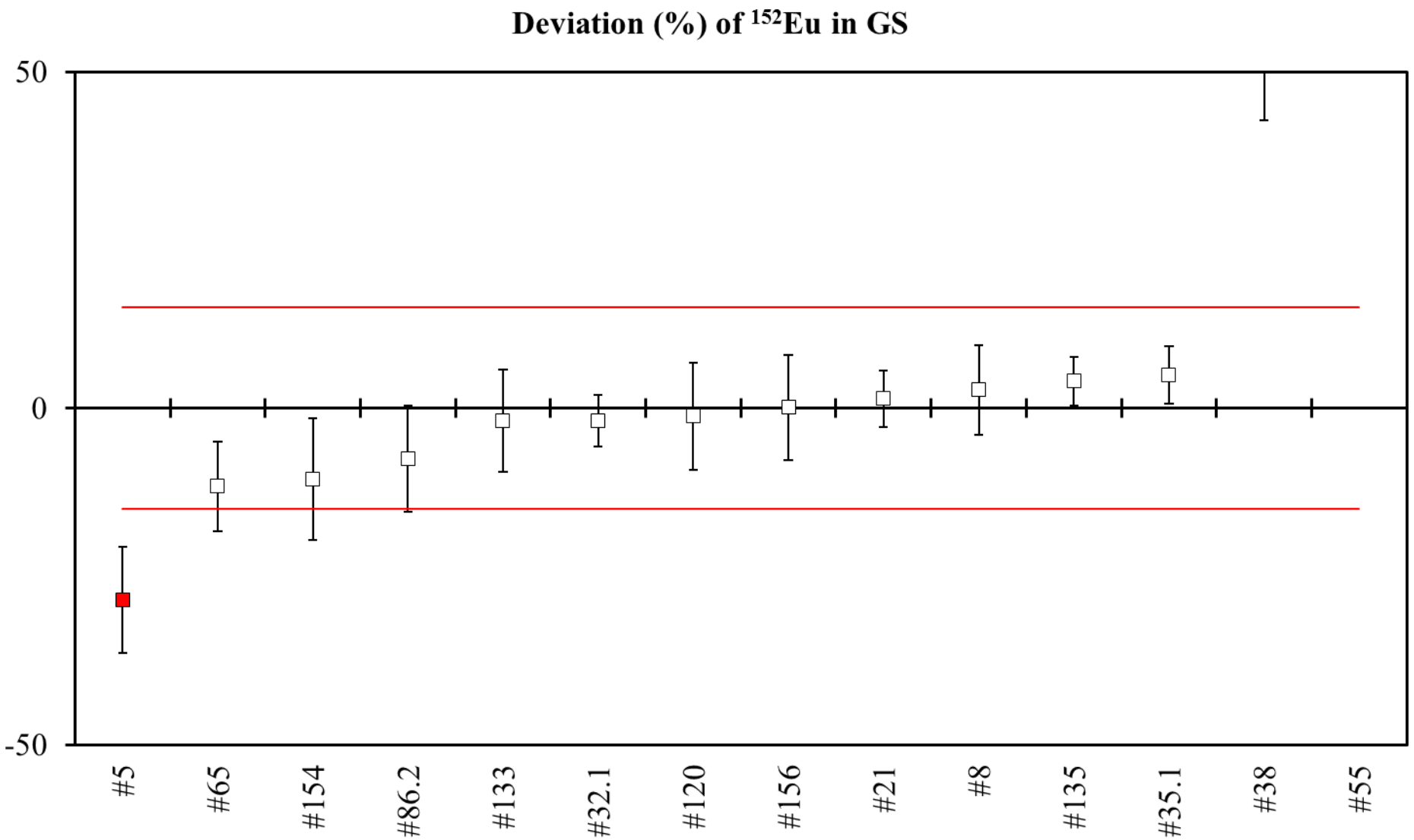

Deviation (%) of 137Cs in GL
50
0
-50
#82
#135
#57
#149
#109
#86.2
#16
#152
#65
#42.1
#155
#21
#35.1
#133
#15
#74
#8
#23
#72
#156
#136
#17
#107
#5
#34
#106
#91
#4
#157
#42.2
#111
#83

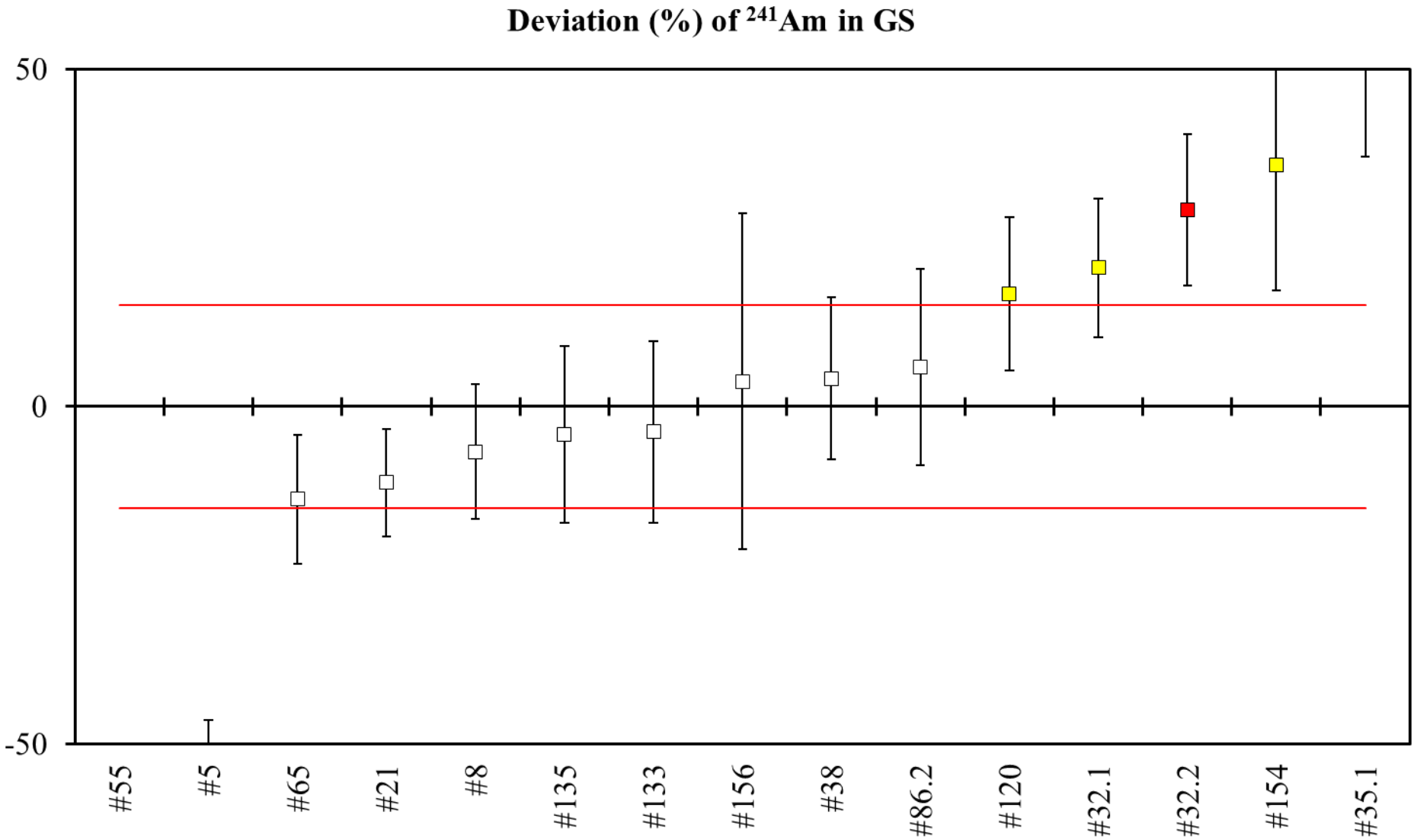

Deviation (%) of 152Eu in GL
50
0
-50
#57
#109
#42.1
#107
#156
#17
#152
#42.2
#34
#106
#155
#86.2
#5
#136
#149
#23
#21
#65
#4
#16
#135
#72
#74
#111
#8
#91
#133
#35.1
#157
#15
#82


Deviation (%) of 241Am in GL
50
0
-50
#72
#152
#155
#106
#57
#133
#107
#149
#156
#65
#21
#8
#111
#135
#35.1
#1
#109
#15
#23
#86.2
#42.2
#4
#74
#34
#42.1
#91
#157
#82
#16

9. Glass (GS) Deviation Plots

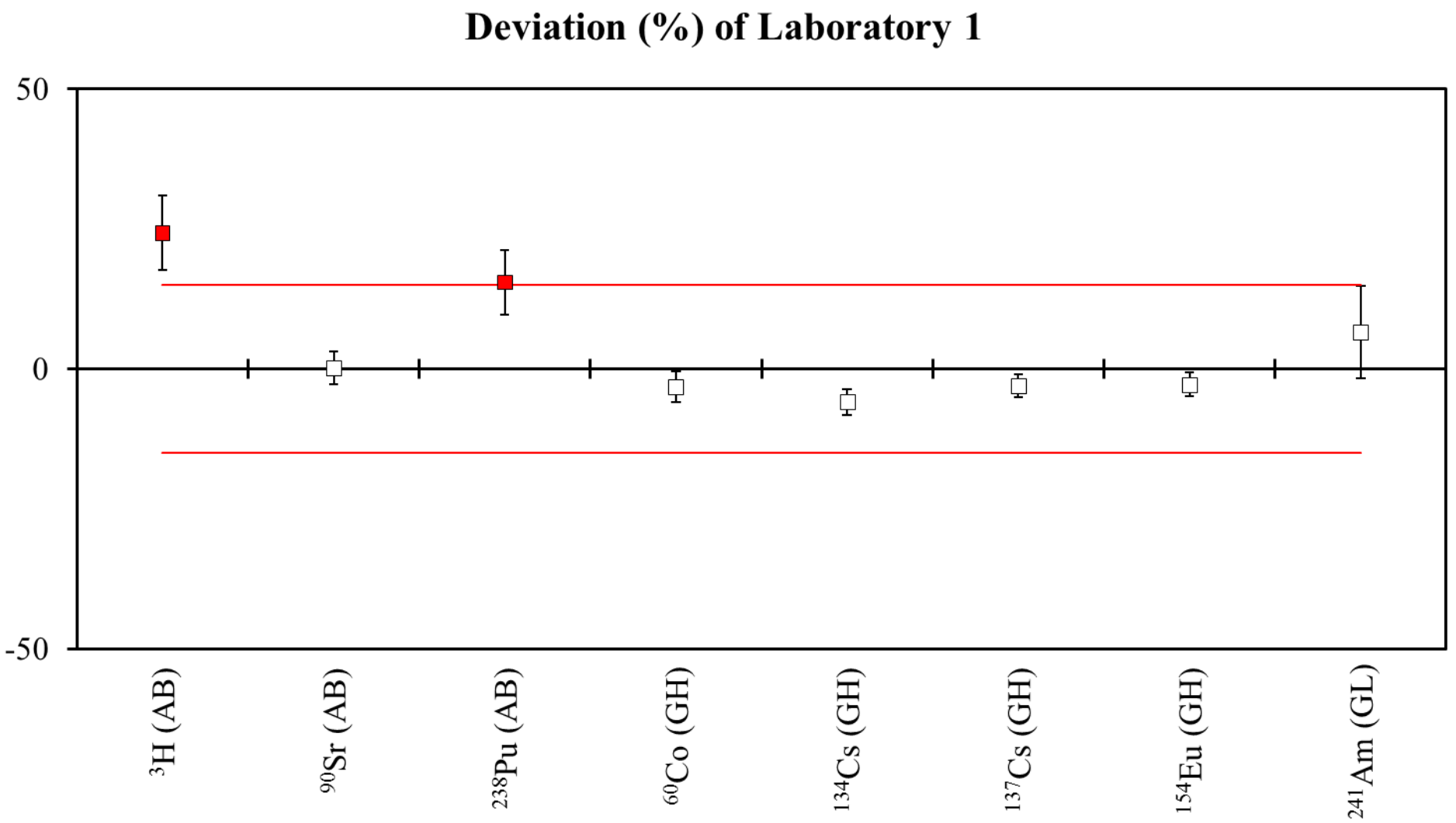

Deviation (%) of 60Co in GS
50
0
-50
#154
#65
#5
#133
#86.2
#8
#21
#32.1
#35.1
#120
#156
#38
#135
#55


Deviation (%) of 152Eu in GS
50
0
-50
#5
#65
#154
#86.2
#133
#32.1
#120
#156
#21
#8
#135
#35.1
#38
#55


Deviation (%) of 241Am in GS
50
0
-50
#55
#5
#65
#21
#8
#135
#133
#156
#38
#86.2
#120
#32.1
#32.2
#154
#35.1

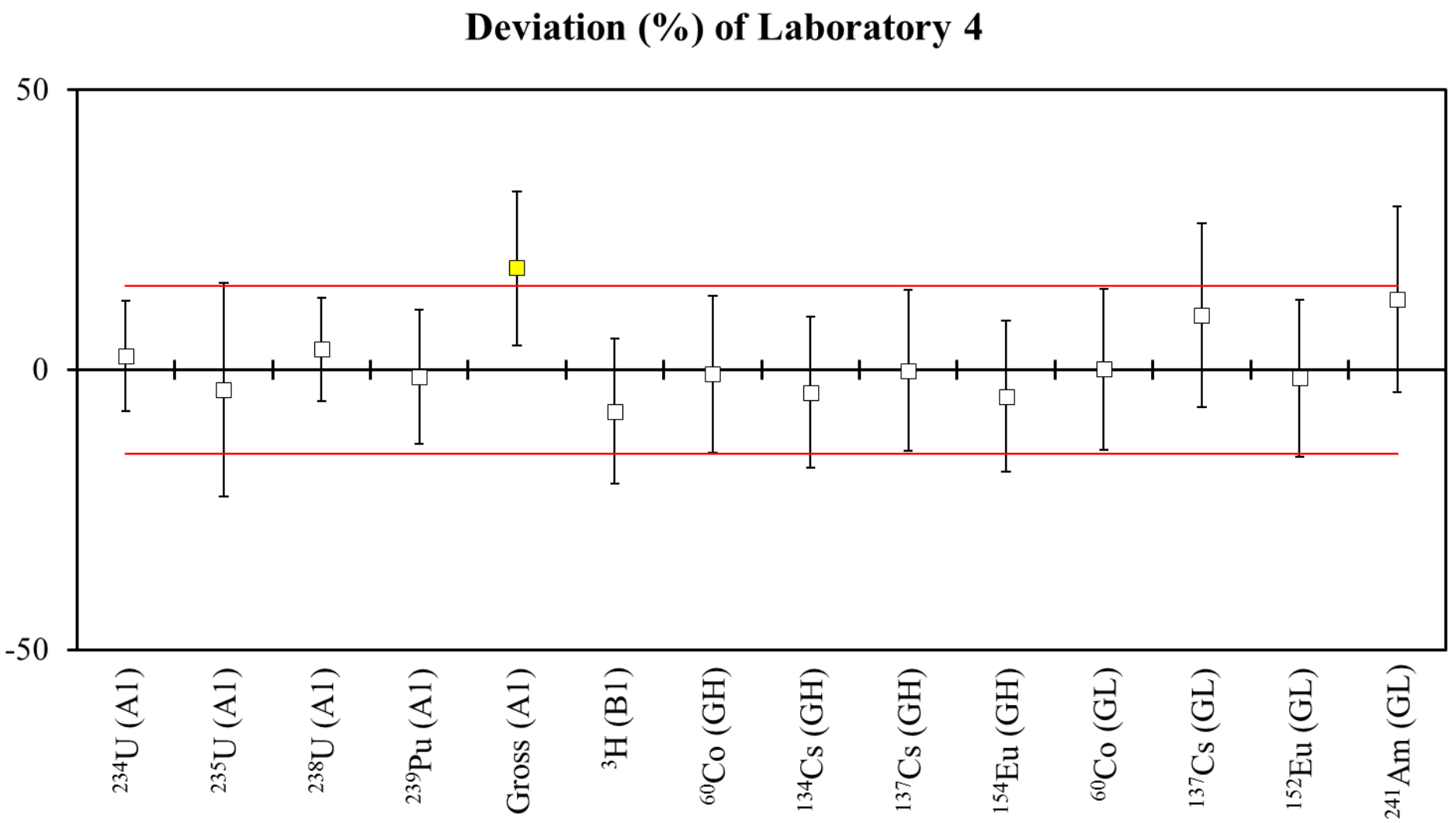
10. Deviation Plots and Tabulated Results Arranged by Lab Number

NOTE: 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 such that the significant figures of the standard uncertainty lie between 3 and 25. The standard rules of rounding have been applied, except in cases where rounding down would have reduced the uncertainty by more than 5 %, in which cases the uncertainty was rounded up.

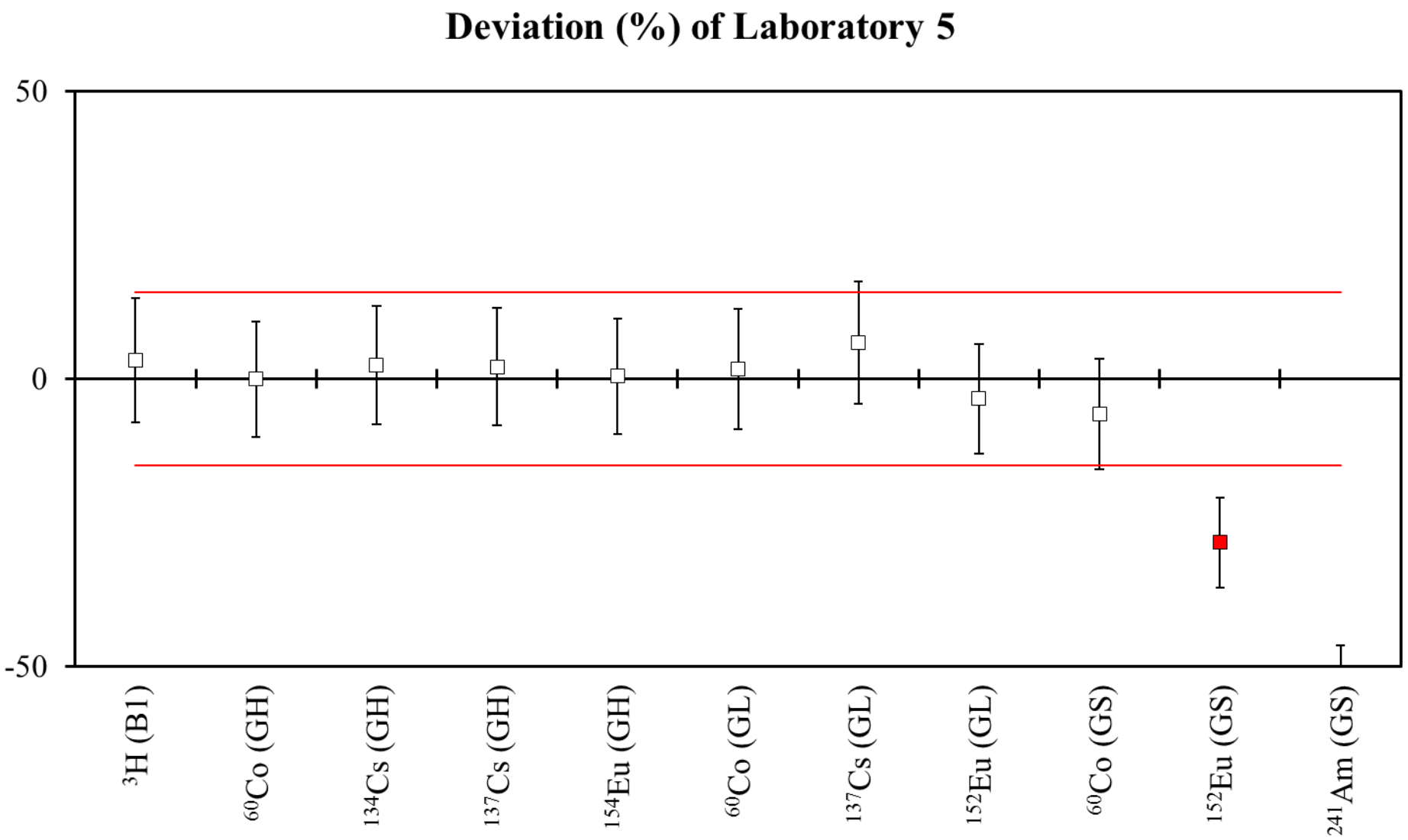

Deviation (%) of Laboratory 1
50
0
-50
^{3}H (AB)
^{90}Sr (AB)
^{238}Pu (AB)
^{60}Co (GH)
^{134}Cs (GH)
^{137}Cs (GH)
^{154}Eu (GH)
^{241}Am (GL)

Radionuclide	Laboratory 1	NPL Assigned Value	Deviation /%	Zeta	Z Score
^{3}H (AB)	7.50 ± 0.40	6.037 ± 0.043	24.2	3.64	4.16
^{90}Sr (AB)	2.42 ± 0.07	2.418 ± 0.011	0.1	0.03	0.01
^{238}Pu (AB)	10.00 ± 0.50	8.666 ± 0.020	15.4	2.67	2.64
Gross Alpha (AB)*	15.9 ± 1.3	-	-	-	-
Gross Beta (AB)*	10.1 ± 1.3	-	-	-	-
^{60}Co (GH)	5.22 ± 0.15	5.394 ± 0.012	-3.2	-1.16	-0.55
^{134}Cs (GH)	4.68 ± 0.11	4.973 ± 0.034	-5.9	-2.54	-1.01
^{137}Cs (GH)	4.000 ± 0.080	4.125 ± 0.031	-3.0	-1.46	-0.52
^{154}Eu (GH)	4.47 ± 0.09	4.600 ± 0.037	-2.8	-1.34	-0.49
^{241}Am (GL)	1.93 ± 0.15	1.8124 ± 0.0039	6.5	0.78	1.11

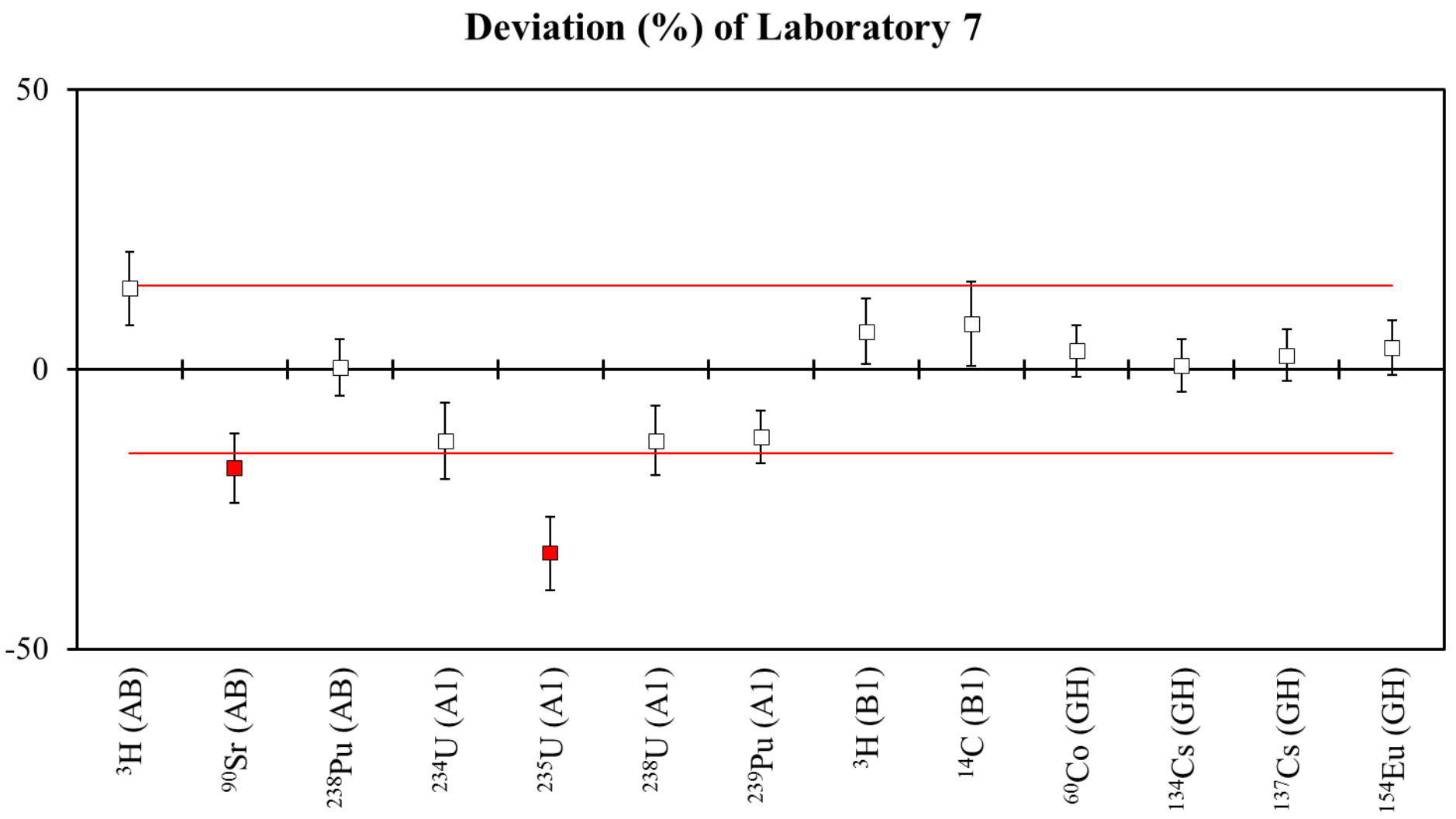
* Does not appear on deviation plot


Deviation (%) of Laboratory 4
50
0
-50
234U (A1)
235U (A1)
238U (A1)
239Pu (A1)
Gross (A1)
3H (B1)
60Co (GH)
134Cs (GH)
137Cs (GH)
154Eu (GH)
60Co (GL)
137Cs (GL)
152Eu (GL)
241Am (GL)

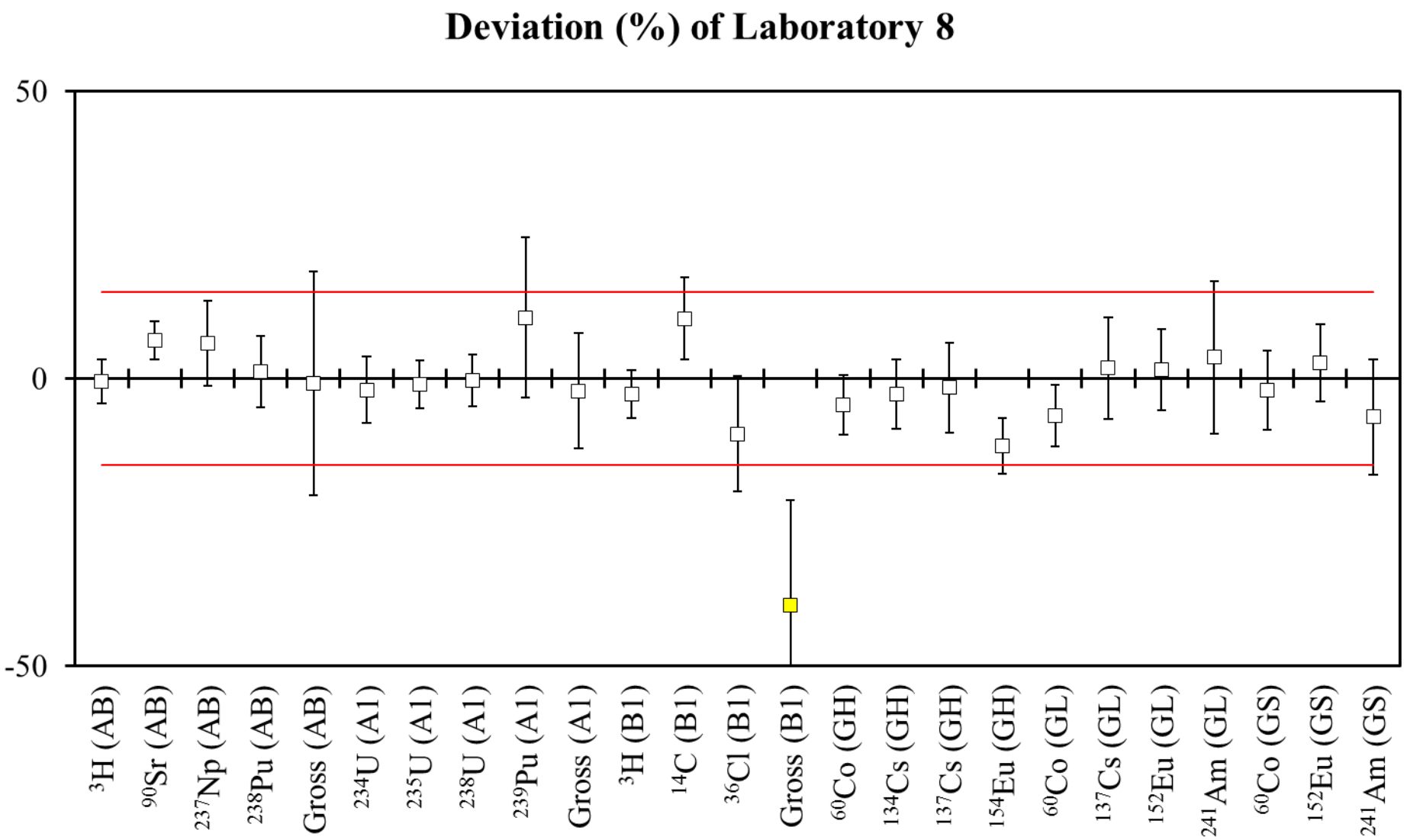
Radionuclide	Laboratory 4	NPL Assigned Value	Deviation /%	Zeta	Z Score
^{234}U (A1)	16.9 ± 1.6	16.50 ± 0.28	2.4	0.25	0.42
^{235}U (A1)	0.76 ± 0.15	0.788 ± 0.013	-3.6	-0.19	-0.61
^{238}U (A1)	17.1 ± 1.5	16.50 ± 0.28	3.6	0.39	0.62
^{239}Pu (A1)	20.6 ± 2.5	20.879 ± 0.039	-1.3	-0.11	-0.23
Gross Alpha (A1)	55.3 ± 4.1	46.8 ± 4.2	18.2	1.45	3.12
^{3}H (B1)	0.685 ± 0.096	0.7400 ± 0.0052	-7.4	-0.57	-1.28
^{60}Co (GH)	5.35 ± 0.76	5.394 ± 0.012	-0.8	-0.06	-0.14
^{134}Cs (GH)	4.77 ± 0.67	4.973 ± 0.034	-4.1	-0.30	-0.70
^{137}Cs (GH)	4.12 ± 0.59	4.125 ± 0.031	-0.1	-0.01	-0.02
^{154}Eu (GH)	4.38 ± 0.62	4.600 ± 0.037	-4.8	-0.35	-0.82
^{60}Co (GL)	12.5 ± 1.8	12.490 ± 0.062	0.1	0.01	0.01
^{137}Cs (GL)	2.48 ± 0.37	2.259 ± 0.020	9.8	0.60	1.68
^{152}Eu (GL)	19.7 ± 2.8	20.00 ± 0.15	-1.5	-0.11	-0.26
^{241}Am (GL)	2.040 ± 0.3	1.8124 ± 0.0039	12.6	0.76	2.16


Deviation (%) of Laboratory 5
50
0
-50
^{3}H (B1)
^{60}Co (GH)
^{134}Cs (GH)
^{137}Cs (GH)
^{154}Eu (GH)
^{60}Co (GL)
^{137}Cs (GL)
^{152}Eu (GL)
^{60}Co (GS)
^{152}Eu (GS)
^{241}Am (GS)

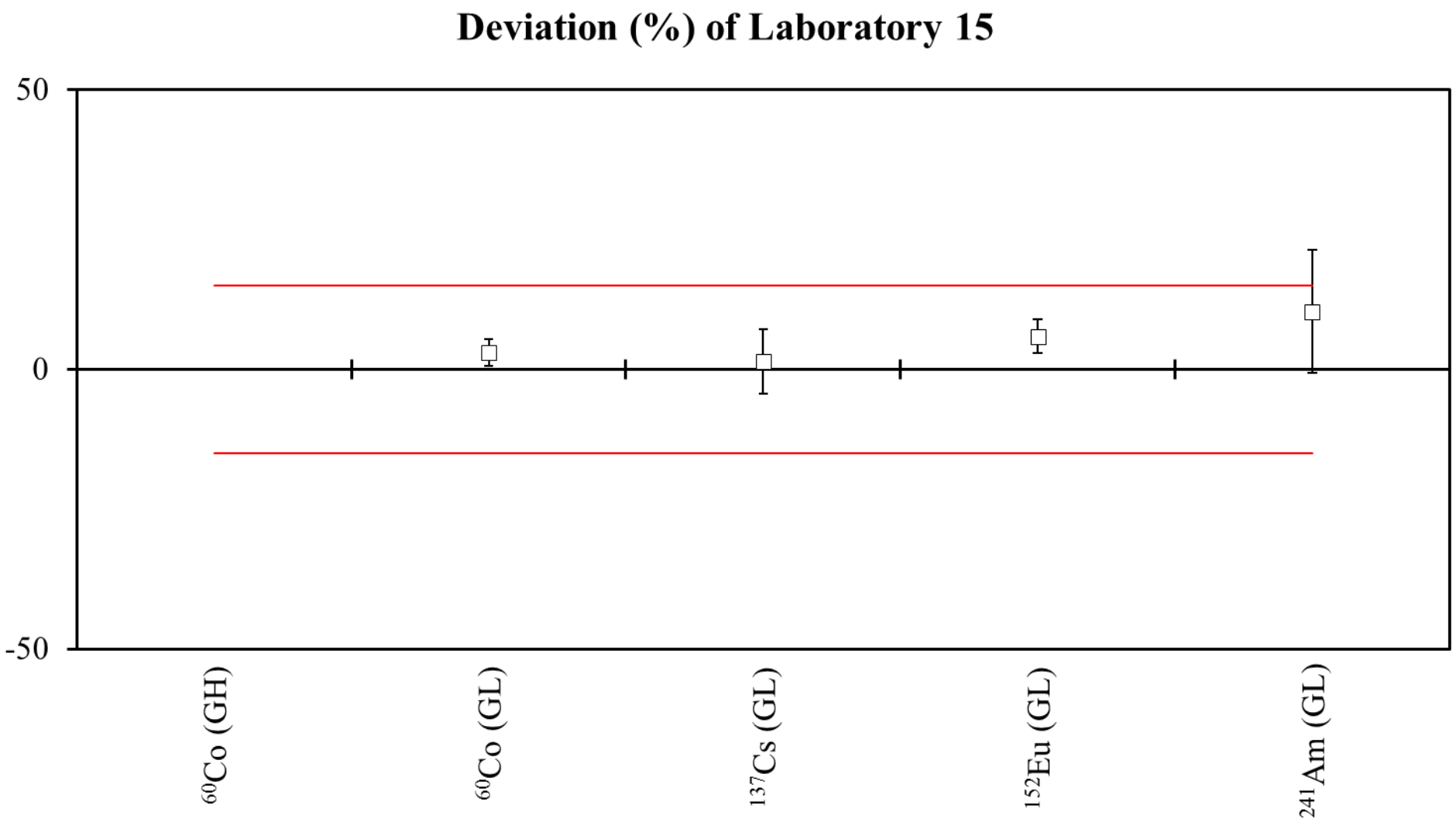
Radionuclide	Laboratory 5	NPL Assigned Value	Deviation /%	Zeta	Z Score
^{3}H (B1)	0.764 ± 0.080	0.7400 ± 0.0052	3.2	0.30	0.56
^{60}Co (GH)	5.39 ± 0.54	5.394 ± 0.012	-0.1	-0.01	-0.01
^{134}Cs (GH)	5.09 ± 0.51	4.973 ± 0.034	2.4	0.23	0.40
^{137}Cs (GH)	4.21 ± 0.42	4.125 ± 0.031	2.1	0.20	0.35
^{154}Eu (GH)	4.62 ± 0.46	4.600 ± 0.037	0.4	0.04	0.07
^{60}Co (GL)	12.7 ± 1.3	12.490 ± 0.062	1.7	0.16	0.29
^{137}Cs (GL)	2.40 ± 0.24	2.259 ± 0.020	6.2	0.59	1.07
^{152}Eu (GL)	19.3 ± 1.9	20.00 ± 0.15	-3.5	-0.37	-0.60
^{60}Co (GS)	1.38 ± 0.14	1.470 ± 0.017	-6.1	-0.64	-1.05
^{152}Eu (GS)	0.55 ± 0.06	0.769 ± 0.012	-28.5	-3.58	-4.89
^{241}Am (GS)	1.04 ± 0.23	2.40 ± 0.20	-56.7	-4.46	-9.73


Deviation (%) of Laboratory 7
50
0
-50
^{3}H (AB)
^{90}Sr (AB)
^{238}Pu (AB)
^{234}U (A1)
^{235}U (A1)
^{238}U (A1)
^{239}Pu (A1)
^{3}H (B1)
^{14}C (B1)
^{60}Co (GH)
^{134}Cs (GH)
^{137}Cs (GH)
^{154}Eu (GH)

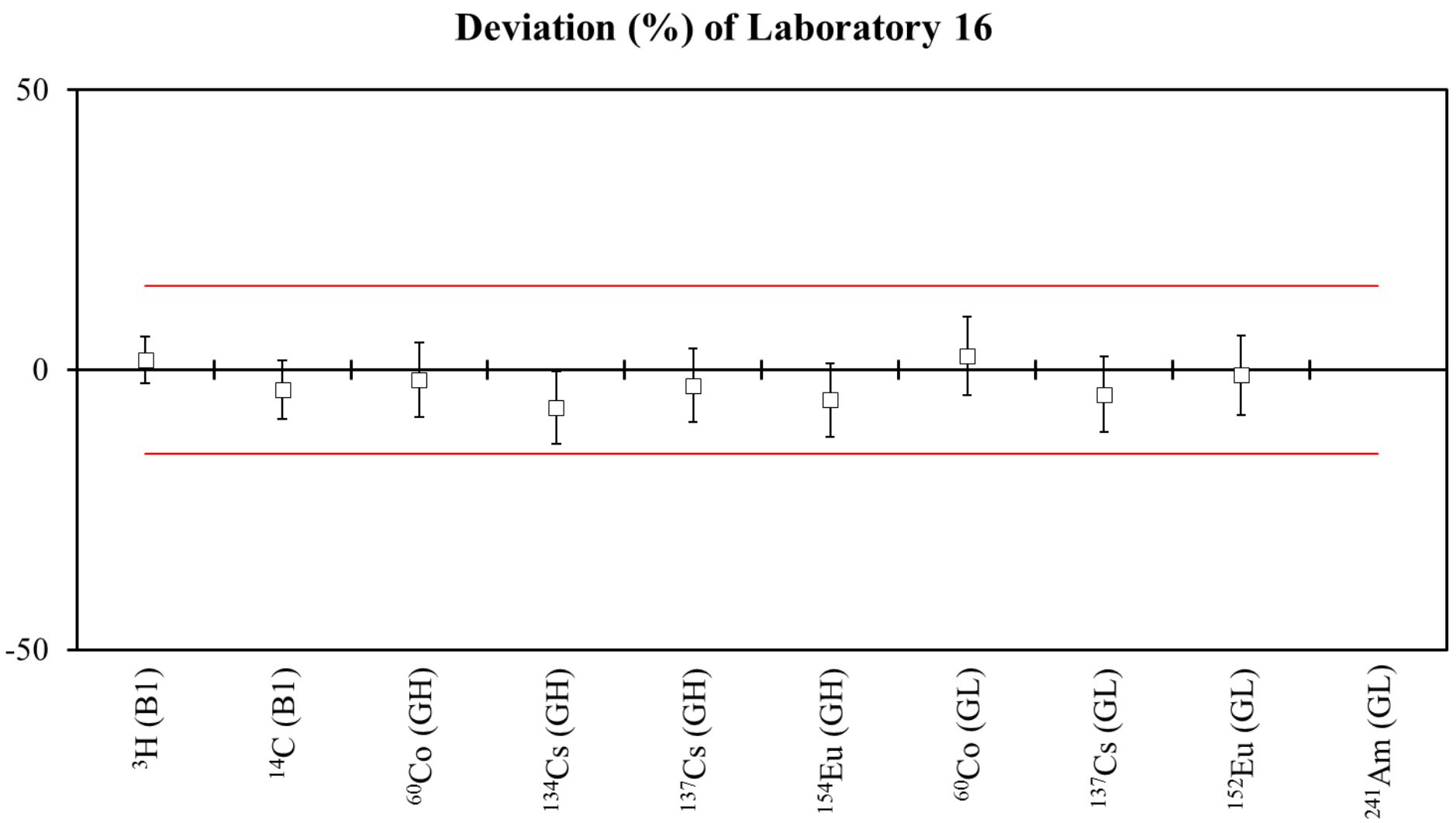
Radionuclide	Laboratory 7	NPL Assigned Value	Deviation /%	Zeta	Z Score
^{3}H (AB)	6.91 ± 0.39	6.037 ± 0.043	14.5	2.22	2.48
^{90}Sr (AB)	1.99 ± 0.15	2.418 ± 0.011	-17.7	-2.85	-3.04
^{238}Pu (AB)	8.70 ± 0.44	8.666 ± 0.020	0.4	0.08	0.07
^{234}U (A1)	14.4 ± 1.1	16.50 ± 0.28	-12.7	-1.85	-2.19
^{235}U (A1)	0.529 ± 0.051	0.788 ± 0.013	-32.9	-4.92	-5.64
^{238}U (A1)	14.4 ± 1.0	16.50 ± 0.28	-12.7	-2.02	-2.19
^{239}Pu (A1)	18.36 ± 0.98	20.879 ± 0.039	-12.1	-2.57	-2.07
^{3}H (B1)	0.790 ± 0.043	0.7400 ± 0.0052	6.8	1.15	1.16
^{14}C (B1)	0.460 ± 0.032	0.4254 ± 0.0028	8.1	1.08	1.40
^{60}Co (GH)	5.57 ± 0.25	5.394 ± 0.012	3.3	0.70	0.56
^{134}Cs (GH)	5.01 ± 0.23	4.973 ± 0.034	0.7	0.16	0.13
^{137}Cs (GH)	4.23 ± 0.19	4.125 ± 0.031	2.5	0.55	0.44
^{154}Eu (GH)	4.78 ± 0.22	4.600 ± 0.037	3.9	0.81	0.67


Deviation (%) of Laboratory 8
50
0
-50
3H (AB)
90Sr (AB)
237Np (AB)
238Pu (AB)
Gross (AB)
234U (A1)
235U (A1)
238U (A1)
239Pu (A1)
Gross (A1)
3H (B1)
14C (B1)
36Cl (B1)
Gross (B1)
60Co (GH)
134Cs (GH)
137Cs (GH)
154Eu (GH)
60Co (GL)
137Cs (GL)
152Eu (GL)
241Am (GL)
60Co (GS)
152Eu (GS)
241Am (GS)

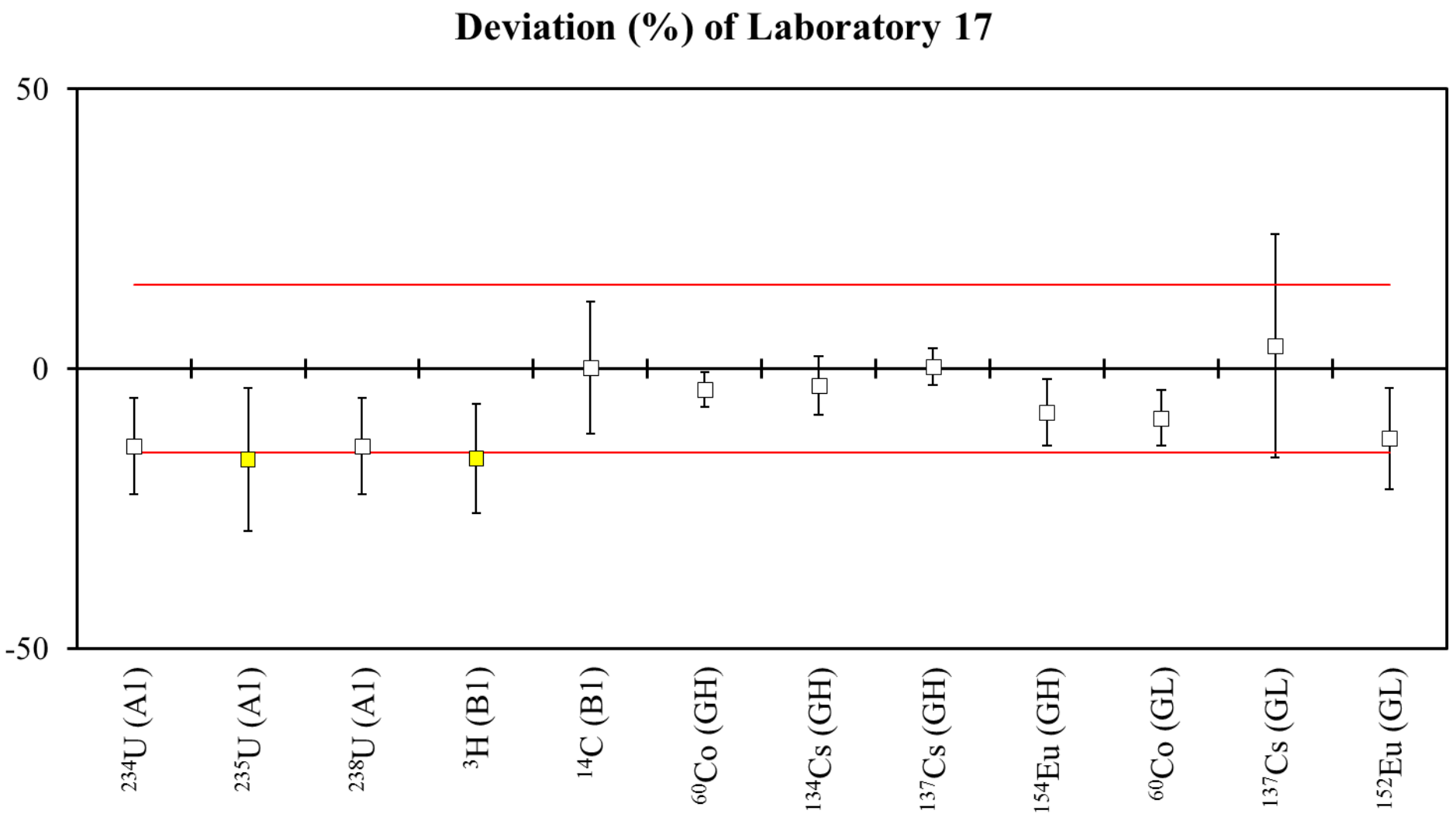
Radionuclide	Laboratory 8	NPL Assigned Value	Deviation /%	Zeta	Z Score
^{3}H (AB)	6.01 ± 0.23	6.037 ± 0.043	-0.4	-0.12	-0.08
^{90}Sr (AB)	2.580 ± 0.080	2.418 ± 0.011	6.7	2.01	1.15
^{237}Np (AB)	7.89 ± 0.54	7.432 ± 0.074	6.2	0.84	1.06
^{238}Pu (AB)	8.77 ± 0.54	8.666 ± 0.020	1.2	0.19	0.21
Gross Alpha-Beta (AB)	26.90 ± 0.40	27.1 ± 5.3	-0.7	-0.04	-0.13
^{234}U (A1)	16.18 ± 0.91	16.50 ± 0.28	-1.9	-0.34	-0.33
^{235}U (A1)	0.78 ± 0.03	0.788 ± 0.013	-1.0	-0.24	-0.17
^{238}U (A1)	16.450 ± 0.7	16.50 ± 0.28	-0.3	-0.07	-0.05
^{239}Pu (A1)	23.1 ± 2.9	20.879 ± 0.039	10.6	0.77	1.83
Gross Alpha (A1)	45.8 ± 2.3	46.8 ± 4.2	-2.1	-0.21	-0.37
^{3}H (B1)	0.72 ± 0.03	0.7400 ± 0.0052	-2.7	-0.66	-0.46
^{14}C (B1)	0.47 ± 0.03	0.4254 ± 0.0028	10.5	1.48	1.80
^{36}Cl (B1)	0.450 ± 0.050	0.4978 ± 0.0020	-9.6	-0.96	-1.65
Gross Beta (B1)	0.570 ± 0.020	0.94 ± 0.28	-39.4	-1.32	-6.76
^{60}Co (GH)	5.15 ± 0.28	5.394 ± 0.012	-4.5	-0.87	-0.78
^{134}Cs (GH)	4.840 ± 0.3	4.973 ± 0.034	-2.7	-0.44	-0.46
^{137}Cs (GH)	4.06 ± 0.32	4.125 ± 0.031	-1.6	-0.20	-0.27
^{154}Eu (GH)	4.06 ± 0.22	4.600 ± 0.037	-11.7	-2.42	-2.02
^{60}Co (GL)	11.69 ± 0.67	12.490 ± 0.062	-6.4	-1.19	-1.10
^{137}Cs (GL)	2.30 ± 0.20	2.259 ± 0.020	1.8	0.20	0.31
^{152}Eu (GL)	20.3 ± 1.4	20.00 ± 0.15	1.5	0.21	0.26
^{241}Am (GL)	1.88 ± 0.24	1.8124 ± 0.0039	3.7	0.28	0.64
^{60}Co (GS)	1.44 ± 0.10	1.470 ± 0.017	-2.0	-0.30	-0.35
^{152}Eu (GS)	0.790 ± 0.050	0.769 ± 0.012	2.7	0.41	0.47
^{241}Am (GS)	2.24 ± 0.15	2.40 ± 0.20	-6.7	-0.64	-1.14


Deviation (%) of Laboratory 15
50
0
-50
^{60}Co (GH)
^{60}Co (GL)
^{137}Cs (GL)
^{152}Eu (GL)
^{241}Am (GL)

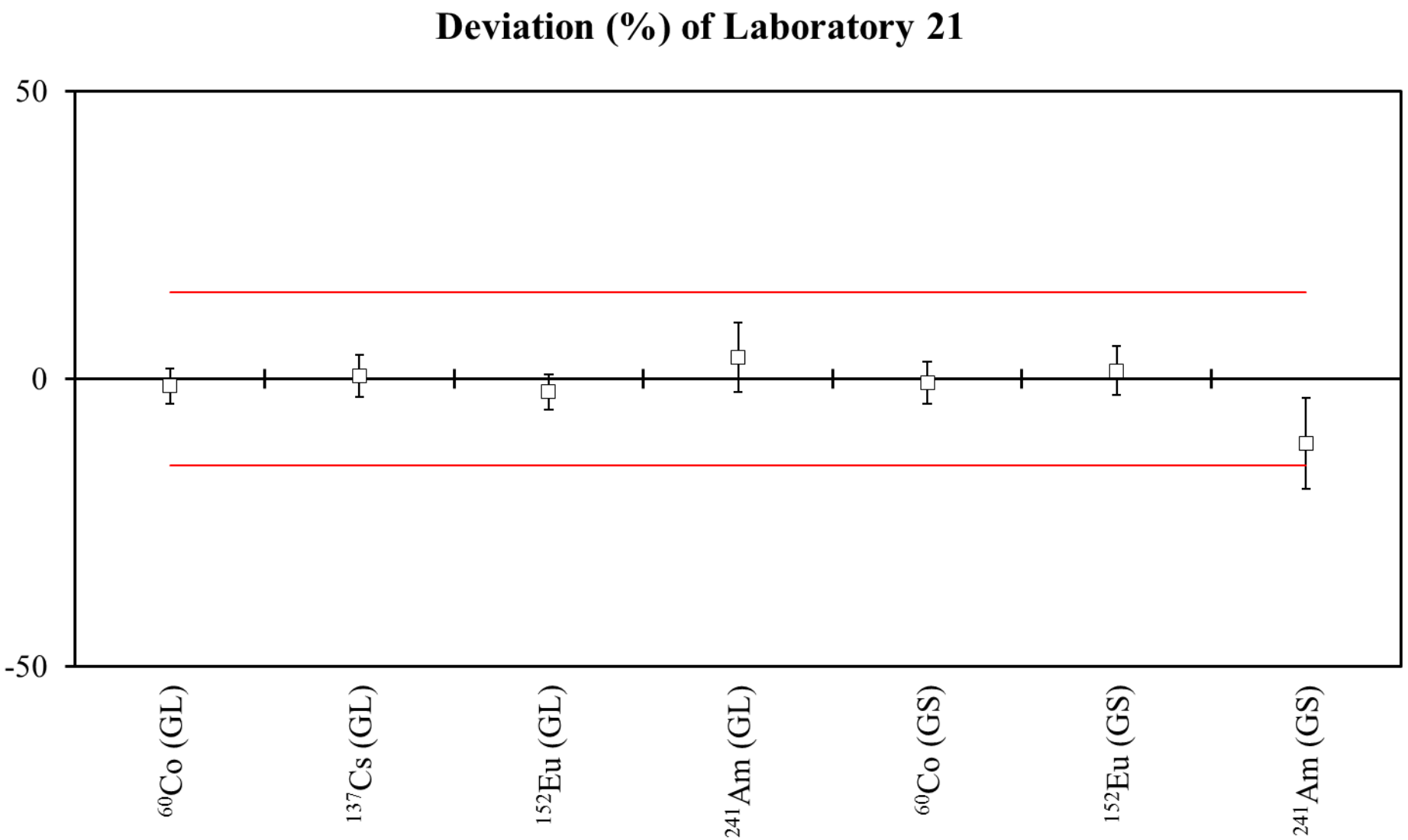
Radionuclide	Laboratory 15	NPL Assigned Value	Deviation /%	Zeta	Z Score
^{60}Co (GH)	9 (uncertainty of zero reported)	5.394 ± 0.012	66.9	300.50	11.48
^{60}Co (GL)	12.86 ± 0.29	12.490 ± 0.062	3.0	1.25	0.51
^{137}Cs (GL)	2.29 ± 0.13	2.259 ± 0.020	1.4	0.24	0.24
^{152}Eu (GL)	21.18 ± 0.59	20.00 ± 0.15	5.9	1.94	1.01
^{241}Am (GL)	2.00 ± 0.20	1.8124 ± 0.0039	10.4	0.94	1.78


Deviation (%) of Laboratory 16
50
0
-50
^{3}H (B1)
^{14}C (B1)
^{60}Co (GH)
^{134}Cs (GH)
^{137}Cs (GH)
^{154}Eu (GH)
^{60}Co (GL)
^{137}Cs (GL)
^{152}Eu (GL)
^{241}Am (GL)

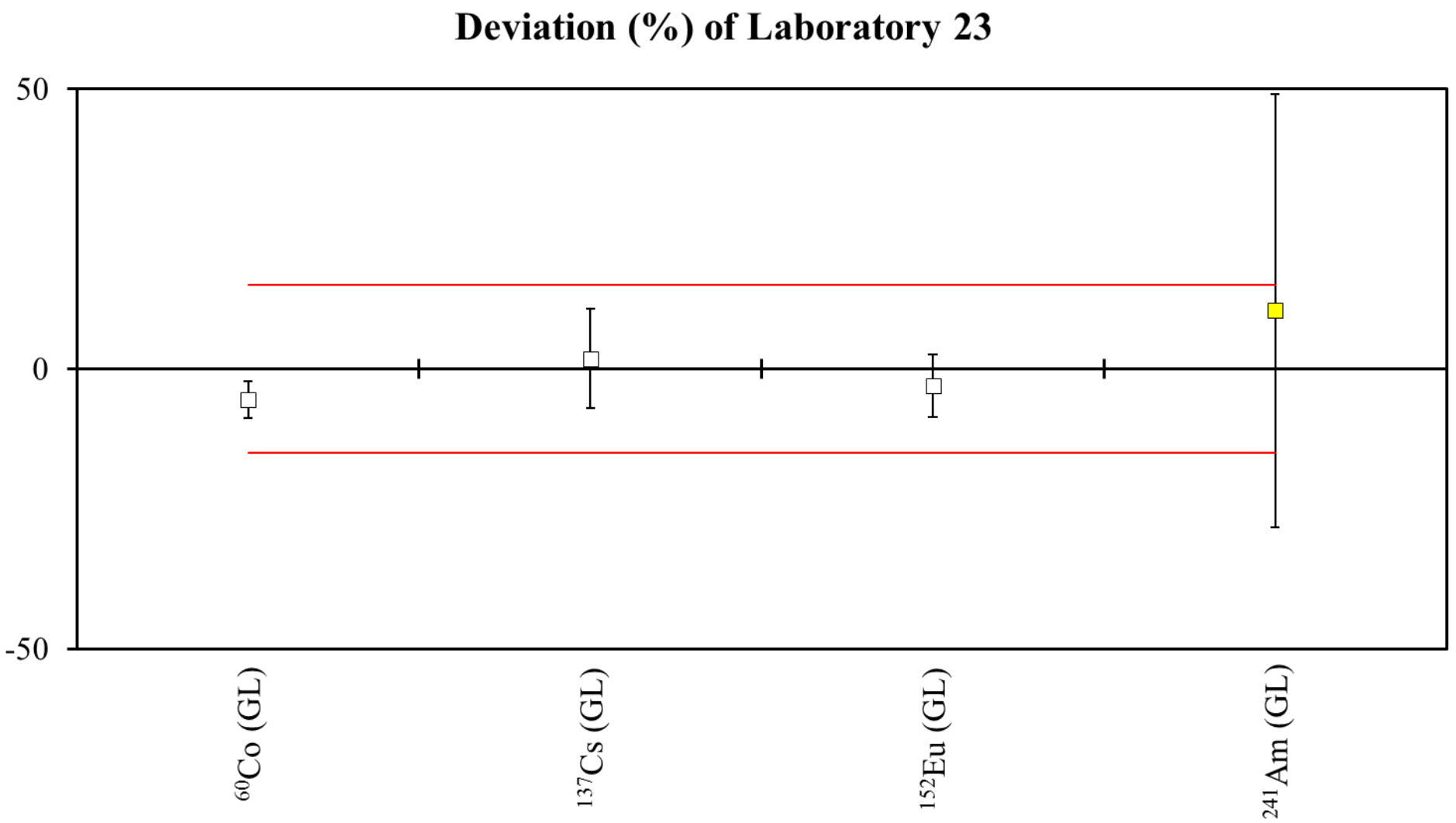
Radionuclide	Laboratory 16	NPL Assigned Value	Deviation /%	Zeta	Z Score
^{3}H (B1)	0.7530 ± 0.03	0.7400 ± 0.0052	1.8	0.43	0.30
^{14}C (B1)	0.410 ± 0.022	0.4254 ± 0.0028	-3.6	-0.69	-0.62
^{60}Co (GH)	5.30 ± 0.36	5.394 ± 0.012	-1.7	-0.26	-0.30
^{134}Cs (GH)	4.64 ± 0.32	4.973 ± 0.034	-6.7	-1.03	-1.15
^{137}Cs (GH)	4.01 ± 0.27	4.125 ± 0.031	-2.8	-0.42	-0.48
^{154}Eu (GH)	4.350 ± 0.3	4.600 ± 0.037	-5.4	-0.83	-0.93
^{60}Co (GL)	12.80 ± 0.88	12.490 ± 0.062	2.5	0.35	0.43
^{137}Cs (GL)	2.16 ± 0.15	2.259 ± 0.020	-4.4	-0.65	-0.75
^{152}Eu (GL)	19.8 ± 1.4	20.00 ± 0.15	-1.0	-0.14	-0.17
^{241}Am (GL)	3.02 ± 0.21	1.8124 ± 0.0039	66.6	5.75	11.44


Deviation (%) of Laboratory 17
50
0
-50
234U (A1)
235U (A1)
238U (A1)
3H (B1)
14C (B1)
60Co (GH)
134Cs (GH)
137Cs (GH)
154Eu (GH)
60Co (GL)
137Cs (GL)
152Eu (GL)

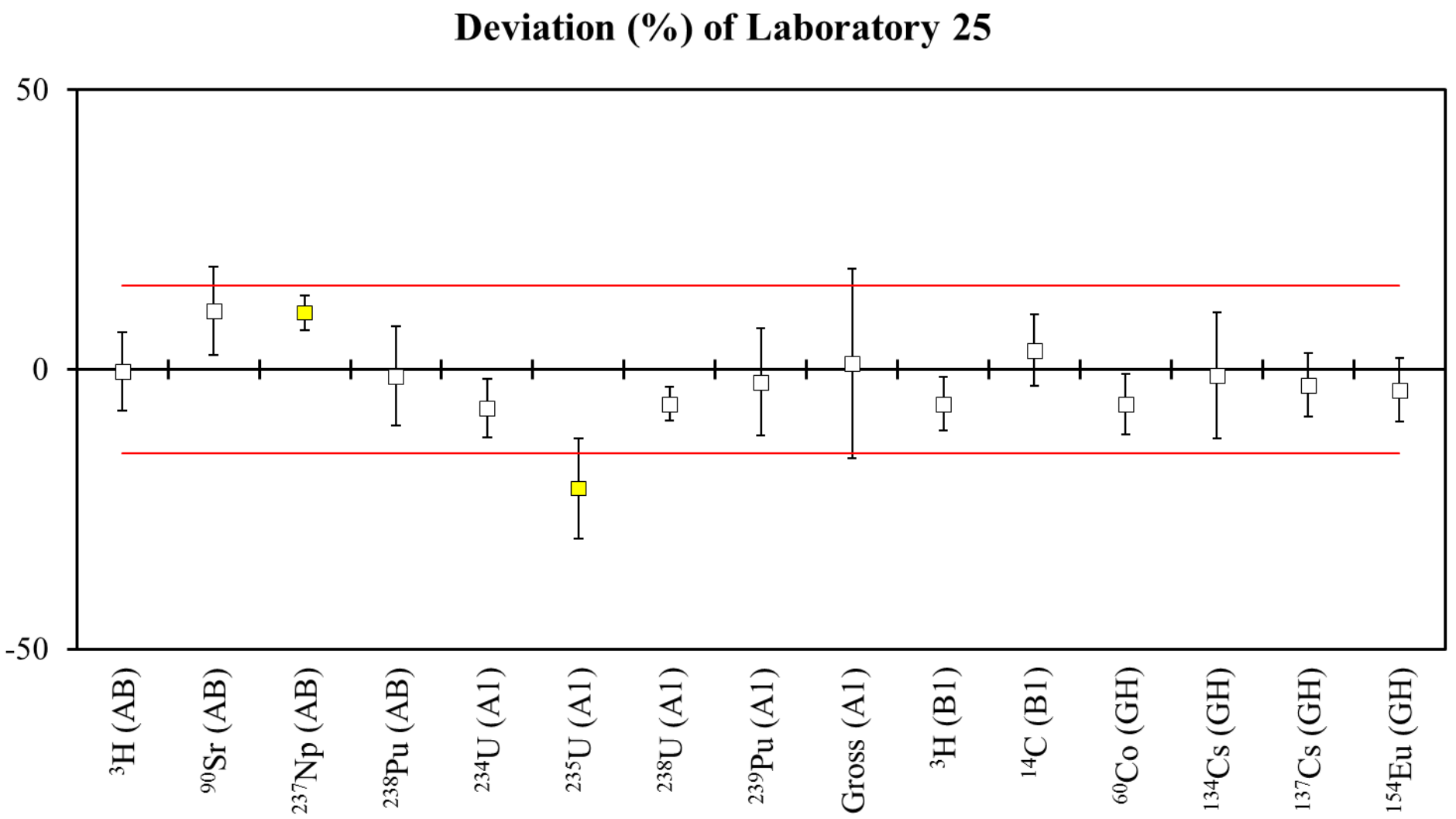
Radionuclide	Laboratory 17	NPL Assigned Value	Deviation /%	Zeta	Z Score
^{234}U (A1)	14.2 ± 1.4	16.50 ± 0.28	-13.9	-1.61	-2.39
^{235}U (A1)	0.66 ± 0.10	0.788 ± 0.013	-16.2	-1.27	-2.79
^{238}U (A1)	14.2 ± 1.4	16.50 ± 0.28	-13.9	-1.61	-2.39
^{3}H (B1)	0.621 ± 0.072	0.7400 ± 0.0052	-16.1	-1.65	-2.76
^{14}C (B1)	0.426 ± 0.050	0.4254 ± 0.0028	0.1	0.01	0.02
^{60}Co (GH)	5.19 ± 0.17	5.394 ± 0.012	-3.8	-1.20	-0.65
^{134}Cs (GH)	4.82 ± 0.26	4.973 ± 0.034	-3.1	-0.58	-0.53
^{137}Cs (GH)	4.14 ± 0.13	4.125 ± 0.031	0.4	0.11	0.06
^{154}Eu (GH)	4.24 ± 0.27	4.600 ± 0.037	-7.8	-1.32	-1.34
^{60}Co (GL)	11.38 ± 0.62	12.490 ± 0.062	-8.9	-1.78	-1.53
^{137}Cs (GL)	2.35 ± 0.45	2.259 ± 0.020	4.0	0.20	0.69
^{152}Eu (GL)	17.5 ± 1.8	20.00 ± 0.15	-12.5	-1.38	-2.15


Deviation (%) of Laboratory 21
50
0
-50
60Co (GL)
137Cs (GL)
152Eu (GL)
241Am (GL)
60Co (GS)
152Eu (GS)
241Am (GS)

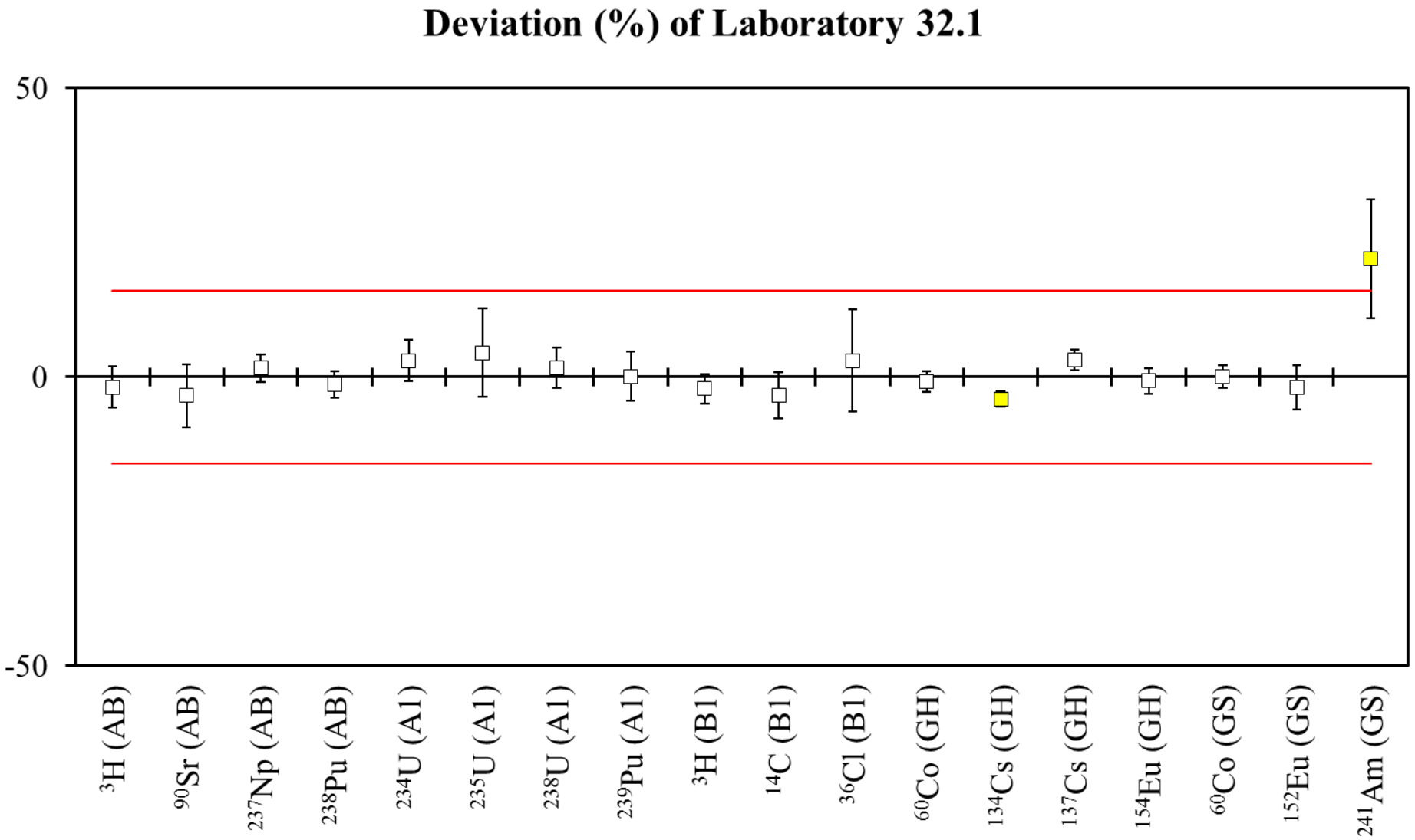
Radionuclide	Laboratory 21	NPL Assigned Value	Deviation /%	Zeta	Z Score
^{60}Co (GL)	12.33 ± 0.37	12.490 ± 0.062	-1.3	-0.43	-0.22
^{137}Cs (GL)	2.270 ± 0.080	2.259 ± 0.020	0.5	0.13	0.08
^{152}Eu (GL)	19.54 ± 0.59	20.00 ± 0.15	-2.3	-0.76	-0.39
^{241}Am (GL)	1.88 ± 0.11	1.8124 ± 0.0039	3.7	0.61	0.64
^{60}Co (GS)	1.460 ± 0.050	1.470 ± 0.017	-0.7	-0.19	-0.12
^{152}Eu (GS)	0.78 ± 0.03	0.769 ± 0.012	1.4	0.34	0.25
^{241}Am (GS)	2.13 ± 0.07	2.40 ± 0.20	-11.3	-1.27	-1.93


Deviation (%) of Laboratory 23
50
0
-50
^{60}Co (GL)
^{137}Cs (GL)
^{152}Eu (GL)
^{241}Am (GL)

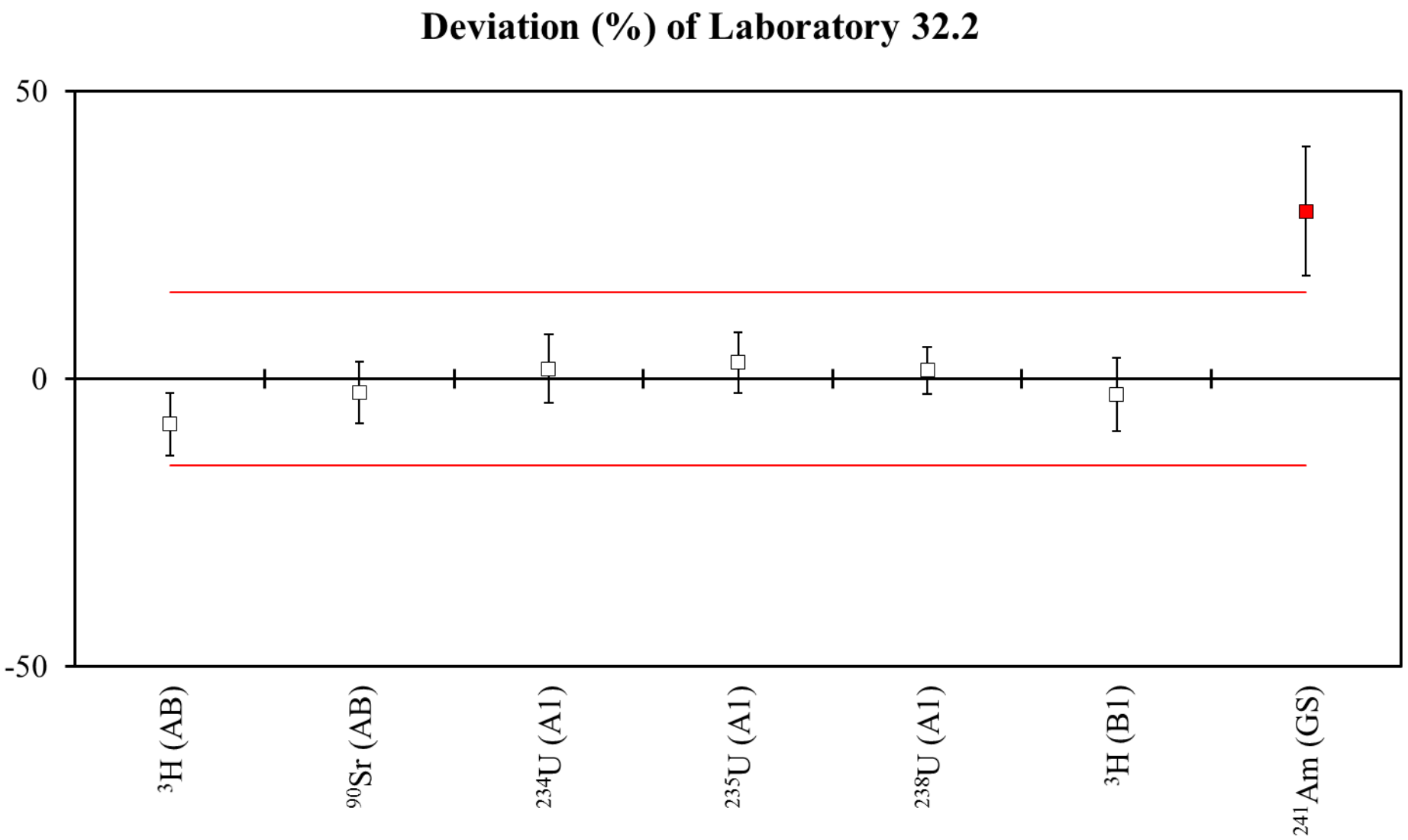
Radionuclide	Laboratory 23	NPL Assigned Value	Deviation /%	Zeta	Z Score
^{60}Co (GL)	11.80 ± 0.40	12.490 ± 0.062	-5.5	-1.70	-0.95
^{137}Cs (GL)	2.30 ± 0.20	2.259 ± 0.020	1.8	0.20	0.31
^{152}Eu (GL)	19.4 ± 1.1	20.00 ± 0.15	-3.0	-0.54	-0.52
^{241}Am (GL)	2.0 ± 0.7	1.8124 ± 0.0039	10.4	0.27	1.78


Deviation (%) of Laboratory 25
50
0
-50
^{3}H (AB)
^{90}Sr (AB)
^{237}Np (AB)
^{238}Pu (AB)
^{234}U (A1)
^{235}U (A1)
^{238}U (A1)
^{239}Pu (A1)
Gross (A1)
^{3}H (B1)
^{14}C (B1)
^{60}Co (GH)
^{134}Cs (GH)
^{137}Cs (GH)
^{154}Eu (GH)

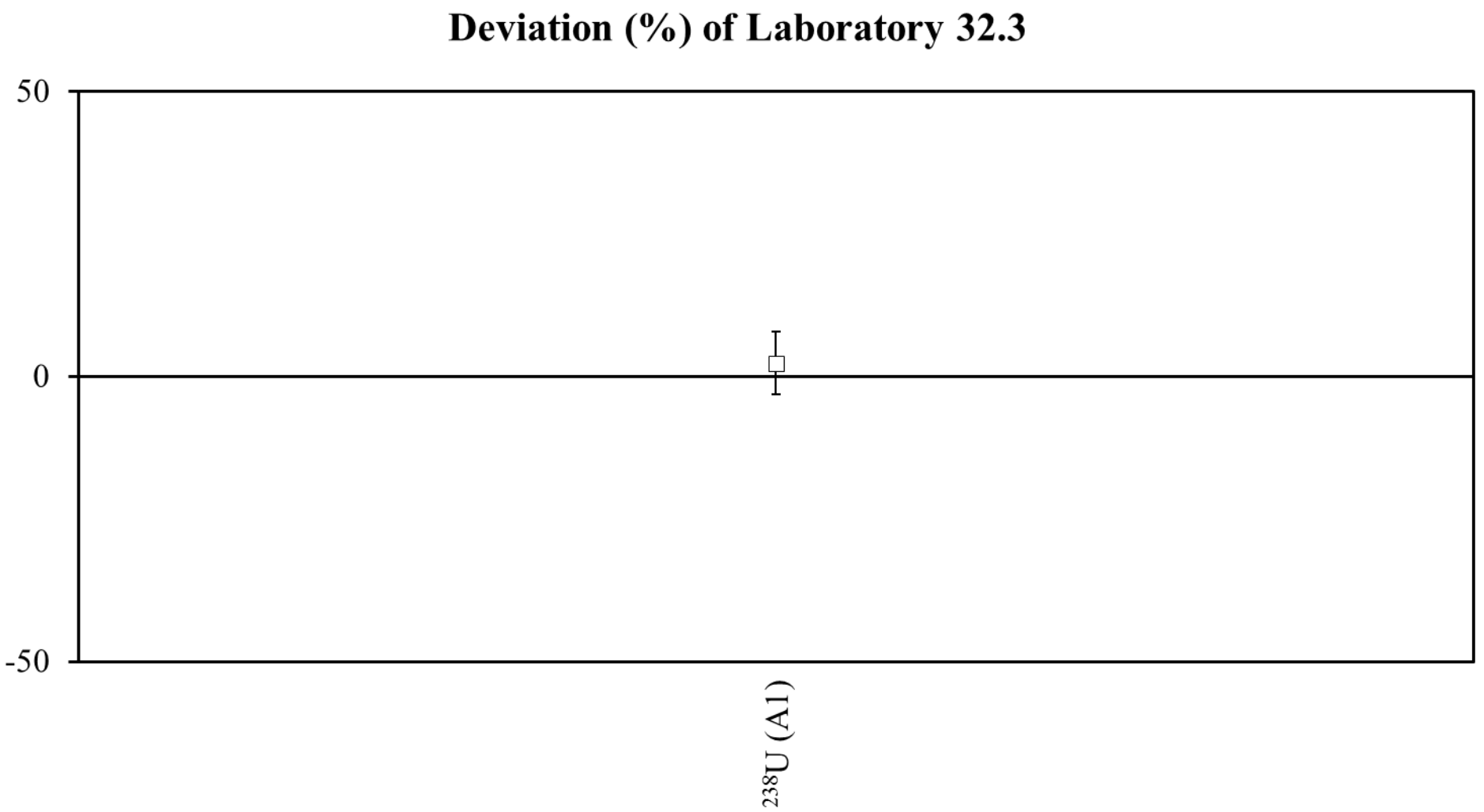
Radionuclide	Laboratory 25	NPL Assigned Value	Deviation /%	Zeta	Z Score
^{3}H (AB)	6.01 ± 0.42	6.037 ± 0.043	-0.4	-0.06	-0.08
^{90}Sr (AB)	2.67 ± 0.19	2.418 ± 0.011	10.4	1.32	1.79
^{237}Np (AB)	8.18 ± 0.22	7.432 ± 0.074	10.1	3.22	1.73
^{238}Pu (AB)	8.56 ± 0.77	8.666 ± 0.020	-1.2	-0.14	-0.21
^{234}U (A1)	15.35 ± 0.83	16.50 ± 0.28	-7.0	-1.31	-1.20
^{235}U (A1)	0.62 ± 0.07	0.788 ± 0.013	-21.3	-2.36	-3.66
^{238}U (A1)	15.48 ± 0.42	16.50 ± 0.28	-6.2	-2.02	-1.06
^{239}Pu (A1)	20.4 ± 2.0	20.879 ± 0.039	-2.3	-0.24	-0.39
Gross Alpha (A1)	47.3 ± 6.7	46.8 ± 4.2	1.1	0.06	0.18
^{3}H (B1)	0.694 ± 0.035	0.7400 ± 0.0052	-6.2	-1.30	-1.07
^{14}C (B1)	0.440 ± 0.027	0.4254 ± 0.0028	3.4	0.54	0.59
^{60}Co (GH)	5.06 ± 0.29	5.394 ± 0.012	-6.2	-1.15	-1.06
^{134}Cs (GH)	4.92 ± 0.56	4.973 ± 0.034	-1.1	-0.09	-0.18
^{137}Cs (GH)	4.01 ± 0.23	4.125 ± 0.031	-2.8	-0.50	-0.48
^{154}Eu (GH)	4.43 ± 0.26	4.600 ± 0.037	-3.7	-0.65	-0.63


Deviation (%) of Laboratory 32.1
50
0
-50
^{3}H (AB)
^{90}Sr (AB)
^{237}Np (AB)
^{238}Pu (AB)
^{234}U (A1)
^{235}U (A1)
^{238}U (A1)
^{239}Pu (A1)
^{3}H (B1)
^{14}C (B1)
^{36}Cl (B1)
^{60}Co (GH)
^{134}Cs (GH)
^{137}Cs (GH)
^{154}Eu (GH)
^{60}Co (GS)
^{152}Eu (GS)
^{241}Am (GS)

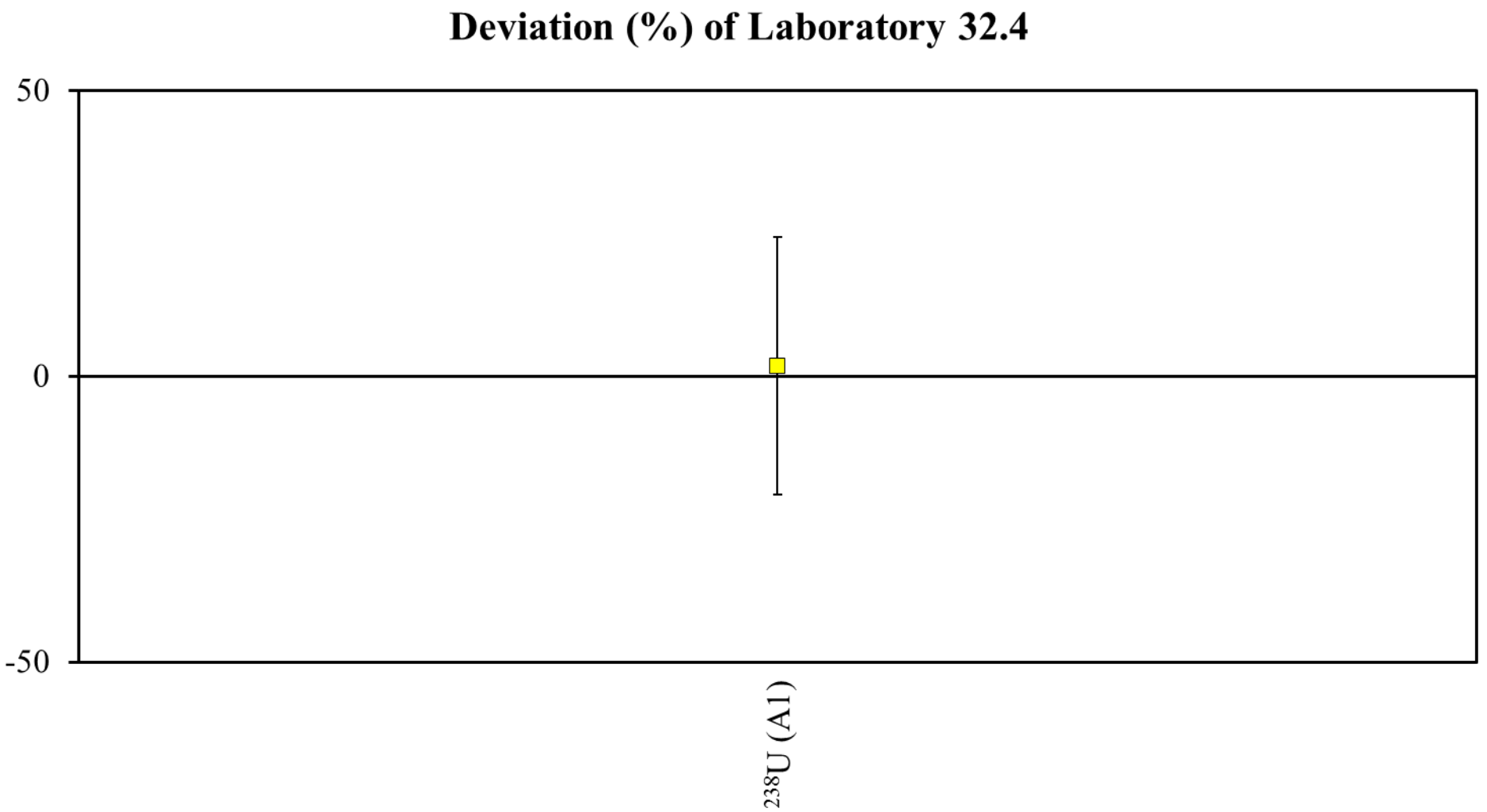
Radionuclide	Laboratory 32.1	NPL Assigned Value	Deviation /%	Zeta	Z Score
^{3}H (AB)	5.93 ± 0.21	6.037 ± 0.043	-1.8	-0.50	-0.30
^{90}Sr (AB)	2.34 ± 0.13	2.418 ± 0.011	-3.2	-0.60	-0.55
^{237}Np (AB)	7.55 ± 0.16	7.432 ± 0.074	1.6	0.67	0.27
^{238}Pu (AB)	8.55 ± 0.20	8.666 ± 0.020	-1.3	-0.58	-0.23
^{234}U (A1)	16.97 ± 0.51	16.50 ± 0.28	2.8	0.81	0.49
^{235}U (A1)	0.821 ± 0.059	0.788 ± 0.013	4.2	0.55	0.72
^{238}U (A1)	16.76 ± 0.50	16.50 ± 0.28	1.6	0.45	0.27
^{239}Pu (A1)	20.91 ± 0.90	20.879 ± 0.039	0.1	0.03	0.03
^{3}H (B1)	0.725 ± 0.018	0.7400 ± 0.0052	-2.0	-0.80	-0.35
^{14}C (B1)	0.412 ± 0.017	0.4254 ± 0.0028	-3.1	-0.78	-0.54
^{36}Cl (B1)	0.512 ± 0.044	0.4978 ± 0.0020	2.9	0.32	0.49
^{60}Co (GH)	5.354 ± 0.096	5.394 ± 0.012	-0.7	-0.41	-0.13
^{134}Cs (GH)	4.7830 ± 0.06	4.973 ± 0.034	-3.8	-2.76	-0.66
^{137}Cs (GH)	4.248 ± 0.068	4.125 ± 0.031	3.0	1.65	0.51
^{154}Eu (GH)	4.570 ± 0.095	4.600 ± 0.037	-0.7	-0.29	-0.11
^{60}Co (GS)	1.471 ± 0.022	1.470 ± 0.017	0.1	0.04	0.01
^{152}Eu (GS)	0.755 ± 0.027	0.769 ± 0.012	-1.8	-0.47	-0.31
^{241}Am (GS)	2.893 ± 0.052	2.40 ± 0.20	20.5	2.39	3.53


Deviation (%) of Laboratory 32.2
50
0
-50
^{3}H (AB)
^{90}Sr (AB)
^{234}U (A1)
^{235}U (A1)
^{238}U (A1)
^{3}H (B1)
^{241}Am (GS)

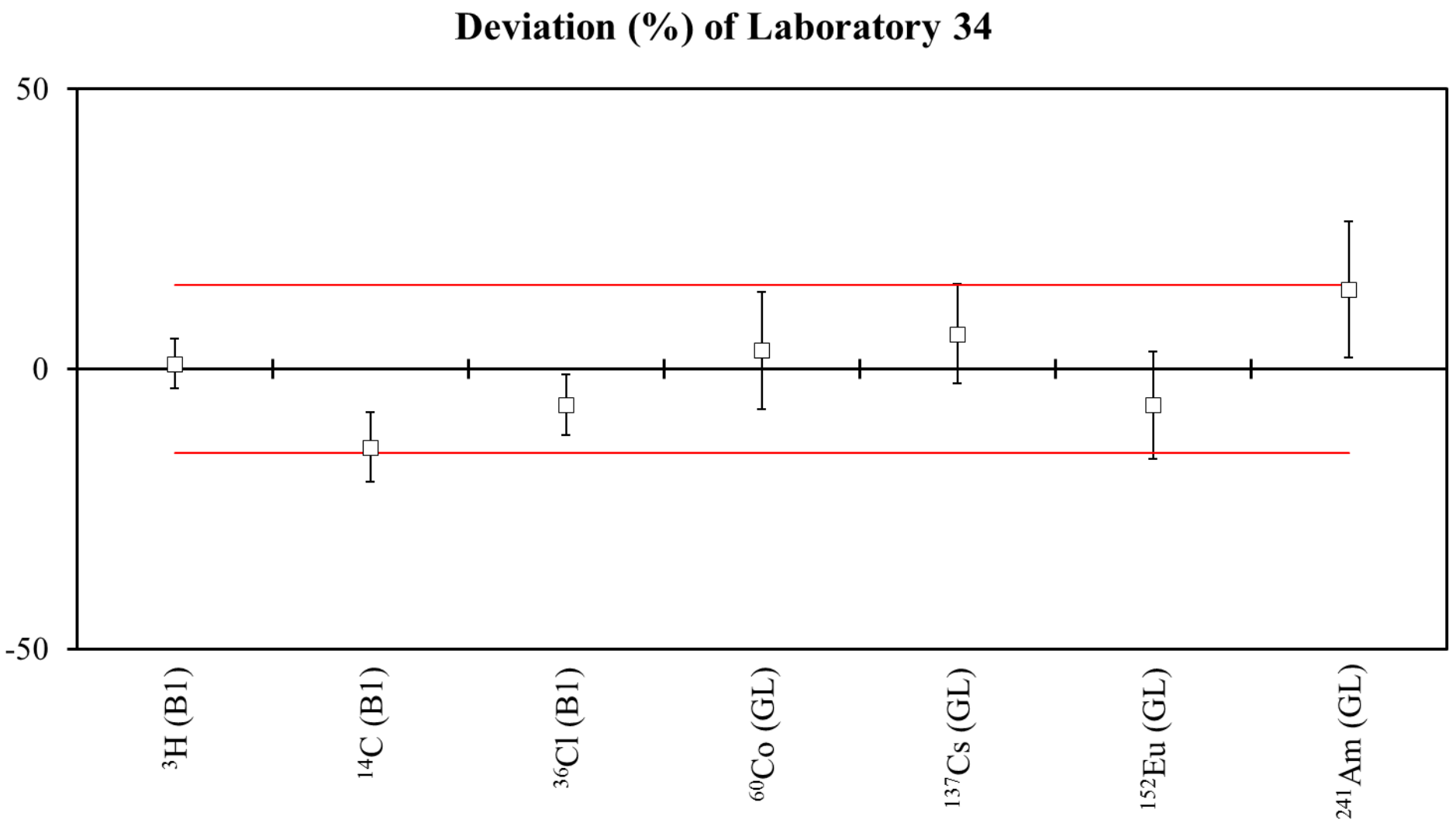
Radionuclide	Laboratory 32.2	NPL Assigned Value	Deviation /%	Zeta	Z Score
^{3}H (AB)	5.56 ± 0.33	6.037 ± 0.043	-7.9	-1.43	-1.36
^{90}Sr (AB)	2.36 ± 0.13	2.418 ± 0.011	-2.4	-0.44	-0.41
^{234}U (A1)	16.79 ± 0.94	16.50 ± 0.28	1.8	0.30	0.30
^{235}U (A1)	0.810 ± 0.040	0.788 ± 0.013	2.8	0.52	0.48
^{238}U (A1)	16.74 ± 0.62	16.50 ± 0.28	1.5	0.35	0.25
^{3}H (B1)	0.720 ± 0.047	0.7400 ± 0.0052	-2.7	-0.42	-0.46
^{241}Am (GS)	3.099 ± 0.076	2.40 ± 0.20	29.1	3.27	5.00


Deviation (%) of Laboratory 32.3
50
0
-50
238U (A1)

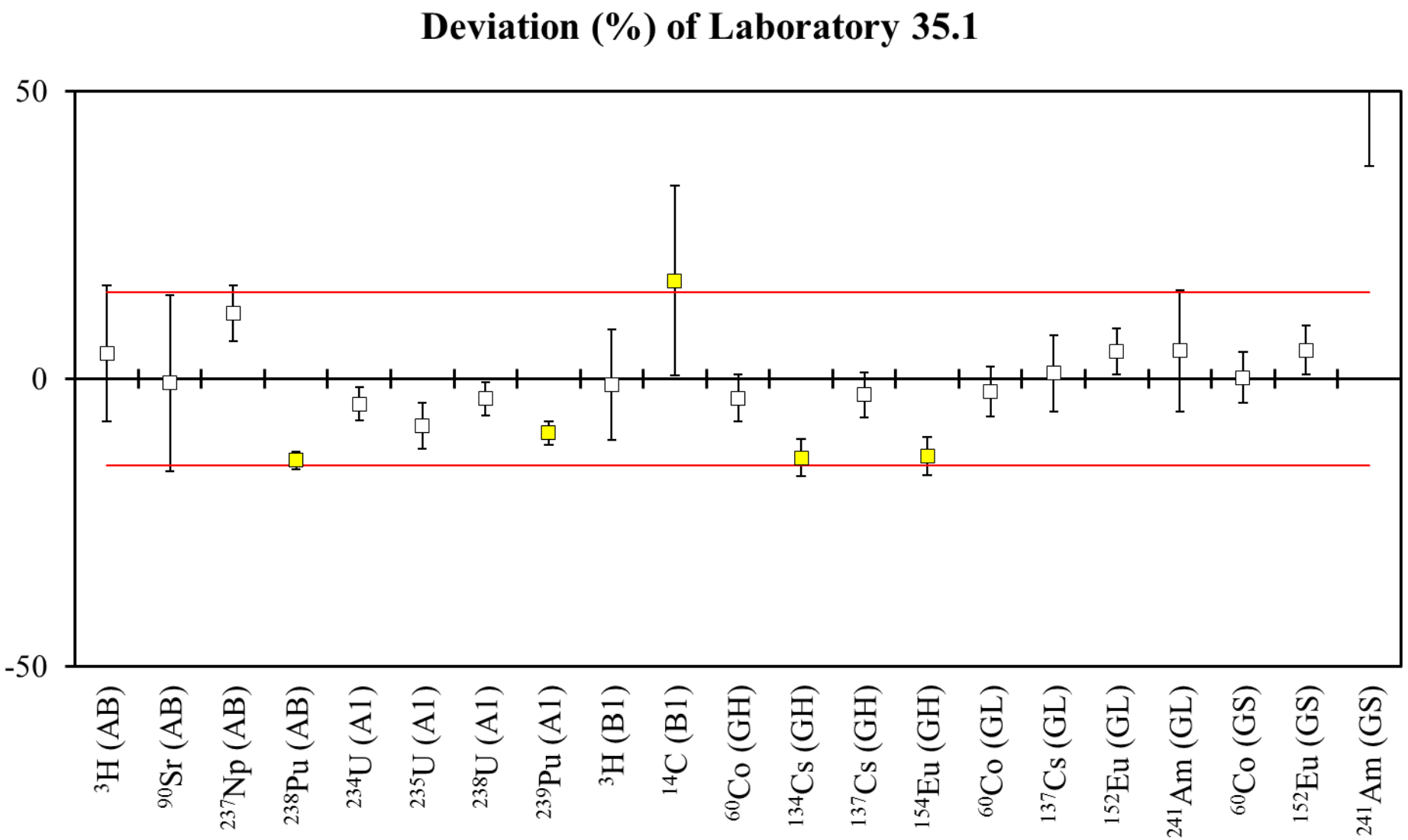
Radionuclide	Laboratory 32.3	NPL Assigned Value	Deviation /%	Zeta	Z Score
^{238}U (A1)	16.89 ± 0.87	16.50 ± 0.28	2.4	0.43	0.41


Deviation (%) of Laboratory 32.4
50
0
-50
238U (A1)

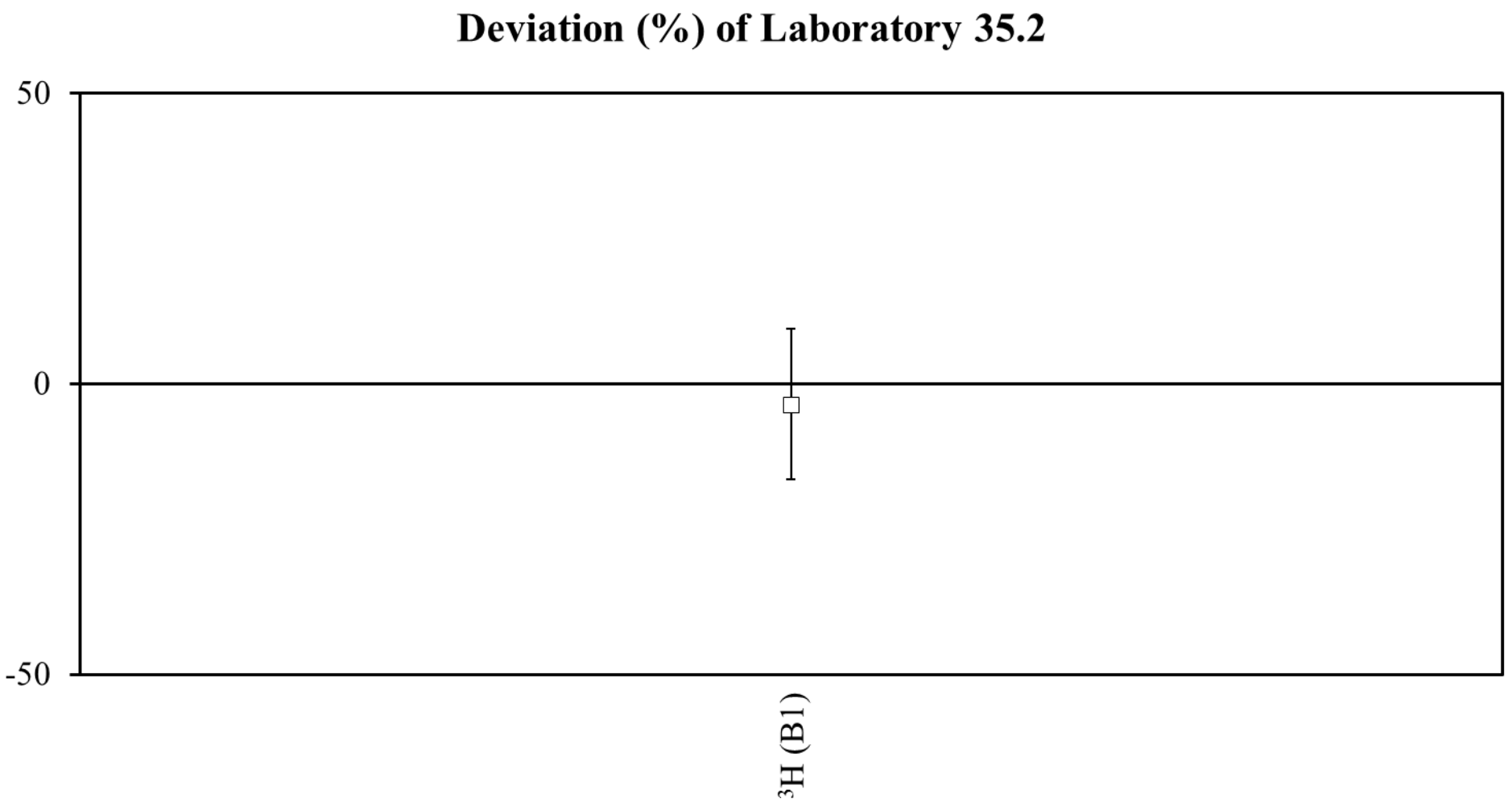
Radionuclide	Laboratory 32.4	NPL Assigned Value	Deviation /%	Zeta	Z Score
^{238}U (A1)	16.8 ± 3.7	16.50 ± 0.28	1.8	0.08	0.31


Deviation (%) of Laboratory 34
50
0
-50
^{3}H (B1)
^{14}C (B1)
^{36}Cl (B1)
^{60}Co (GL)
^{137}Cs (GL)
^{152}Eu (GL)
^{241}Am (GL)

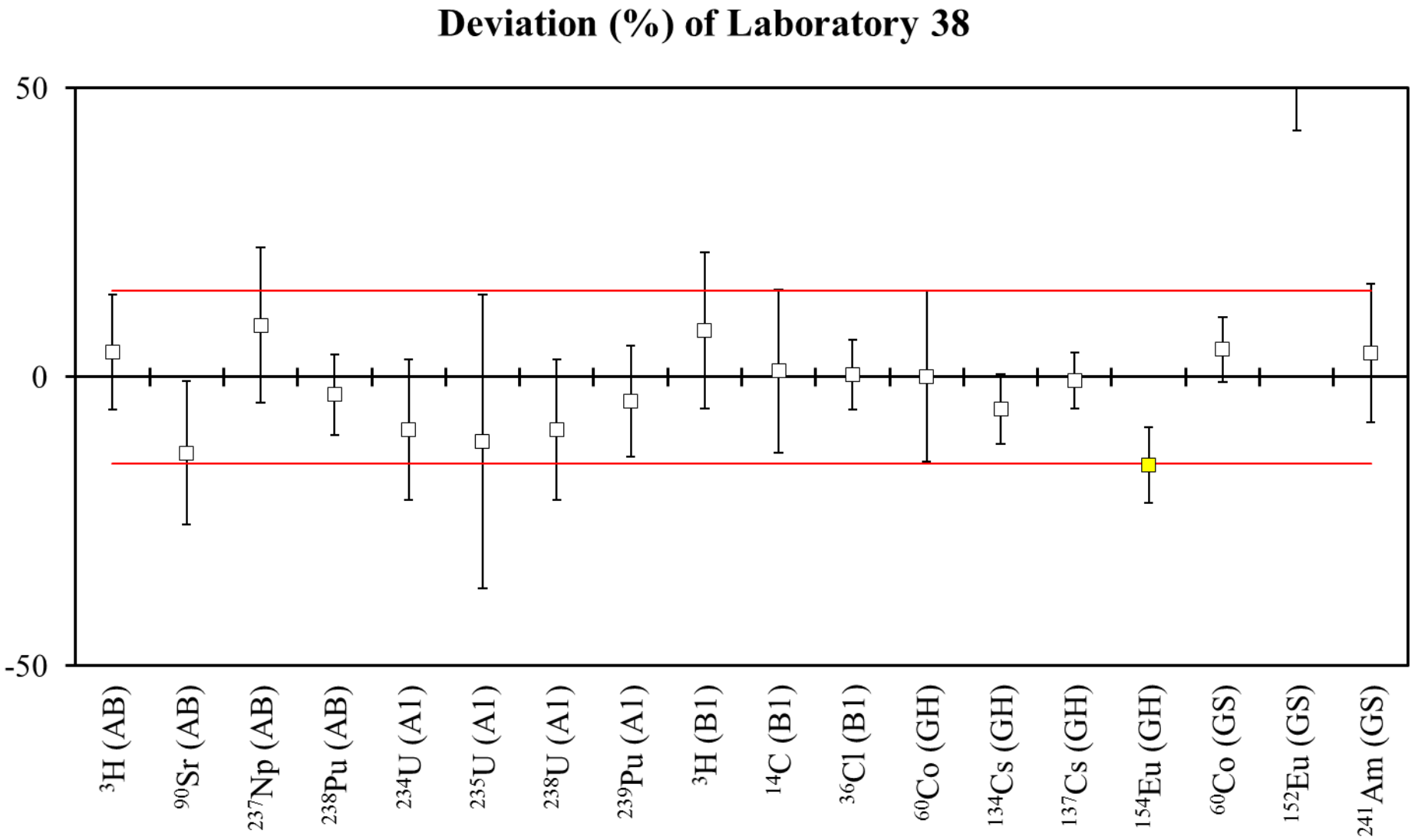
Radionuclide	Laboratory 34	NPL Assigned Value	Deviation /%	Zeta	Z Score
^{3}H (B1)	0.747 ± 0.033	0.7400 ± 0.0052	0.9	0.21	0.16
^{14}C (B1)	0.366 ± 0.026	0.4254 ± 0.0028	-14.0	-2.27	-2.40
^{36}Cl (B1)	0.466 ± 0.027	0.4978 ± 0.0020	-6.4	-1.17	-1.10
^{60}Co (GL)	12.9 ± 1.3	12.490 ± 0.062	3.3	0.32	0.56
^{137}Cs (GL)	2.40 ± 0.20	2.259 ± 0.020	6.2	0.70	1.07
^{152}Eu (GL)	18.7 ± 1.9	20.00 ± 0.15	-6.5	-0.68	-1.12
^{241}Am (GL)	2.07 ± 0.22	1.8124 ± 0.0039	14.2	1.17	2.44


Deviation (%) of Laboratory 35.1
50
0
-50
^{3}H (AB)
^{90}Sr (AB)
^{237}Np (AB)
^{238}Pu (AB)
^{234}U (A1)
^{235}U (A1)
^{238}U (A1)
^{239}Pu (A1)
^{3}H (B1)
^{14}C (B1)
^{60}Co (GH)
^{134}Cs (GH)
^{137}Cs (GH)
^{154}Eu (GH)
^{60}Co (GL)
^{137}Cs (GL)
^{152}Eu (GL)
^{241}Am (GL)
^{60}Co (GS)
^{152}Eu (GS)
^{241}Am (GS)

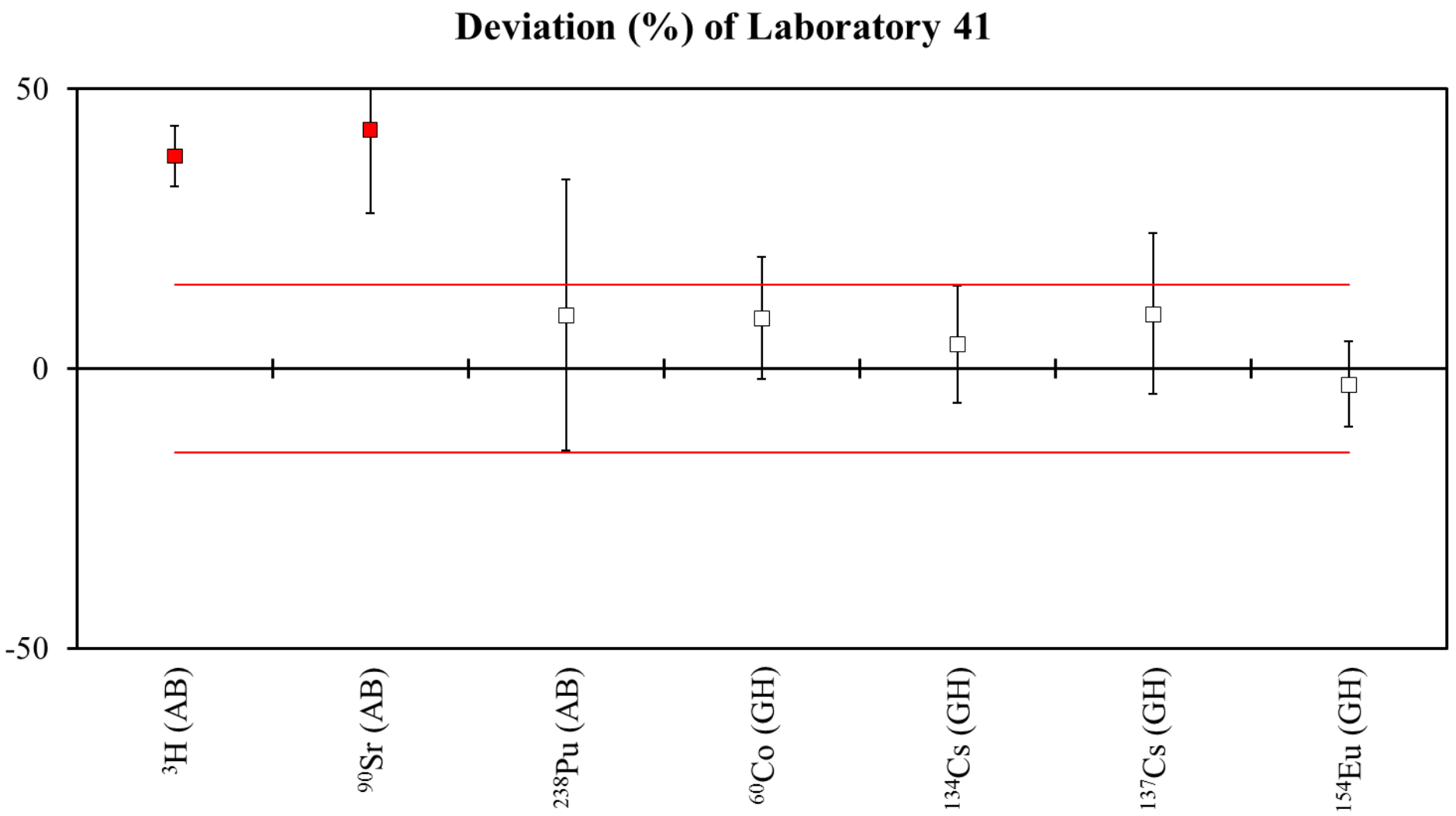
Radionuclide	Laboratory 35.1	NPL Assigned Value	Deviation /%	Zeta	Z Score
^{3}H (AB)	6.30 ± 0.71	6.037 ± 0.043	4.4	0.37	0.75
^{90}Sr (AB)	2.40 ± 0.37	2.418 ± 0.011	-0.7	-0.05	-0.13
^{237}Np (AB)	8.28 ± 0.35	7.432 ± 0.074	11.4	2.37	1.96
^{238}Pu (AB)	7.44 ± 0.13	8.666 ± 0.020	-14.1	-9.32	-2.43
^{234}U (A1)	15.78 ± 0.40	16.50 ± 0.28	-4.4	-1.47	-0.75
^{235}U (A1)	0.724 ± 0.029	0.788 ± 0.013	-8.1	-2.01	-1.39
^{238}U (A1)	15.93 ± 0.40	16.50 ± 0.28	-3.5	-1.17	-0.59
^{239}Pu (A1)	18.91 ± 0.42	20.879 ± 0.039	-9.4	-4.67	-1.62
^{3}H (B1)	0.732 ± 0.071	0.7400 ± 0.0052	-1.1	-0.11	-0.19
^{14}C (B1)	0.4980 ± 0.07	0.4254 ± 0.0028	17.1	1.04	2.93
^{60}Co (GH)	5.21 ± 0.22	5.394 ± 0.012	-3.4	-0.84	-0.59
^{134}Cs (GH)	4.29 ± 0.16	4.973 ± 0.034	-13.7	-4.18	-2.36
^{137}Cs (GH)	4.01 ± 0.16	4.125 ± 0.031	-2.8	-0.71	-0.48
^{154}Eu (GH)	3.98 ± 0.15	4.600 ± 0.037	-13.5	-4.01	-2.31
^{60}Co (GL)	12.21 ± 0.54	12.490 ± 0.062	-2.2	-0.52	-0.38
^{137}Cs (GL)	2.28 ± 0.15	2.259 ± 0.020	0.9	0.14	0.16
^{152}Eu (GL)	20.95 ± 0.80	20.00 ± 0.15	4.8	1.17	0.82
^{241}Am (GL)	1.90 ± 0.19	1.8124 ± 0.0039	4.8	0.46	0.83
^{60}Co (GS)	1.473 ± 0.062	1.470 ± 0.017	0.2	0.05	0.04
^{152}Eu (GS)	0.8070 ± 0.03	0.769 ± 0.012	4.9	1.18	0.85
^{241}Am (GS)	3.63 ± 0.16	2.40 ± 0.20	51.3	4.80	8.80


Deviation (%) of Laboratory 35.2
50
0
-50
^{3}H (B1)

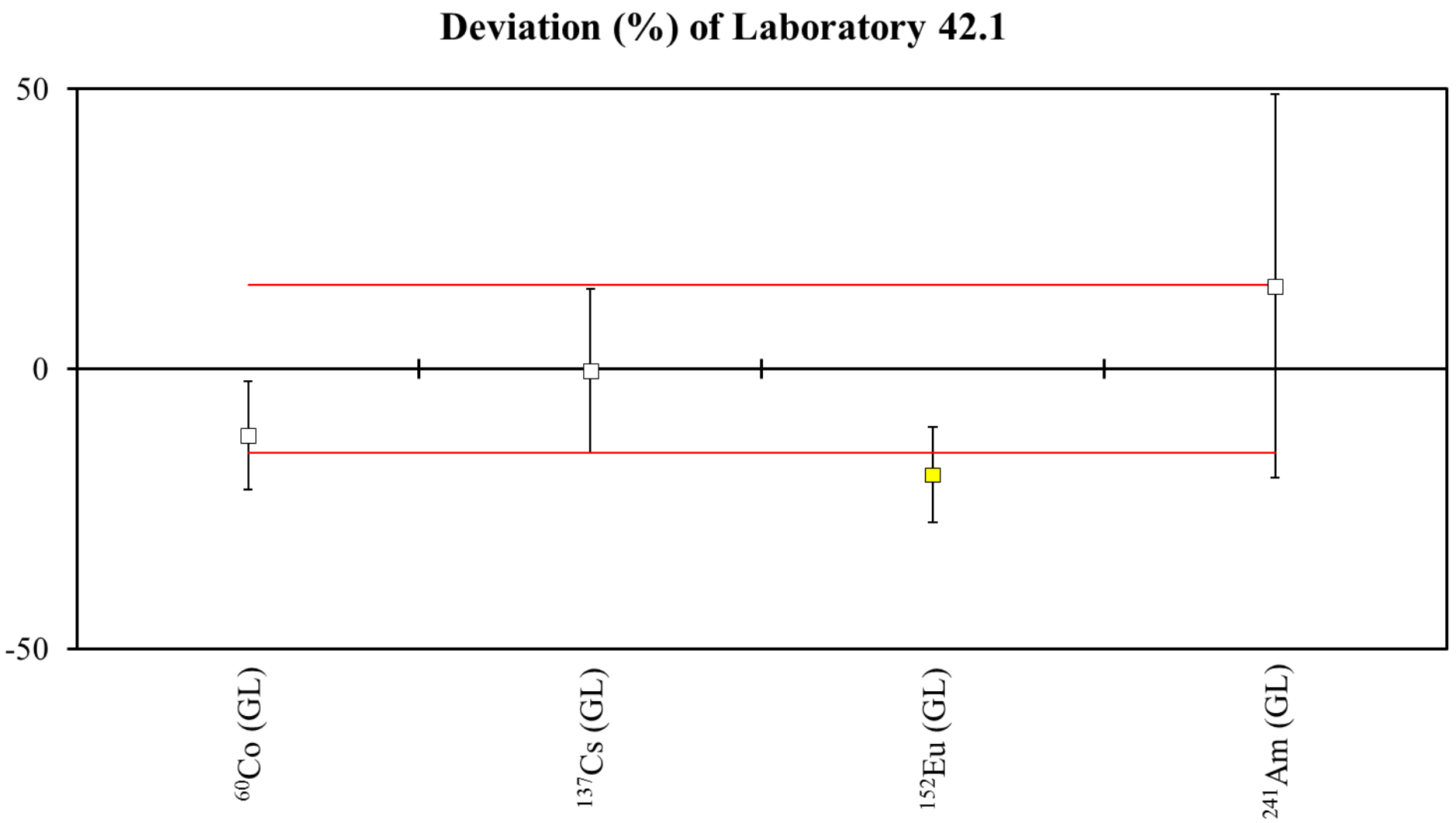
Radionuclide	Laboratory 35.2	NPL Assigned Value	Deviation /%	Zeta	Z Score
^{3}H (B1)	0.714 ± 0.096	0.7400 ± 0.0052	-3.5	-0.27	-0.60


Deviation (%) of Laboratory 38
50
0
-50
^{3}H (AB)
^{90}Sr (AB)
^{237}Np (AB)
^{238}Pu (AB)
^{234}U (A1)
^{235}U (A1)
^{238}U (A1)
^{239}Pu (A1)
^{3}H (B1)
^{14}C (B1)
^{36}Cl (B1)
^{60}Co (GH)
^{134}Cs (GH)
^{137}Cs (GH)
^{154}Eu (GH)
^{60}Co (GS)
^{152}Eu (GS)
^{241}Am (GS)

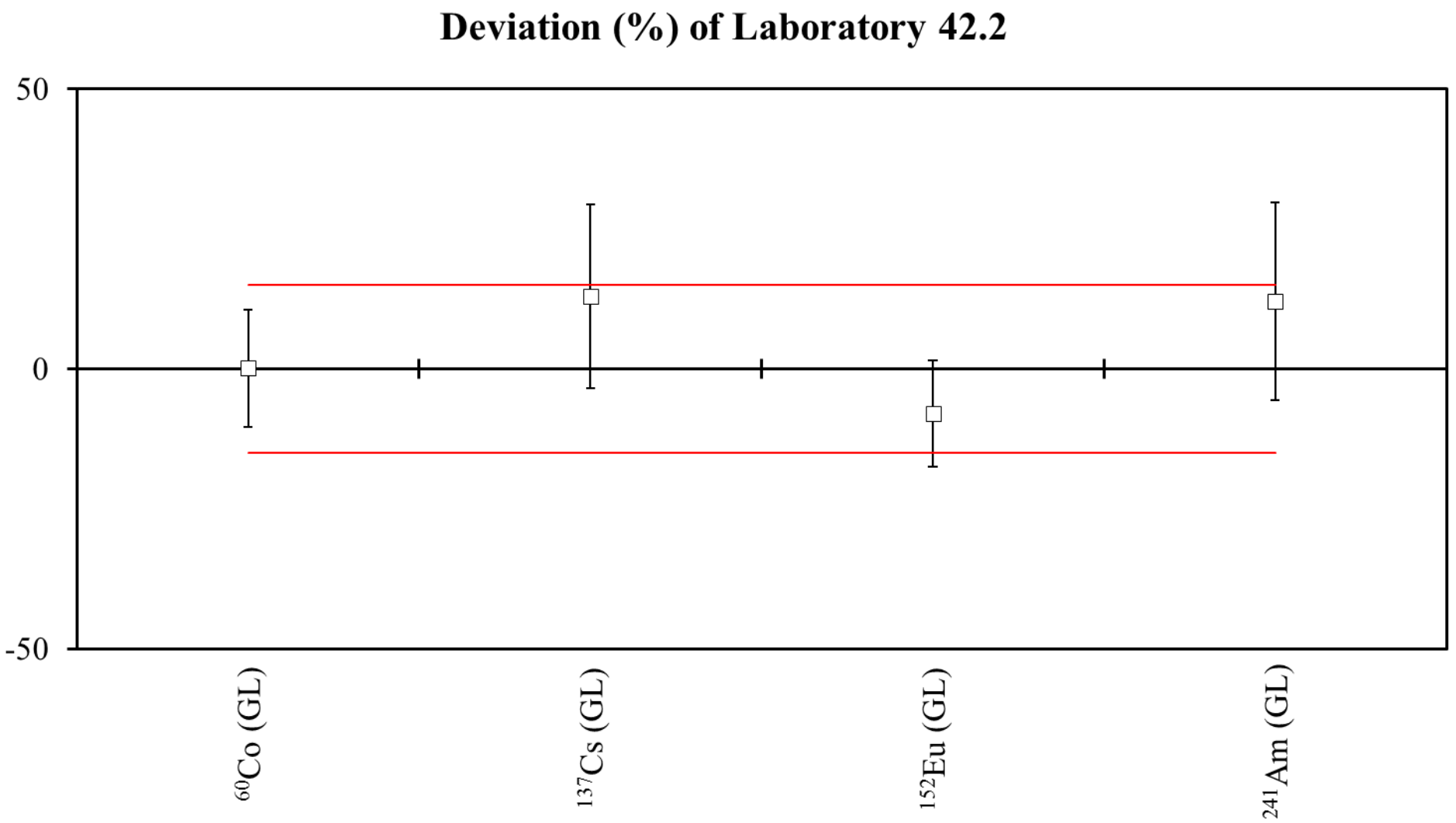
Radionuclide	Laboratory 38	NPL Assigned Value	Deviation /%	Zeta	Z Score
^{3}H (AB)	6.3 ± 0.6	6.037 ± 0.043	4.4	0.44	0.75
^{90}Sr (AB)	2.1 ± 0.3	2.418 ± 0.011	-13.2	-1.06	-2.26
^{237}Np (AB)	8.1 ± 1.0	7.432 ± 0.074	9.0	0.67	1.54
^{238}Pu (AB)	8.4 ± 0.6	8.666 ± 0.020	-3.1	-0.44	-0.53
^{234}U (A1)	15.0 ± 2.0	16.50 ± 0.28	-9.1	-0.74	-1.56
^{235}U (A1)	0.70 ± 0.20	0.788 ± 0.013	-11.2	-0.44	-1.92
^{238}U (A1)	15.0 ± 2.0	16.50 ± 0.28	-9.1	-0.74	-1.56
^{239}Pu (A1)	20.0 ± 2.0	20.879 ± 0.039	-4.2	-0.44	-0.72
^{3}H (B1)	0.80 ± 0.10	0.7400 ± 0.0052	8.1	0.60	1.39
^{14}C (B1)	0.43 ± 0.06	0.4254 ± 0.0028	1.1	0.08	0.19
^{36}Cl (B1)	0.50 ± 0.03	0.4978 ± 0.0020	0.4	0.07	0.08
^{60}Co (GH)	5.40 ± 0.80	5.394 ± 0.012	0.1	0.01	0.02
^{134}Cs (GH)	4.7 ± 0.3	4.973 ± 0.034	-5.5	-0.90	-0.94
^{137}Cs (GH)	4.10 ± 0.20	4.125 ± 0.031	-0.6	-0.12	-0.10
^{154}Eu (GH)	3.9 ± 0.3	4.600 ± 0.037	-15.2	-2.32	-2.61
^{60}Co (GS)	1.540 ± 0.080	1.470 ± 0.017	4.8	0.86	0.82
^{152}Eu (GS)	1.17 ± 0.07	0.769 ± 0.012	52.1	5.65	8.96
^{241}Am (GS)	2.50 ± 0.20	2.40 ± 0.20	4.2	0.35	0.72


Deviation (%) of Laboratory 41
50
0
-50
^{3}H (AB)
^{90}Sr (AB)
^{238}Pu (AB)
^{60}Co (GH)
^{134}Cs (GH)
^{137}Cs (GH)
^{154}Eu (GH)

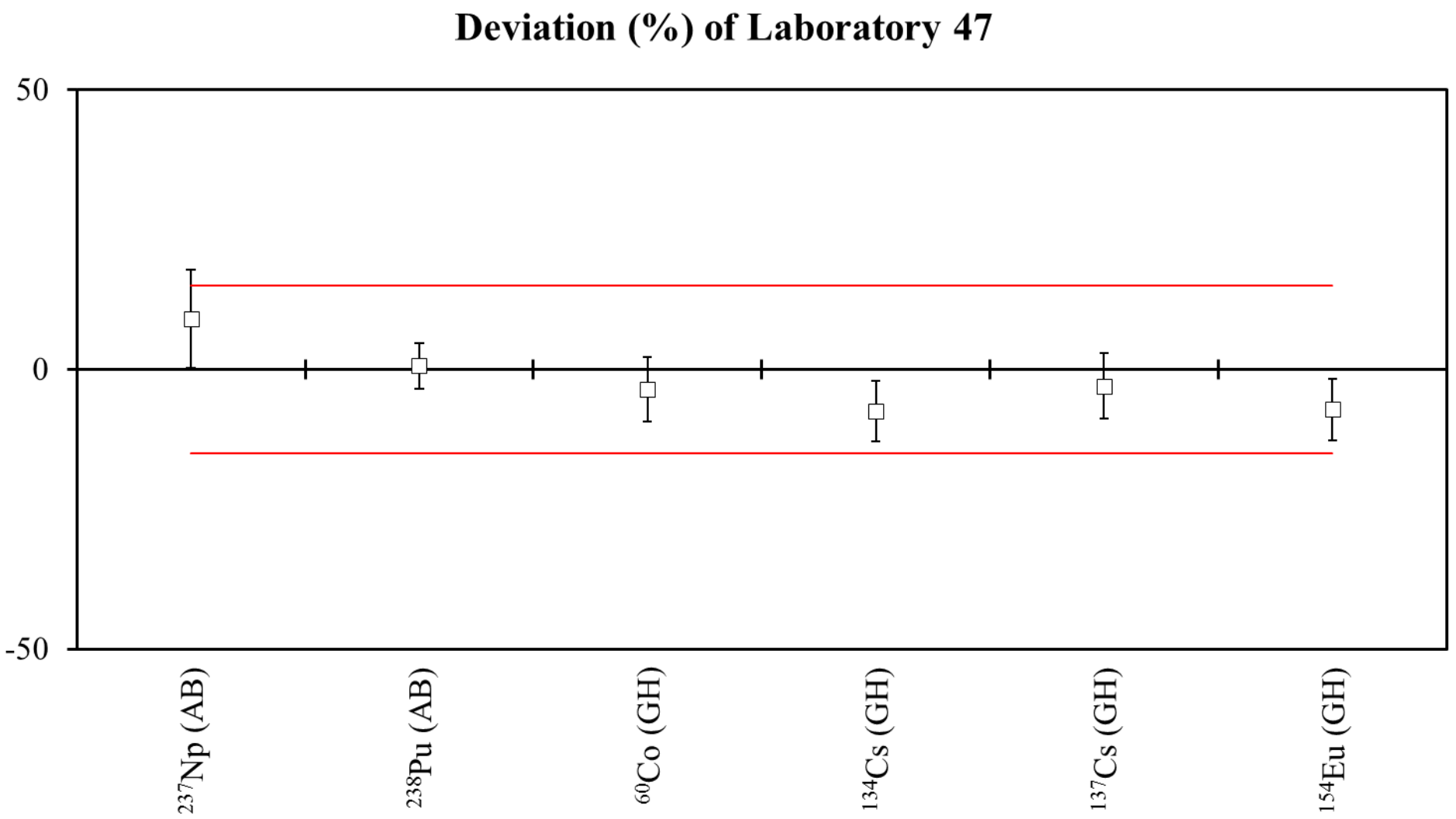
Radionuclide	Laboratory 41	NPL Assigned Value	Deviation /%	Zeta	Z Score
^{3}H (AB)	8.33 ± 0.32	6.037 ± 0.043	38.0	7.10	6.52
^{90}Sr (AB)	3.45 ± 0.36	2.418 ± 0.011	42.7	2.87	7.33
^{238}Pu (AB)	9.5 ± 2.1	8.666 ± 0.020	9.6	0.40	1.65
^{60}Co (GH)	5.88 ± 0.59	5.394 ± 0.012	9.0	0.82	1.55
^{134}Cs (GH)	5.19 ± 0.52	4.973 ± 0.034	4.4	0.42	0.75
^{137}Cs (GH)	4.53 ± 0.59	4.125 ± 0.031	9.8	0.69	1.69
^{154}Eu (GH)	4.47 ± 0.35	4.600 ± 0.037	-2.8	-0.37	-0.49


Deviation (%) of Laboratory 42.1
50
0
-50
^{60}Co (GL)
^{137}Cs (GL)
^{152}Eu (GL)
^{241}Am (GL)

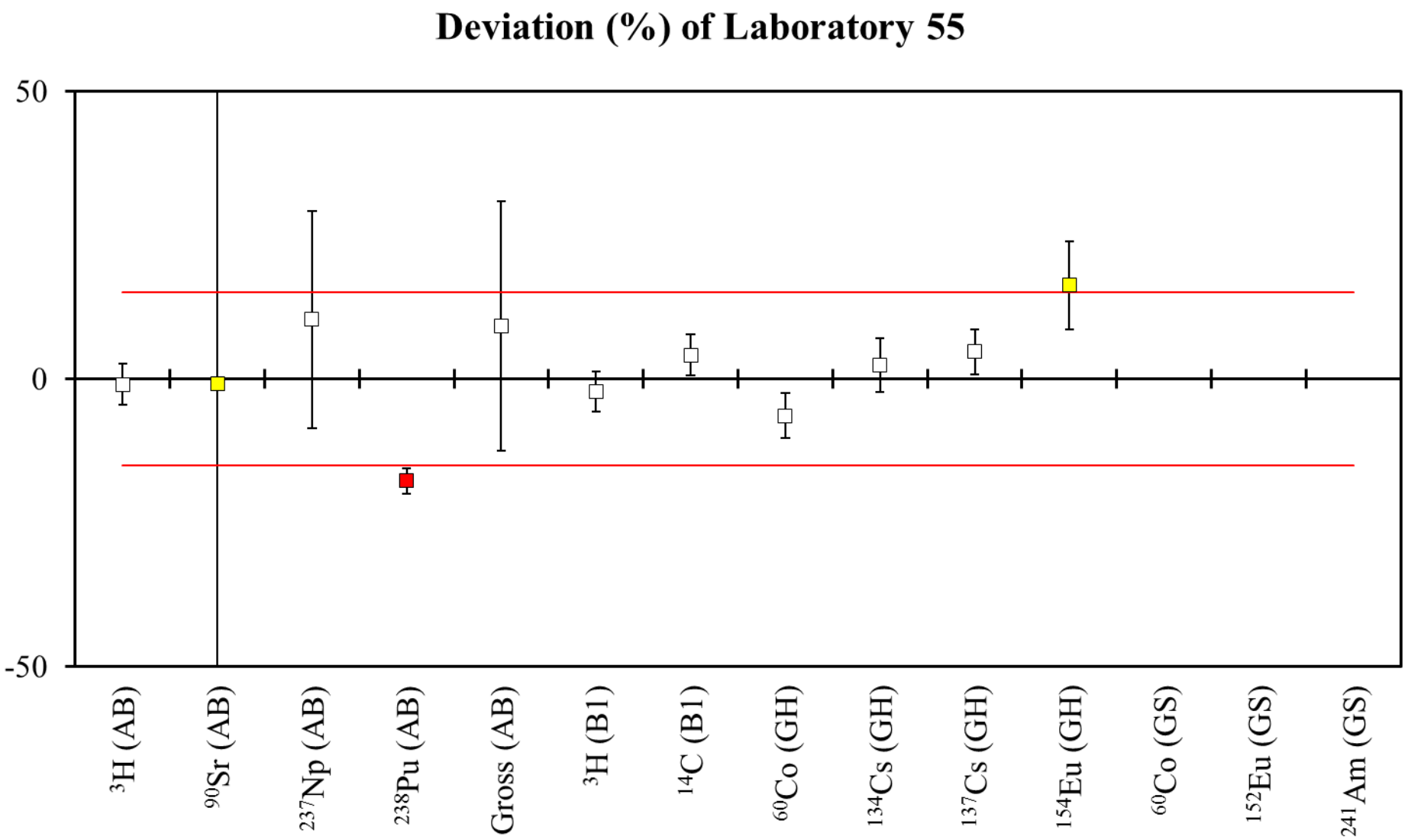
Radionuclide	Laboratory 42.1	NPL Assigned Value	Deviation /%	Zeta	Z Score
^{60}Co (GL)	11.0 ± 1.2	12.490 ± 0.062	-11.9	-1.24	-2.05
^{137}Cs (GL)	2.25 ± 0.33	2.259 ± 0.020	-0.4	-0.03	-0.07
^{152}Eu (GL)	16.2 ± 1.7	20.00 ± 0.15	-19.0	-2.23	-3.26
^{241}Am (GL)	2.08 ± 0.62	1.8124 ± 0.0039	14.8	0.43	2.54


Deviation (%) of Laboratory 42.2
50
0
-50
^{60}Co (GL)
^{137}Cs (GL)
^{152}Eu (GL)
^{241}Am (GL)

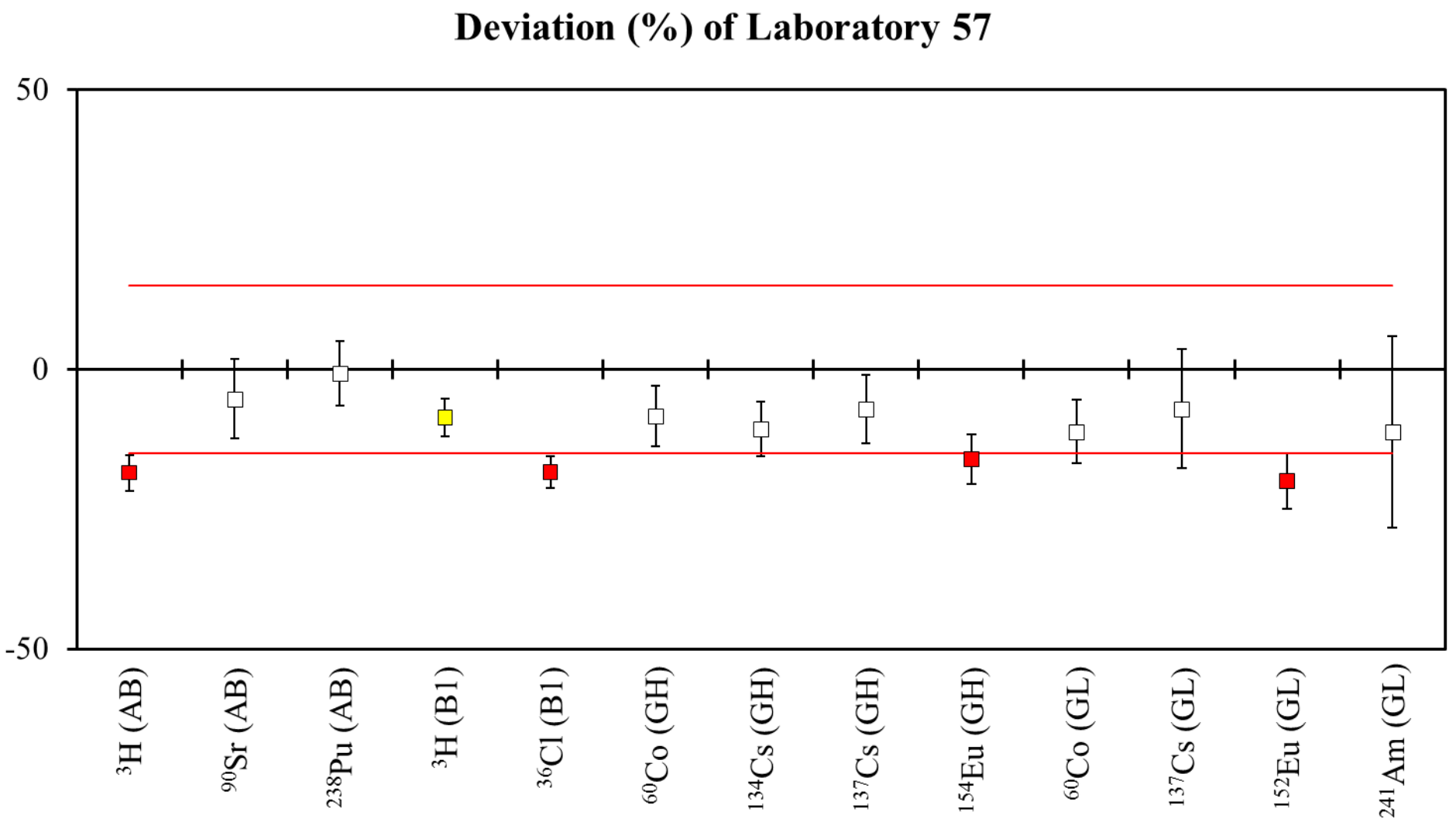
Radionuclide	Laboratory 42.2	NPL Assigned Value	Deviation /%	Zeta	Z Score
^{60}Co (GL)	12.5 ± 1.3	12.490 ± 0.062	0.1	0.01	0.01
^{137}Cs (GL)	2.55 ± 0.37	2.259 ± 0.020	12.9	0.79	2.21
^{152}Eu (GL)	18.4 ± 1.9	20.00 ± 0.15	-8.0	-0.84	-1.37
^{241}Am (GL)	2.03 ± 0.32	1.8124 ± 0.0039	12.0	0.68	2.06


Deviation (%) of Laboratory 47
50
0
-50
^{237}Np (AB)
^{238}Pu (AB)
^{60}Co (GH)
^{134}Cs (GH)
^{137}Cs (GH)
^{154}Eu (GH)

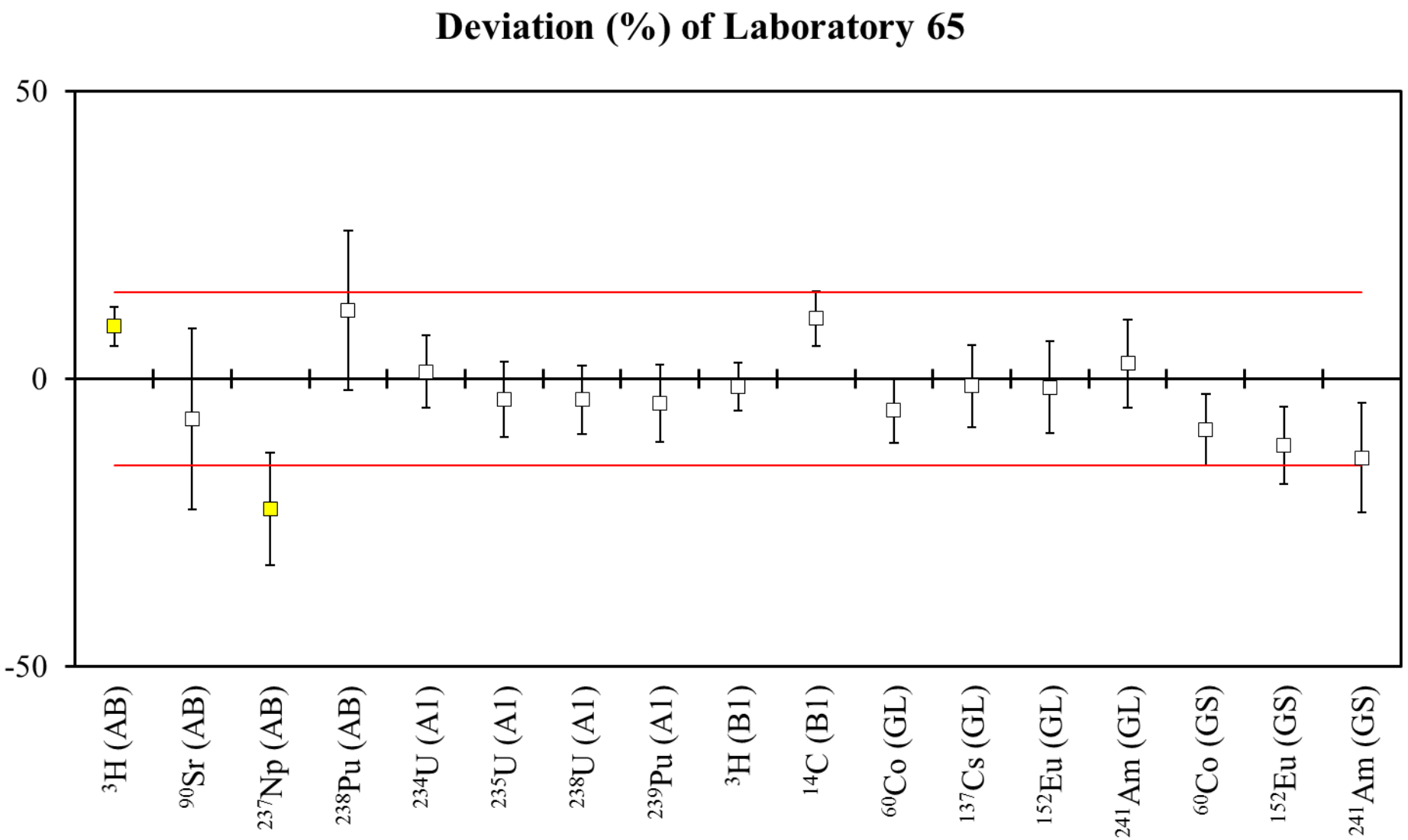
Radionuclide	Laboratory 47	NPL Assigned Value	Deviation /%	Zeta	Z Score
^{237}Np (AB)	8.10 ± 0.65	7.432 ± 0.074	9.0	1.02	1.54
^{238}Pu (AB)	8.72 ± 0.35	8.666 ± 0.020	0.6	0.15	0.11
^{60}Co (GH)	5.20 ± 0.31	5.394 ± 0.012	-3.6	-0.63	-0.62
^{134}Cs (GH)	4.60 ± 0.27	4.973 ± 0.034	-7.5	-1.37	-1.29
^{137}Cs (GH)	4.00 ± 0.24	4.125 ± 0.031	-3.0	-0.52	-0.52
^{154}Eu (GH)	4.27 ± 0.25	4.600 ± 0.037	-7.2	-1.31	-1.23


Deviation (%) of Laboratory 55
50
0
-50
^{3}H (AB)
^{90}Sr (AB)
^{237}Np (AB)
^{238}Pu (AB)
Gross (AB)
^{3}H (B1)
^{14}C (B1)
^{60}Co (GH)
^{134}Cs (GH)
^{137}Cs (GH)
^{154}Eu (GH)
^{60}Co (GS)
^{152}Eu (GS)
^{241}Am (GS)

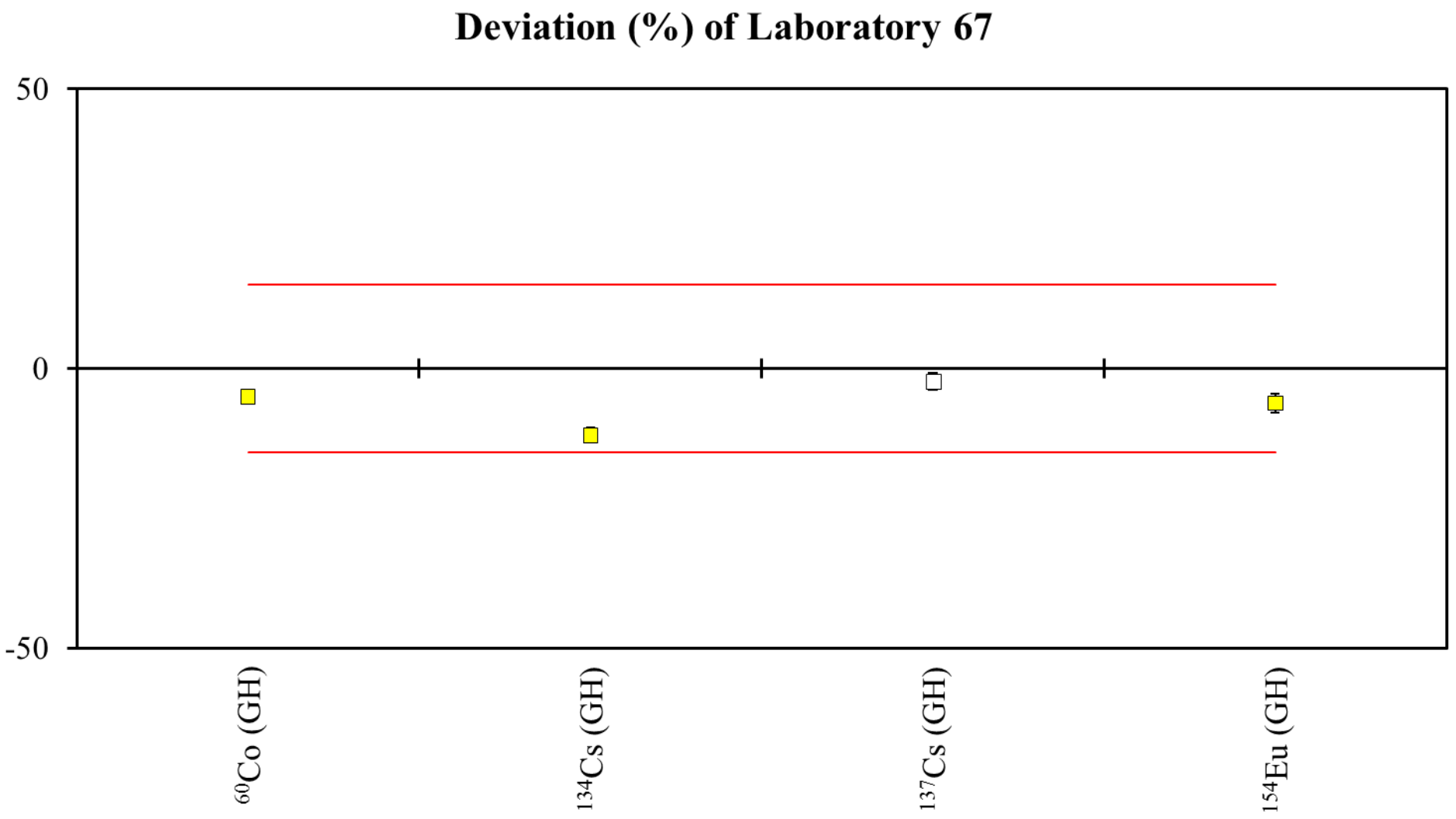
Radionuclide	Laboratory 55	NPL Assigned Value	Deviation /%	Zeta	Z Score
^{3}H (AB)	5.98 ± 0.21	6.037 ± 0.043	-0.9	-0.27	-0.16
^{90}Sr (AB)	2.4 ± 2.0	2.418 ± 0.011	-0.7	-0.01	-0.13
^{237}Np (AB)	8.2 ± 1.4	7.432 ± 0.074	10.3	0.55	1.77
^{238}Pu (AB)	7.13 ± 0.19	8.666 ± 0.020	-17.7	-8.04	-3.04
Gross Alpha-Beta (AB)	29.6 ± 1.1	27.1 ± 5.3	9.2	0.46	1.58
^{3}H (B1)	0.724 ± 0.025	0.7400 ± 0.0052	-2.2	-0.63	-0.37
^{14}C (B1)	0.443 ± 0.015	0.4254 ± 0.0028	4.1	1.15	0.71
^{60}Co (GH)	5.05 ± 0.21	5.394 ± 0.012	-6.4	-1.64	-1.10
^{134}Cs (GH)	5.09 ± 0.23	4.973 ± 0.034	2.4	0.50	0.40
^{137}Cs (GH)	4.32 ± 0.16	4.125 ± 0.031	4.7	1.20	0.81
^{154}Eu (GH)	5.35 ± 0.35	4.600 ± 0.037	16.3	2.13	2.80
^{60}Co (GS)	2.540 ± 0.046	1.470 ± 0.017	72.8	21.82	12.50
^{152}Eu (GS)	1.460 ± 0.028	0.769 ± 0.012	89.9	22.68	15.43
^{241}Am (GS)	0.764 ± 0.040	2.40 ± 0.20	-68.2	-8.02	-11.71


Deviation (%) of Laboratory 57
50
0
-50
^{3}H (AB)
^{90}Sr (AB)
^{238}Pu (AB)
^{3}H (B1)
^{36}Cl (B1)
^{60}Co (GH)
^{134}Cs (GH)
^{137}Cs (GH)
^{154}Eu (GH)
^{60}Co (GL)
^{137}Cs (GL)
^{152}Eu (GL)
^{241}Am (GL)

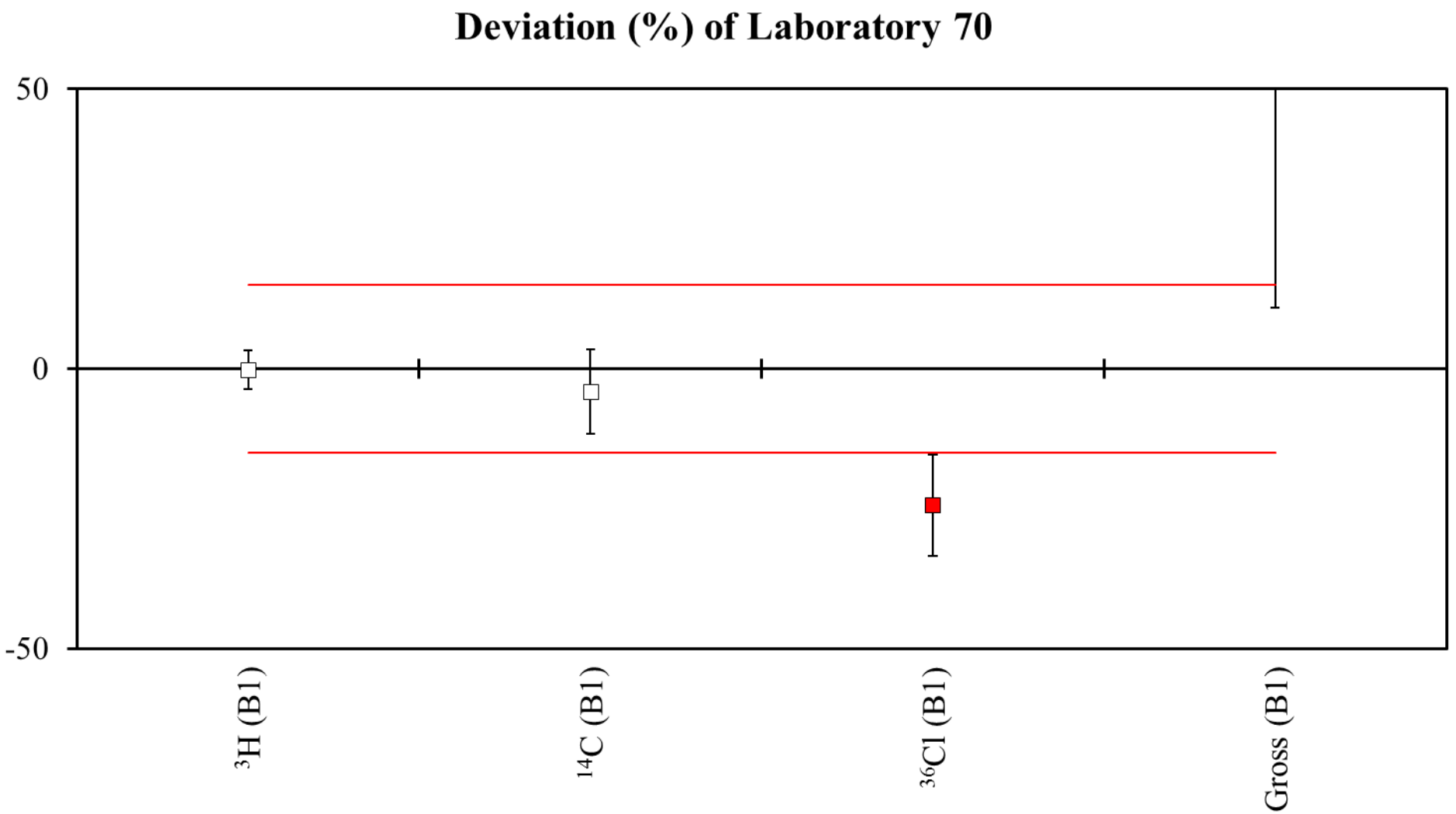
Radionuclide	Laboratory 57	NPL Assigned Value	Deviation /%	Zeta	Z Score
^{3}H (AB)	4.92 ± 0.19	6.037 ± 0.043	-18.5	-5.73	-3.18
^{90}Sr (AB)	2.29 ± 0.17	2.418 ± 0.011	-5.3	-0.75	-0.91
^{238}Pu (AB)	8.60 ± 0.50	8.666 ± 0.020	-0.8	-0.13	-0.13
^{3}H (B1)	0.676 ± 0.024	0.7400 ± 0.0052	-8.6	-2.61	-1.49
^{36}Cl (B1)	0.406 ± 0.014	0.4978 ± 0.0020	-18.4	-6.49	-3.17
^{60}Co (GH)	4.94 ± 0.29	5.394 ± 0.012	-8.4	-1.56	-1.45
^{134}Cs (GH)	4.44 ± 0.24	4.973 ± 0.034	-10.7	-2.20	-1.84
^{137}Cs (GH)	3.83 ± 0.25	4.125 ± 0.031	-7.2	-1.17	-1.23
^{154}Eu (GH)	3.86 ± 0.20	4.600 ± 0.037	-16.1	-3.64	-2.76
^{60}Co (GL)	11.1 ± 0.7	12.490 ± 0.062	-11.1	-1.98	-1.91
^{137}Cs (GL)	2.10 ± 0.24	2.259 ± 0.020	-7.0	-0.66	-1.21
^{152}Eu (GL)	16.0 ± 1.0	20.00 ± 0.15	-20.0	-3.96	-3.43
^{241}Am (GL)	1.61 ± 0.31	1.8124 ± 0.0039	-11.2	-0.65	-1.92


Deviation (%) of Laboratory 65
50
0
-50
^{3}H (AB)
^{90}Sr (AB)
^{237}Np (AB)
^{238}Pu (AB)
^{234}U (A1)
^{235}U (A1)
^{238}U (A1)
^{239}Pu (A1)
^{3}H (B1)
^{14}C (B1)
^{60}Co (GL)
^{137}Cs (GL)
^{152}Eu (GL)
^{241}Am (GL)
^{60}Co (GS)
^{152}Eu (GS)
^{241}Am (GS)

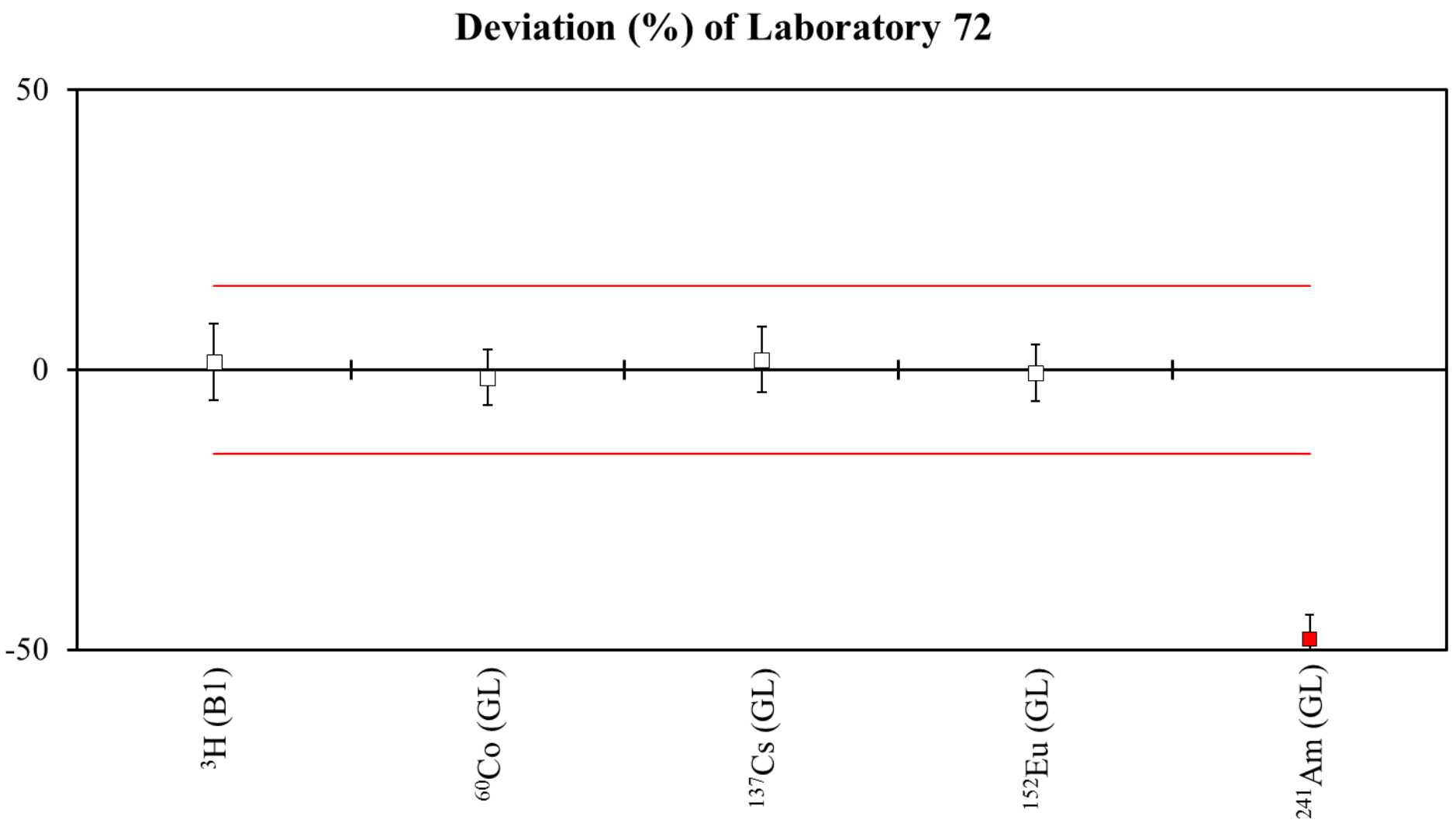
Radionuclide	Laboratory 65	NPL Assigned Value	Deviation /%	Zeta	Z Score
^{3}H (AB)	6.59 ± 0.20	6.037 ± 0.043	9.2	2.70	1.57
^{90}Sr (AB)	2.25 ± 0.38	2.418 ± 0.011	-6.9	-0.44	-1.19
^{237}Np (AB)	5.75 ± 0.72	7.432 ± 0.074	-22.6	-2.32	-3.89
^{238}Pu (AB)	9.7 ± 1.2	8.666 ± 0.020	11.9	0.86	2.05
^{234}U (A1)	16.7 ± 1.0	16.50 ± 0.28	1.2	0.19	0.21
^{235}U (A1)	0.760 ± 0.050	0.788 ± 0.013	-3.6	-0.54	-0.61
^{238}U (A1)	15.90 ± 0.95	16.50 ± 0.28	-3.6	-0.61	-0.62
^{239}Pu (A1)	20.0 ± 1.4	20.879 ± 0.039	-4.2	-0.63	-0.72
^{3}H (B1)	0.73 ± 0.03	0.7400 ± 0.0052	-1.4	-0.33	-0.23
^{14}C (B1)	0.470 ± 0.020	0.4254 ± 0.0028	10.5	2.21	1.80
^{60}Co (GL)	11.8 ± 0.7	12.490 ± 0.062	-5.5	-0.98	-0.95
^{137}Cs (GL)	2.23 ± 0.16	2.259 ± 0.020	-1.3	-0.18	-0.22
^{152}Eu (GL)	19.7 ± 1.6	20.00 ± 0.15	-1.5	-0.19	-0.26
^{241}Am (GL)	1.86 ± 0.14	1.8124 ± 0.0039	2.6	0.34	0.45
^{60}Co (GS)	1.34 ± 0.09	1.470 ± 0.017	-8.8	-1.42	-1.52
^{152}Eu (GS)	0.680 ± 0.050	0.769 ± 0.012	-11.6	-1.73	-1.99
^{241}Am (GS)	2.07 ± 0.15	2.40 ± 0.20	-13.8	-1.32	-2.36


Deviation (%) of Laboratory 67
50
0
-50
60Co (GH)
134Cs (GH)
137Cs (GH)
154Eu (GH)

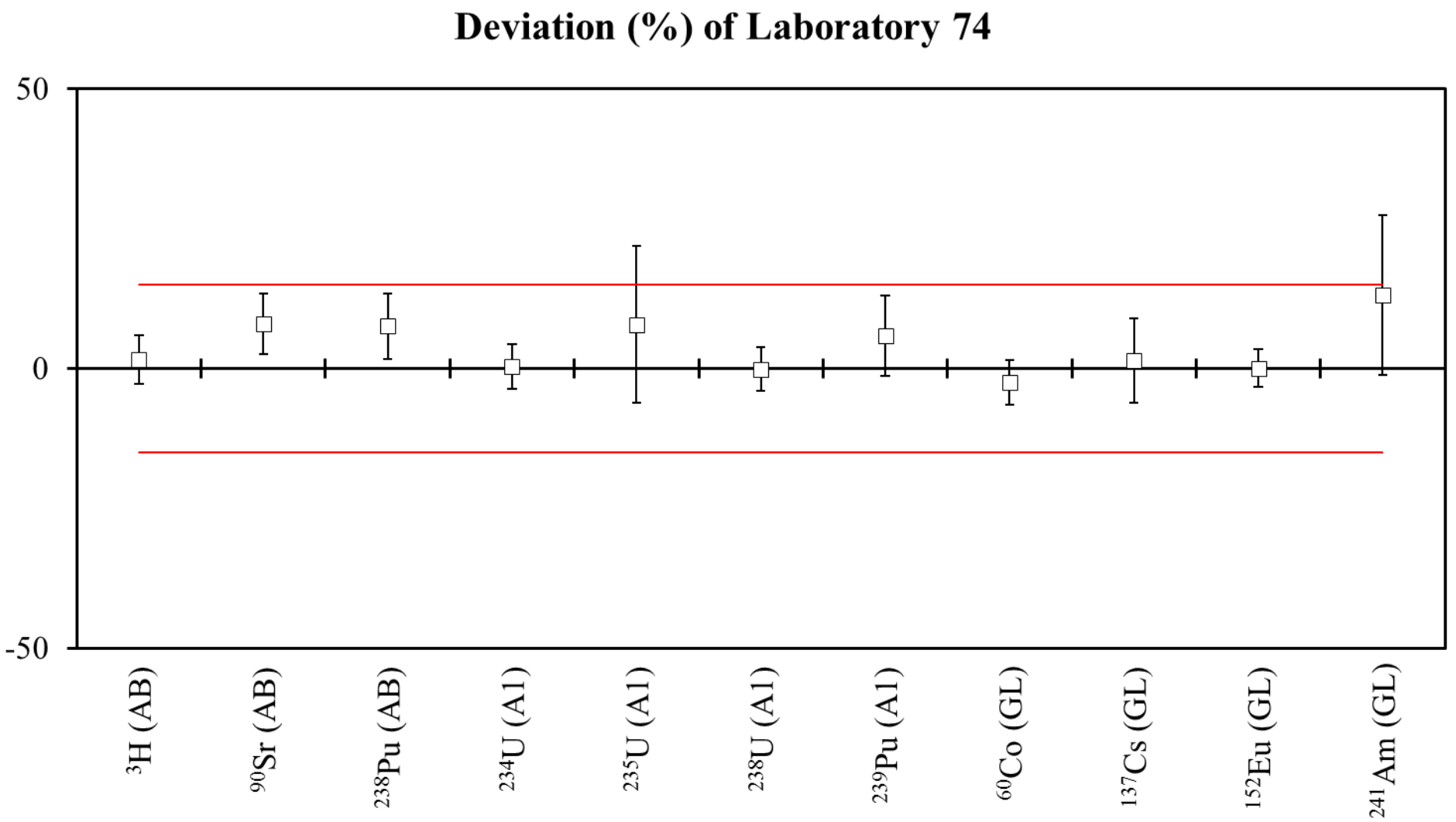
Radionuclide	Laboratory 67	NPL Assigned Value	Deviation /%	Zeta	Z Score
^{60}Co (GH)	5.122 ± 0.058	5.394 ± 0.012	-5.0	-4.59	-0.87
^{134}Cs (GH)	4.378 ± 0.059	4.973 ± 0.034	-12.0	-8.74	-2.05
^{137}Cs (GH)	4.029 ± 0.056	4.125 ± 0.031	-2.3	-1.50	-0.40
^{154}Eu (GH)	4.313 ± 0.069	4.600 ± 0.037	-6.2	-3.67	-1.07


Deviation (%) of Laboratory 70
50
0
-50
^{3}H (B1)
^{14}C (B1)
^{36}Cl (B1)
Gross (B1)

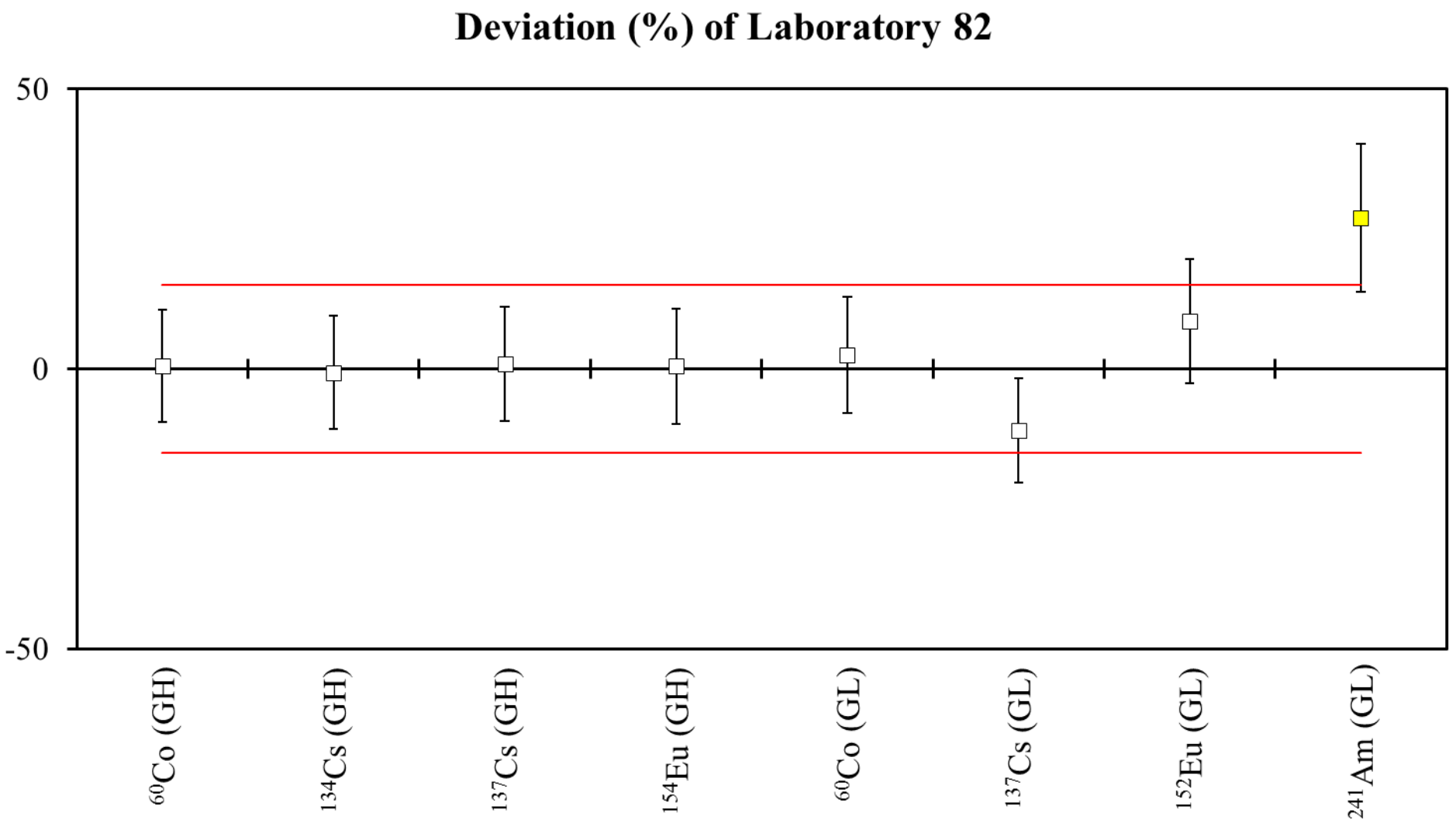
Radionuclide	Laboratory 70	NPL Assigned Value	Deviation /%	Zeta	Z Score
^{3}H (B1)	0.739 ± 0.025	0.7400 ± 0.0052	-0.1	-0.04	-0.02
^{14}C (B1)	0.408 ± 0.032	0.4254 ± 0.0028	-4.1	-0.54	-0.70
^{36}Cl (B1)	0.376 ± 0.045	0.4978 ± 0.0020	-24.5	-2.70	-4.20
Gross Beta (B1)	1.50 ± 0.10	0.94 ± 0.28	59.6	1.88	10.23


Deviation (%) of Laboratory 72
50
0
-50
^{3}H (B1)
^{60}Co (GL)
^{137}Cs (GL)
^{152}Eu (GL)
^{241}Am (GL)

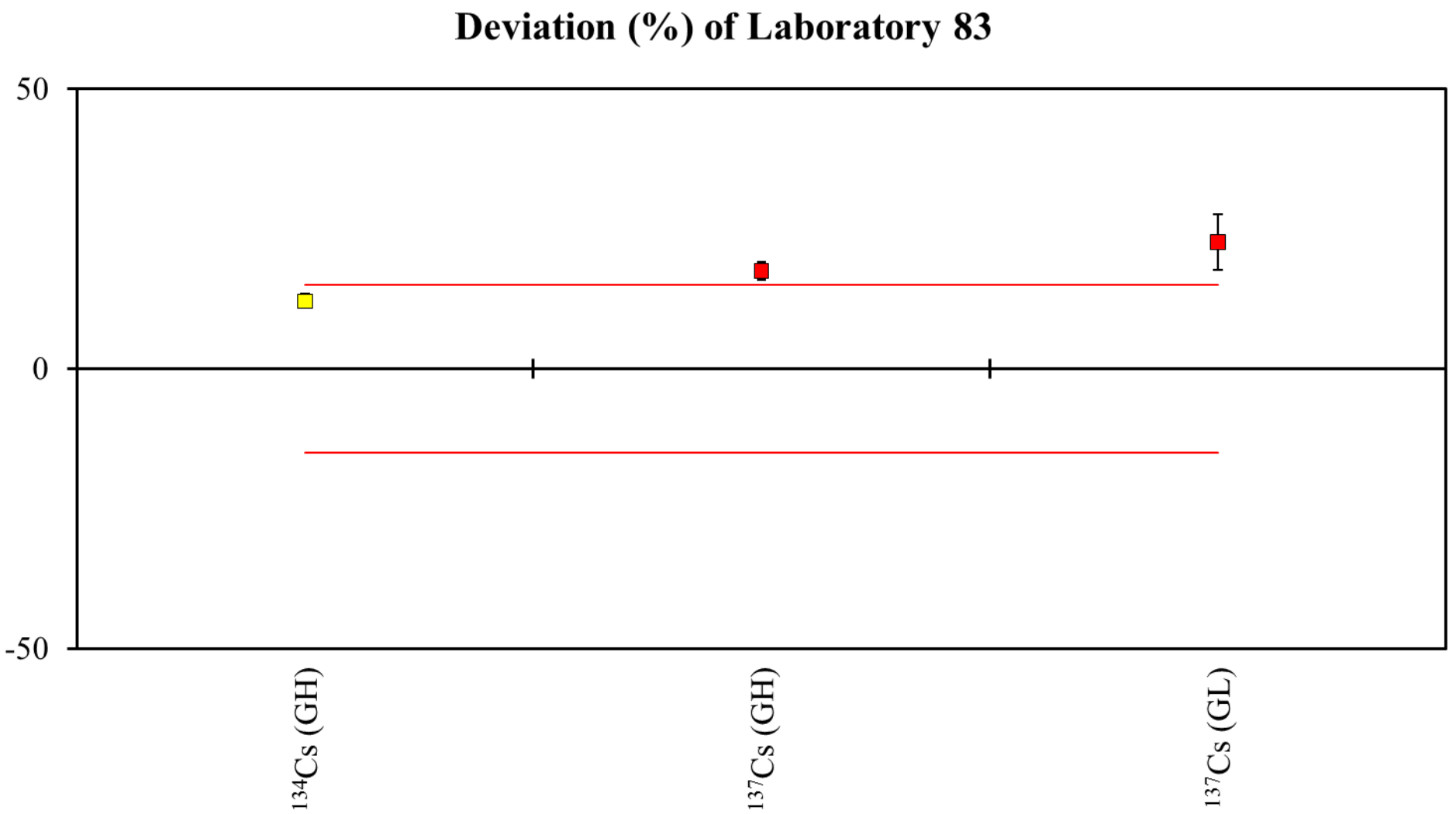
Radionuclide	Laboratory 72	NPL Assigned Value	Deviation /%	Zeta	Z Score
^{3}H (B1)	0.750 ± 0.050	0.7400 ± 0.0052	1.4	0.20	0.23
^{60}Co (GL)	12.32 ± 0.62	12.490 ± 0.062	-1.4	-0.27	-0.23
^{137}Cs (GL)	2.30 ± 0.13	2.259 ± 0.020	1.8	0.31	0.31
^{152}Eu (GL)	19.9 ± 1.0	20.00 ± 0.15	-0.5	-0.10	-0.09
^{241}Am (GL)	0.940 ± 0.080	1.8124 ± 0.0039	-48.1	-10.89	-8.27


Deviation (%) of Laboratory 74
50
0
-50
^{3}H (AB)
^{90}Sr (AB)
^{238}Pu (AB)
^{234}U (A1)
^{235}U (A1)
^{238}U (A1)
^{239}Pu (A1)
^{60}Co (GL)
^{137}Cs (GL)
^{152}Eu (GL)
^{241}Am (GL)

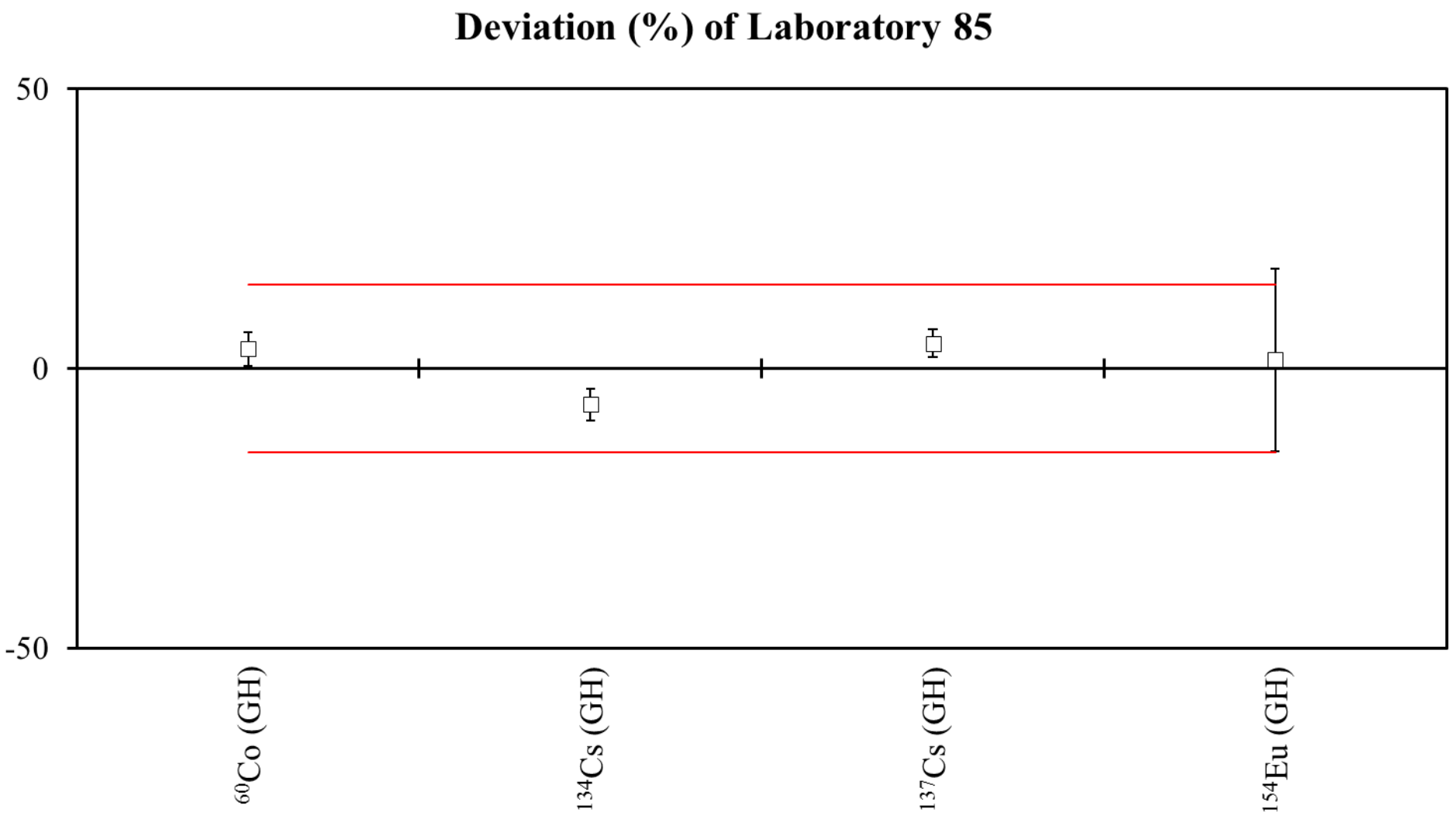
Radionuclide	Laboratory 74	NPL Assigned Value	Deviation /%	Zeta	Z Score
^{3}H (AB)	6.13 ± 0.26	6.037 ± 0.043	1.5	0.35	0.26
^{90}Sr (AB)	2.61 ± 0.13	2.418 ± 0.011	7.9	1.47	1.36
^{238}Pu (AB)	9.32 ± 0.51	8.666 ± 0.020	7.5	1.28	1.30
^{234}U (A1)	16.56 ± 0.59	16.50 ± 0.28	0.4	0.09	0.06
^{235}U (A1)	0.85 ± 0.11	0.788 ± 0.013	7.9	0.56	1.35
^{238}U (A1)	16.48 ± 0.59	16.50 ± 0.28	-0.1	-0.03	-0.02
^{239}Pu (A1)	22.1 ± 1.5	20.879 ± 0.039	5.8	0.81	1.00
^{60}Co (GL)	12.17 ± 0.50	12.490 ± 0.062	-2.6	-0.64	-0.44
^{137}Cs (GL)	2.29 ± 0.17	2.259 ± 0.020	1.4	0.18	0.24
^{152}Eu (GL)	20.00 ± 0.66	20.00 ± 0.15	0.0	0.00	0.00
^{241}Am (GL)	2.05 ± 0.26	1.8124 ± 0.0039	13.1	0.91	2.25


Deviation (%) of Laboratory 82
50
0
-50
60Co (GH)
134Cs (GH)
137Cs (GH)
154Eu (GH)
60Co (GL)
137Cs (GL)
152Eu (GL)
241Am (GL)

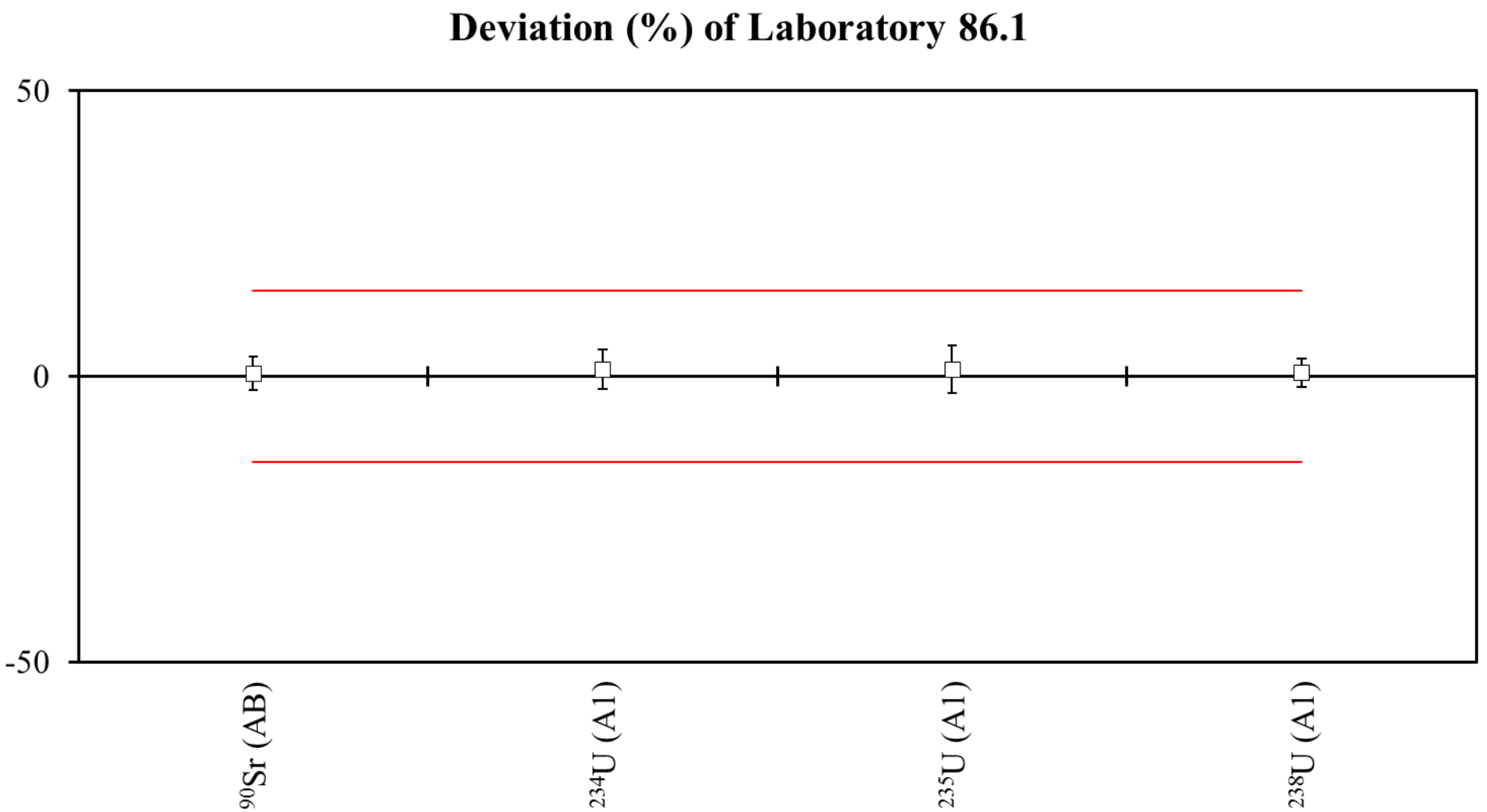
Radionuclide	Laboratory 82	NPL Assigned Value	Deviation /%	Zeta	Z Score
^{60}Co (GH)	5.42 ± 0.54	5.394 ± 0.012	0.5	0.05	0.08
^{134}Cs (GH)	4.94 ± 0.50	4.973 ± 0.034	-0.7	-0.07	-0.11
^{137}Cs (GH)	4.16 ± 0.42	4.125 ± 0.031	0.8	0.08	0.15
^{154}Eu (GH)	4.62 ± 0.47	4.600 ± 0.037	0.4	0.04	0.07
^{60}Co (GL)	12.8 ± 1.3	12.490 ± 0.062	2.5	0.24	0.43
^{137}Cs (GL)	2.01 ± 0.21	2.259 ± 0.020	-11.0	-1.18	-1.89
^{152}Eu (GL)	21.7 ± 2.2	20.00 ± 0.15	8.5	0.77	1.46
^{241}Am (GL)	2.30 ± 0.24	1.8124 ± 0.0039	26.9	2.03	4.62


Deviation (%) of Laboratory 83
50
0
-50
134Cs (GH)
137Cs (GH)
137Cs (GL)

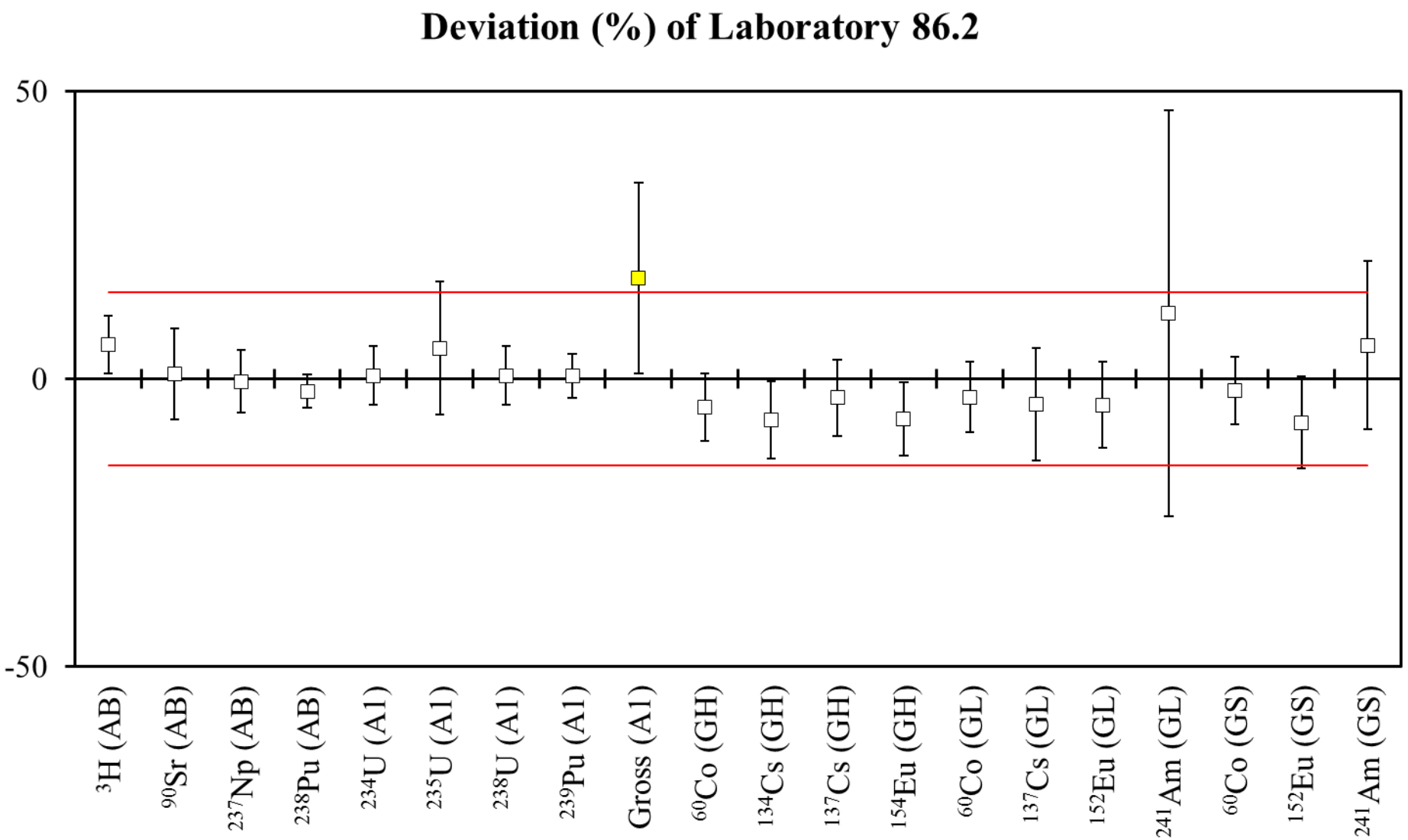
Radionuclide	Laboratory 83	NPL Assigned Value	Deviation /%	Zeta	Z Score
^{134}Cs (GH)	5.573 ± 0.050	4.973 ± 0.034	12.1	9.92	2.07
^{137}Cs (GH)	4.847 ± 0.056	4.125 ± 0.031	17.5	11.28	3.01
^{137}Cs (GL)	2.77 ± 0.11	2.259 ± 0.020	22.6	4.57	3.88


Deviation (%) of Laboratory 85
50
0
-50
^{60}Co (GH)
^{134}Cs (GH)
^{137}Cs (GH)
^{154}Eu (GH)

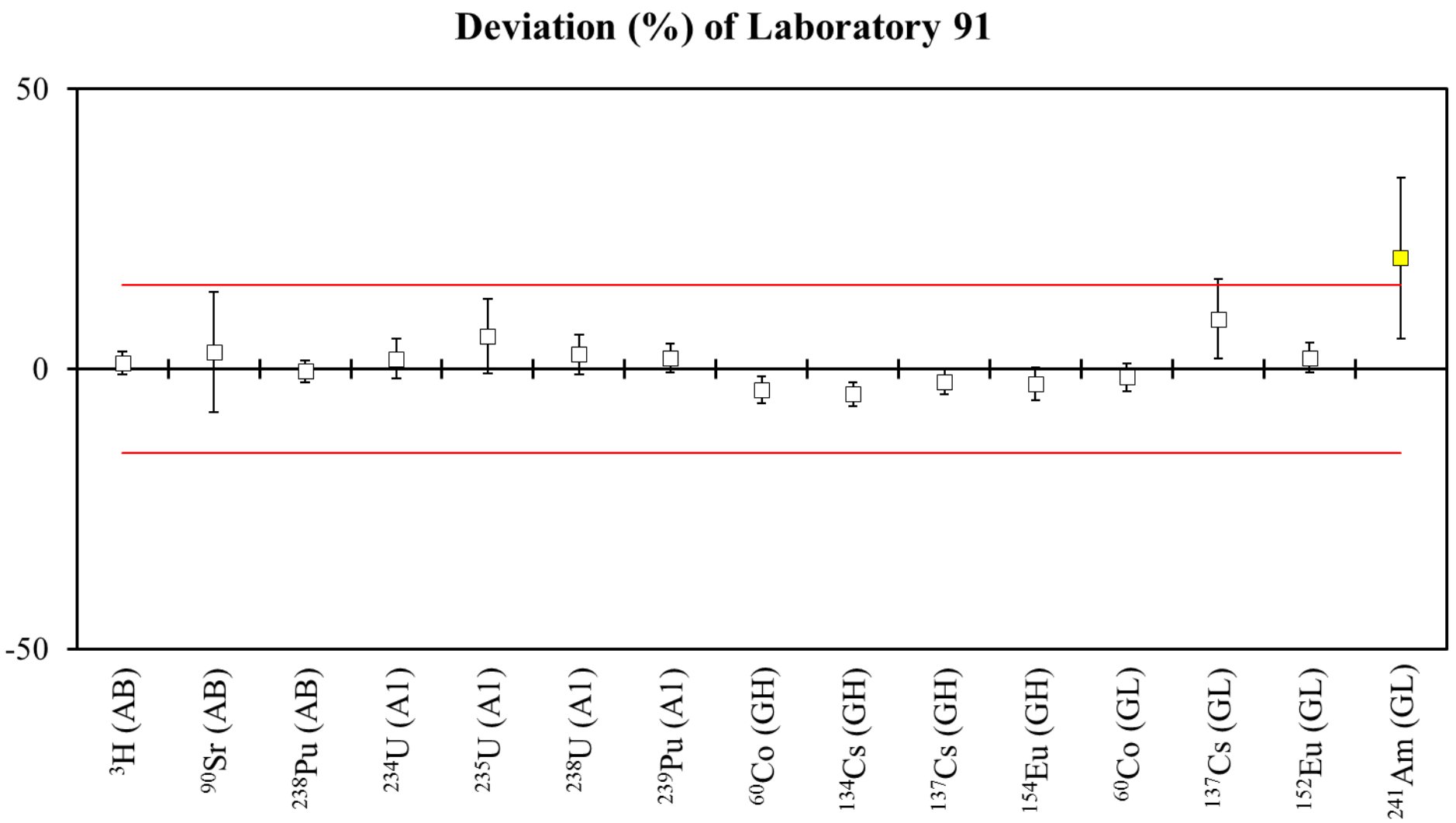
Radionuclide	Laboratory 85	NPL Assigned Value	Deviation /%	Zeta	Z Score
^{60}Co (GH)	5.58 ± 0.16	5.394 ± 0.012	3.4	1.16	0.59
^{134}Cs (GH)	4.65 ± 0.14	4.973 ± 0.034	-6.5	-2.24	-1.12
^{137}Cs (GH)	4.31 ± 0.10	4.125 ± 0.031	4.5	1.77	0.77
^{154}Eu (GH)	4.67 ± 0.75	4.600 ± 0.037	1.5	0.09	0.26


Deviation (%) of Laboratory 86.1
50
0
-50
^{90}Sr (AB)
^{234}U (A1)
^{235}U (A1)
^{238}U (A1)

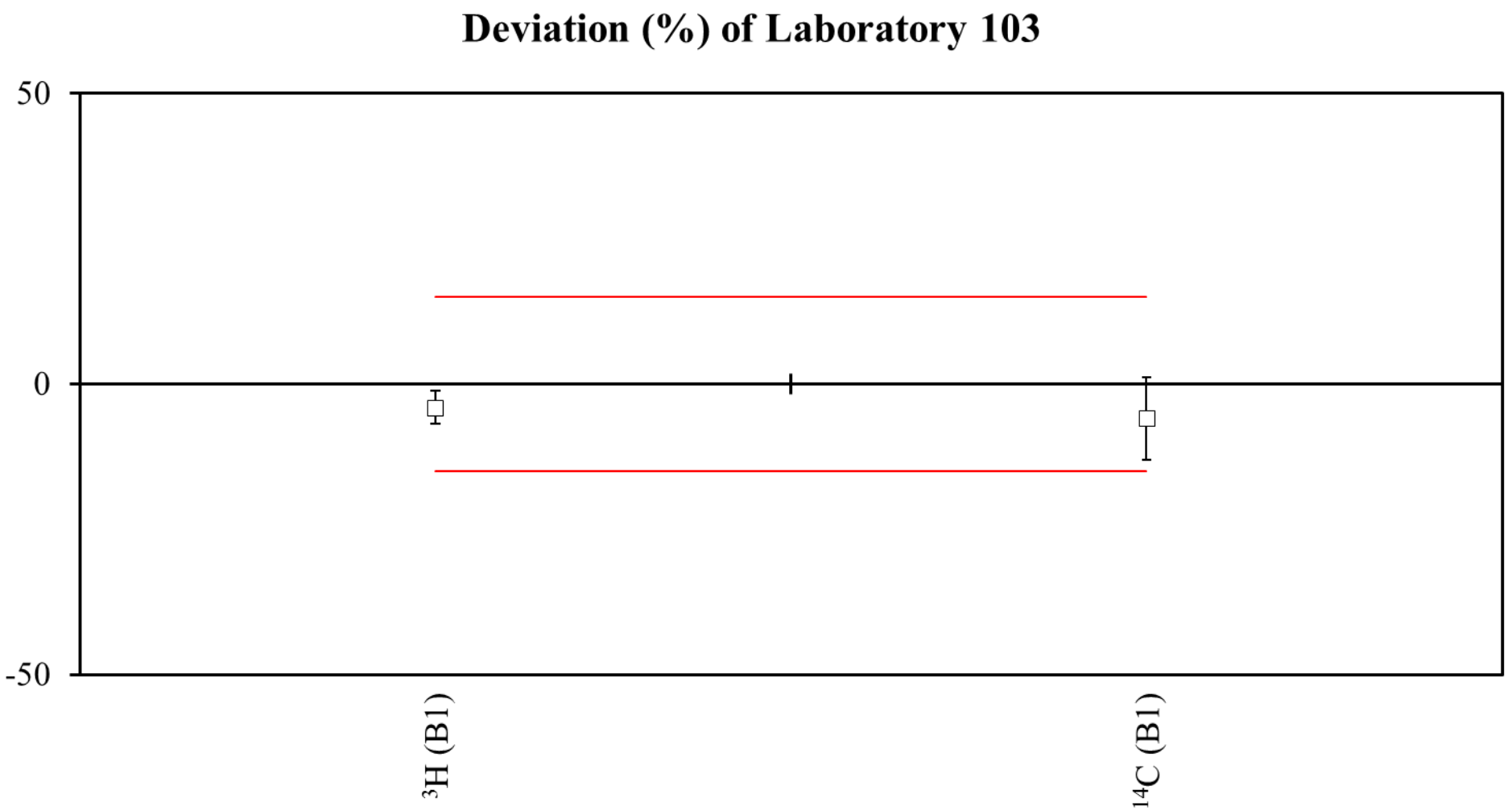
Radionuclide	Laboratory 86.1	NPL Assigned Value	Deviation /%	Zeta	Z Score
^{90}Sr (AB)	2.43 ± 0.07	2.418 ± 0.011	0.5	0.17	0.09
^{234}U (A1)	16.70 ± 0.50	16.50 ± 0.28	1.2	0.35	0.21
^{235}U (A1)	0.7970 ± 0.03	0.788 ± 0.013	1.1	0.28	0.20
^{238}U (A1)	16.6 ± 0.3	16.50 ± 0.28	0.6	0.24	0.10


Deviation (%) of Laboratory 86.2
50
0
-50
^{3}H (AB)
^{90}Sr (AB)
^{237}Np (AB)
^{238}Pu (AB)
^{234}U (A1)
^{235}U (A1)
^{238}U (A1)
^{239}Pu (A1)
Gross (A1)
^{60}Co (GH)
^{134}Cs (GH)
^{137}Cs (GH)
^{154}Eu (GH)
^{60}Co (GL)
^{137}Cs (GL)
^{152}Eu (GL)
^{241}Am (GL)
^{60}Co (GS)
^{152}Eu (GS)
^{241}Am (GS)

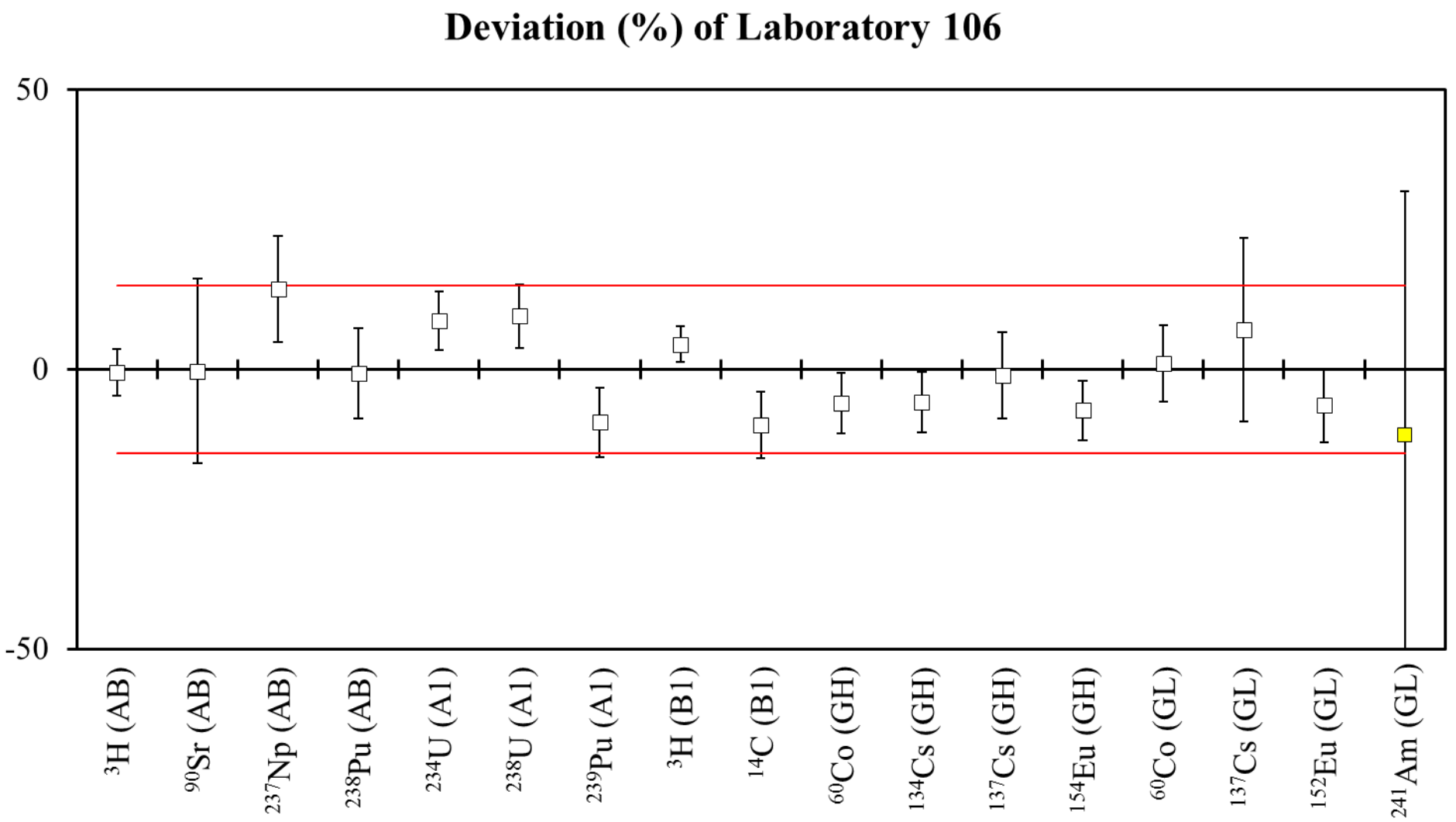
Radionuclide	Laboratory 86.2	NPL Assigned Value	Deviation /%	Zeta	Z Score
^{3}H (AB)	6.4 ± 0.3	6.037 ± 0.043	6.0	1.20	1.03
^{90}Sr (AB)	2.44 ± 0.19	2.418 ± 0.011	0.9	0.12	0.16
^{237}Np (AB)	7.40 ± 0.40	7.432 ± 0.074	-0.4	-0.08	-0.07
^{238}Pu (AB)	8.48 ± 0.25	8.666 ± 0.020	-2.1	-0.74	-0.37
^{234}U (A1)	16.60 ± 0.80	16.50 ± 0.28	0.6	0.12	0.10
^{235}U (A1)	0.83 ± 0.09	0.788 ± 0.013	5.3	0.46	0.92
^{238}U (A1)	16.60 ± 0.80	16.50 ± 0.28	0.6	0.12	0.10
^{239}Pu (A1)	21.00 ± 0.80	20.879 ± 0.039	0.6	0.15	0.10
Gross Alpha (A1)	55.0 ± 6.0	46.8 ± 4.2	17.5	1.12	3.01
^{60}Co (GH)	5.13 ± 0.32	5.394 ± 0.012	-4.9	-0.82	-0.84
^{134}Cs (GH)	4.62 ± 0.33	4.973 ± 0.034	-7.1	-1.06	-1.22
^{137}Cs (GH)	3.99 ± 0.27	4.125 ± 0.031	-3.3	-0.50	-0.56
^{154}Eu (GH)	4.28 ± 0.29	4.600 ± 0.037	-7.0	-1.09	-1.19
^{60}Co (GL)	12.10 ± 0.77	12.490 ± 0.062	-3.1	-0.50	-0.54
^{137}Cs (GL)	2.16 ± 0.22	2.259 ± 0.020	-4.4	-0.45	-0.75
^{152}Eu (GL)	19.1 ± 1.5	20.00 ± 0.15	-4.5	-0.60	-0.77
^{241}Am (GL)	2.02 ± 0.64	1.8124 ± 0.0039	11.5	0.32	1.97
^{60}Co (GS)	1.440 ± 0.085	1.470 ± 0.017	-2.0	-0.35	-0.35
^{152}Eu (GS)	0.7110 ± 0.06	0.769 ± 0.012	-7.5	-0.95	-1.30
^{241}Am (GS)	2.54 ± 0.28	2.40 ± 0.20	5.8	0.41	1.00


Deviation (%) of Laboratory 91
50
0
-50
^{3}H (AB)
^{90}Sr (AB)
^{238}Pu (AB)
^{234}U (A1)
^{235}U (A1)
^{238}U (A1)
^{239}Pu (A1)
^{60}Co (GH)
^{134}Cs (GH)
^{137}Cs (GH)
^{154}Eu (GH)
^{60}Co (GL)
^{137}Cs (GL)
^{152}Eu (GL)
^{241}Am (GL)

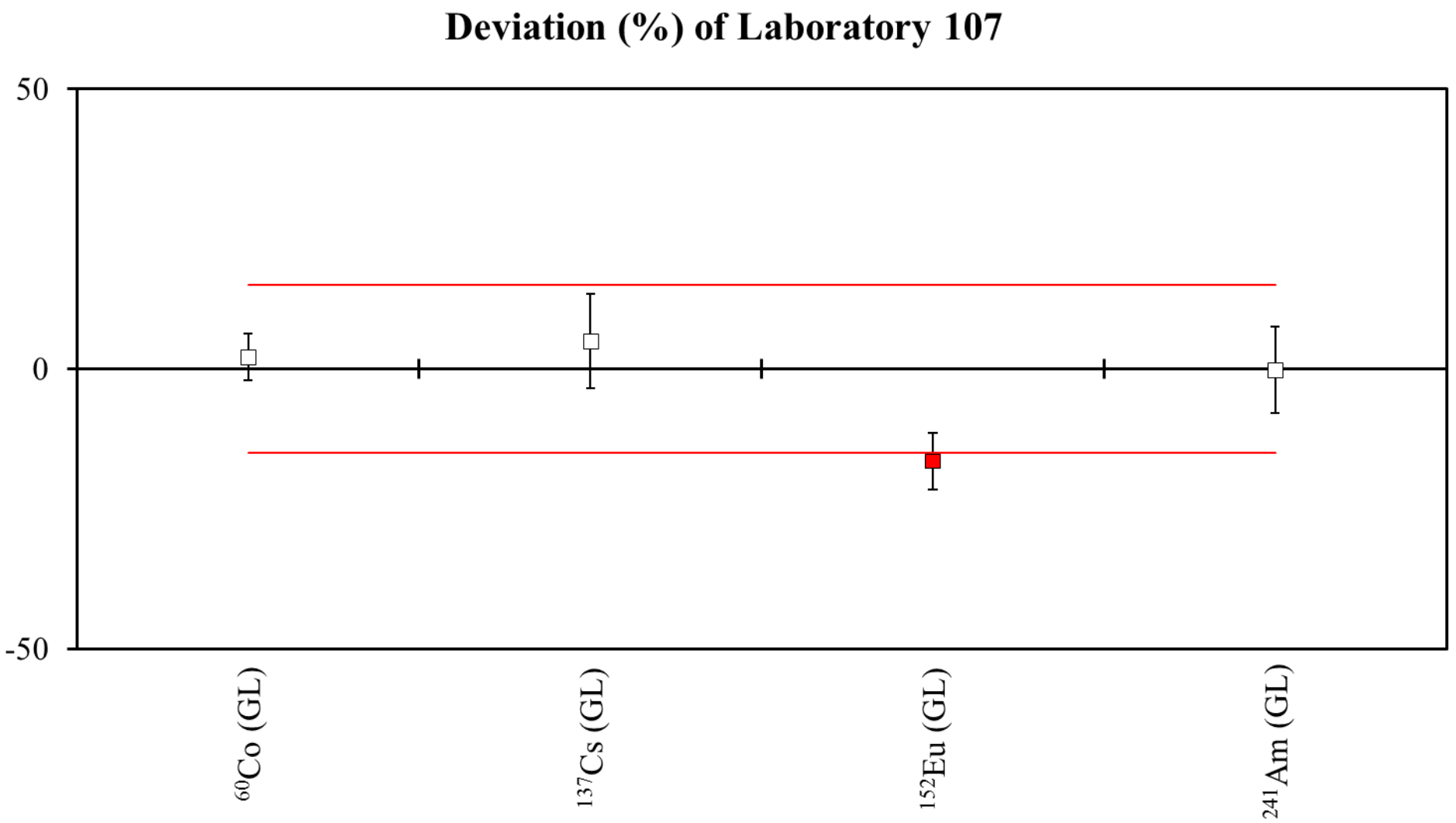
Radionuclide	Laboratory 91	NPL Assigned Value	Deviation /%	Zeta	Z Score
^{3}H (AB)	6.10 ± 0.12	6.037 ± 0.043	1.0	0.49	0.18
^{90}Sr (AB)	2.49 ± 0.26	2.418 ± 0.011	3.0	0.28	0.51
^{238}Pu (AB)	8.63 ± 0.17	8.666 ± 0.020	-0.4	-0.21	-0.07
^{234}U (A1)	16.80 ± 0.50	16.50 ± 0.28	1.8	0.52	0.31
^{235}U (A1)	0.834 ± 0.050	0.788 ± 0.013	5.8	0.89	1.00
^{238}U (A1)	16.93 ± 0.51	16.50 ± 0.28	2.6	0.74	0.45
^{239}Pu (A1)	21.28 ± 0.53	20.879 ± 0.039	1.9	0.75	0.33
^{60}Co (GH)	5.19 ± 0.13	5.394 ± 0.012	-3.8	-1.56	-0.65
^{134}Cs (GH)	4.75 ± 0.10	4.973 ± 0.034	-4.5	-2.11	-0.77
^{137}Cs (GH)	4.03 ± 0.09	4.125 ± 0.031	-2.3	-1.00	-0.40
^{154}Eu (GH)	4.48 ± 0.13	4.600 ± 0.037	-2.6	-0.89	-0.45
^{60}Co (GL)	12.3 ± 0.3	12.490 ± 0.062	-1.5	-0.62	-0.26
^{137}Cs (GL)	2.46 ± 0.16	2.259 ± 0.020	8.9	1.25	1.53
^{152}Eu (GL)	20.40 ± 0.50	20.00 ± 0.15	2.0	0.77	0.34
^{241}Am (GL)	2.17 ± 0.26	1.8124 ± 0.0039	19.7	1.38	3.39


Deviation (%) of Laboratory 103
50
0
-50
^{3}H (B1)
^{14}C (B1)

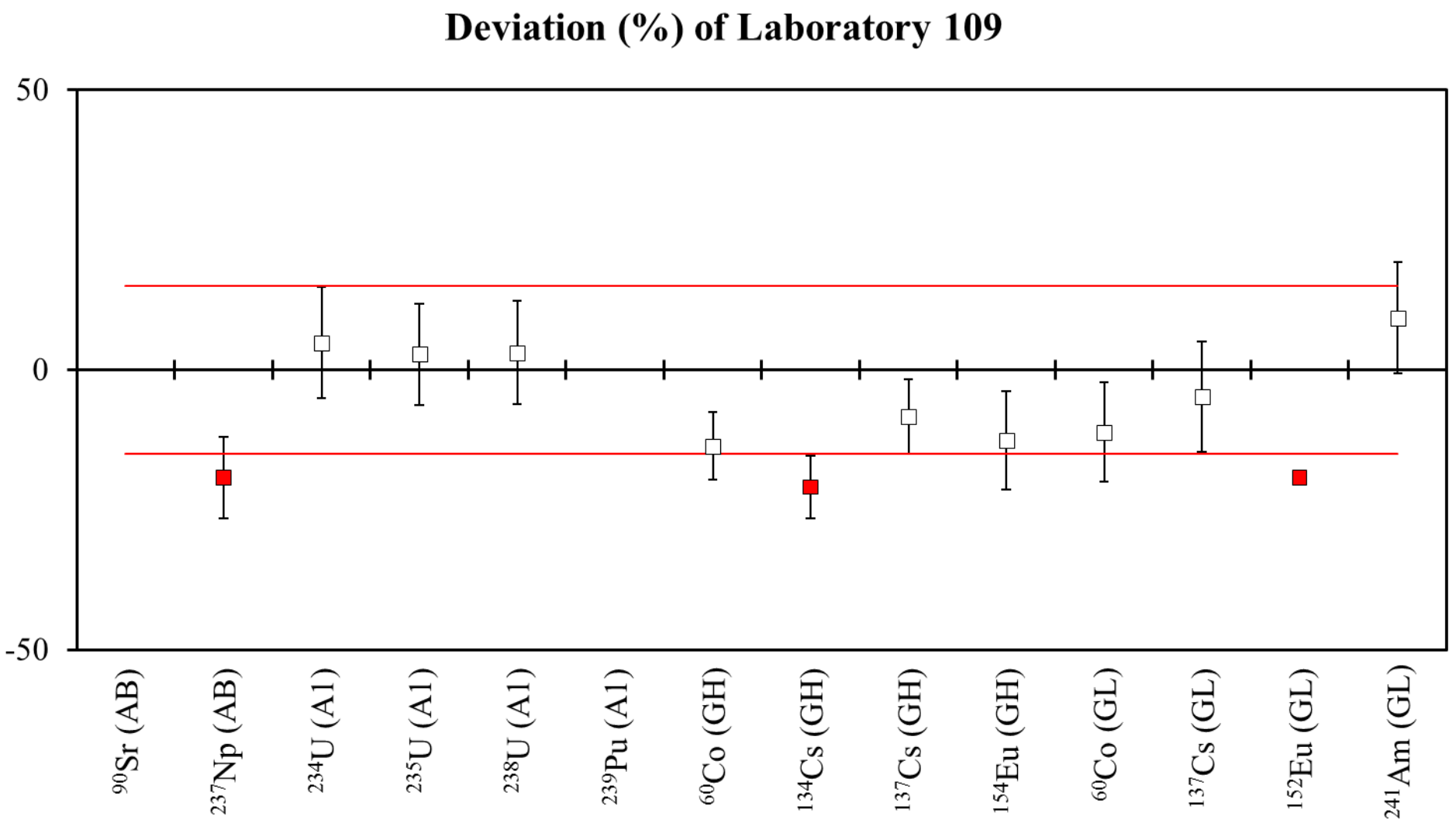
Radionuclide	Laboratory 103	NPL Assigned Value	Deviation /%	Zeta	Z Score
^{3}H (B1)	0.710 ± 0.020	0.7400 ± 0.0052	-4.1	-1.45	-0.70
^{14}C (B1)	0.40 ± 0.03	0.4254 ± 0.0028	-6.0	-0.84	-1.03


Deviation (%) of Laboratory 106
50
0
-50
^{3}H (AB)
^{90}Sr (AB)
^{237}Np (AB)
^{238}Pu (AB)
^{234}U (A1)
^{238}U (A1)
^{239}Pu (A1)
^{3}H (B1)
^{14}C (B1)
^{60}Co (GH)
^{134}Cs (GH)
^{137}Cs (GH)
^{154}Eu (GH)
^{60}Co (GL)
^{137}Cs (GL)
^{152}Eu (GL)
^{241}Am (GL)

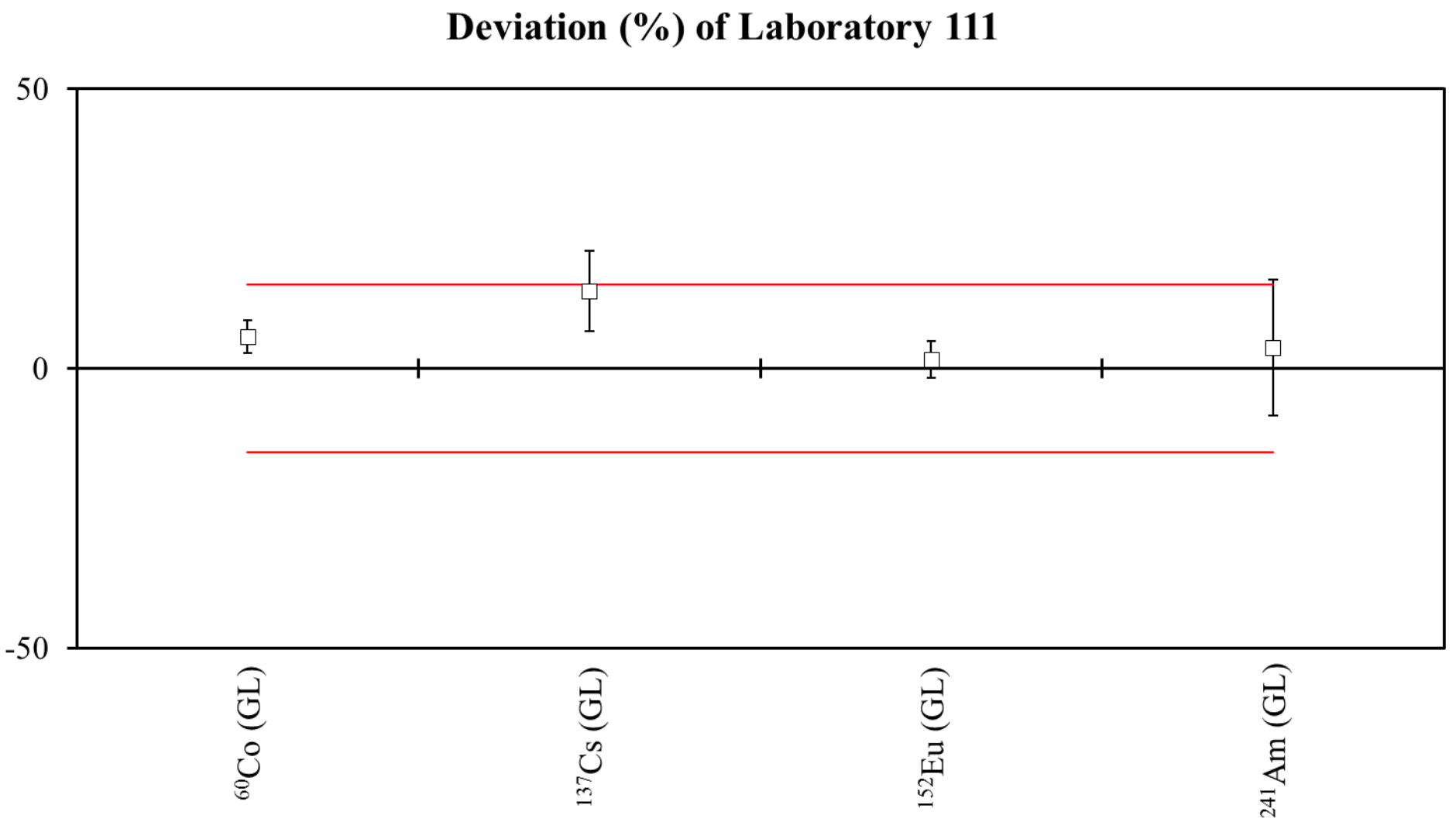
Radionuclide	Laboratory 106	NPL Assigned Value	Deviation /%	Zeta	Z Score
^{3}H (AB)	6.00 ± 0.25	6.037 ± 0.043	-0.6	-0.15	-0.11
^{90}Sr (AB)	2.41 ± 0.40	2.418 ± 0.011	-0.3	-0.02	-0.06
^{237}Np (AB)	8.5 ± 0.7	7.432 ± 0.074	14.4	1.52	2.47
^{238}Pu (AB)	8.6 ± 0.7	8.666 ± 0.020	-0.8	-0.09	-0.13
^{234}U (A1)	17.93 ± 0.80	16.50 ± 0.28	8.7	1.69	1.49
^{238}U (A1)	18.07 ± 0.88	16.50 ± 0.28	9.5	1.70	1.63
^{239}Pu (A1)	18.9 ± 1.3	20.879 ± 0.039	-9.5	-1.52	-1.63
^{3}H (B1)	0.773 ± 0.023	0.7400 ± 0.0052	4.5	1.40	0.77
^{14}C (B1)	0.383 ± 0.025	0.4254 ± 0.0028	-10.0	-1.69	-1.71
^{60}Co (GH)	5.07 ± 0.29	5.394 ± 0.012	-6.0	-1.12	-1.03
^{134}Cs (GH)	4.68 ± 0.27	4.973 ± 0.034	-5.9	-1.08	-1.01
^{137}Cs (GH)	4.08 ± 0.32	4.125 ± 0.031	-1.1	-0.14	-0.19
^{154}Eu (GH)	4.26 ± 0.24	4.600 ± 0.037	-7.4	-1.40	-1.27
^{60}Co (GL)	12.62 ± 0.85	12.490 ± 0.062	1.0	0.15	0.18
^{137}Cs (GL)	2.42 ± 0.37	2.259 ± 0.020	7.1	0.43	1.22
^{152}Eu (GL)	18.7 ± 1.3	20.00 ± 0.15	-6.5	-0.99	-1.12
^{241}Am (GL)	1.60 ± 0.79	1.8124 ± 0.0039	-11.7	-0.27	-2.01


Deviation (%) of Laboratory 107
50
0
-50
^{60}Co (GL)
^{137}Cs (GL)
^{152}Eu (GL)
^{241}Am (GL)

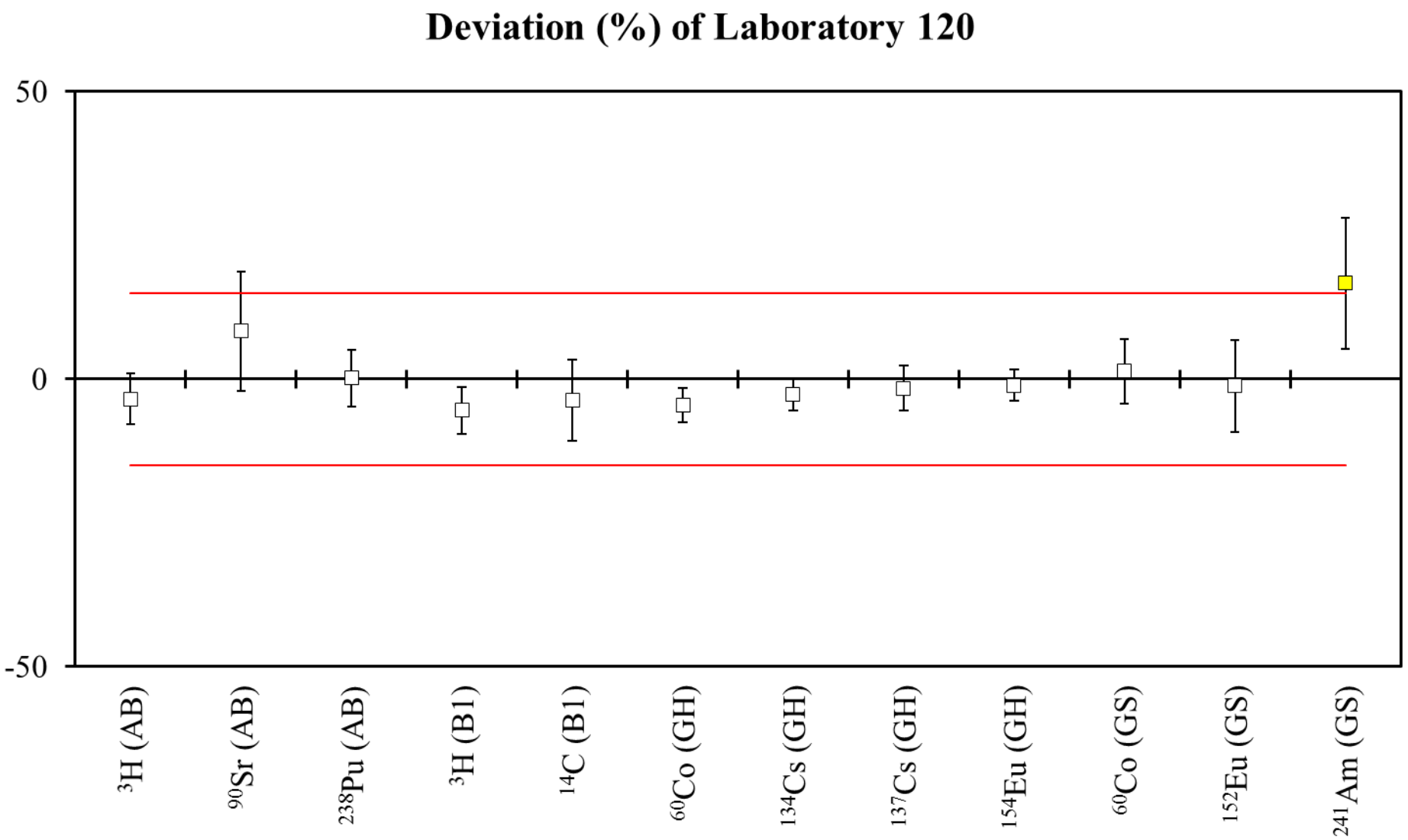
Radionuclide	Laboratory 107	NPL Assigned Value	Deviation /%	Zeta	Z Score
^{60}Co (GL)	12.75 ± 0.51	12.490 ± 0.062	2.1	0.51	0.36
^{137}Cs (GL)	2.37 ± 0.19	2.259 ± 0.020	4.9	0.58	0.84
^{152}Eu (GL)	16.650 ± 1.0	20.00 ± 0.15	-16.5	-3.26	-2.83
^{241}Am (GL)	1.81 ± 0.14	1.8124 ± 0.0039	-0.1	-0.02	-0.02


Deviation (%) of Laboratory 109
50
0
-50
90Sr (AB)
237Np (AB)
234U (A1)
235U (A1)
238U (A1)
239Pu (A1)
60Co (GH)
134Cs (GH)
137Cs (GH)
154Eu (GH)
60Co (GL)
137Cs (GL)
152Eu (GL)
241Am (GL)

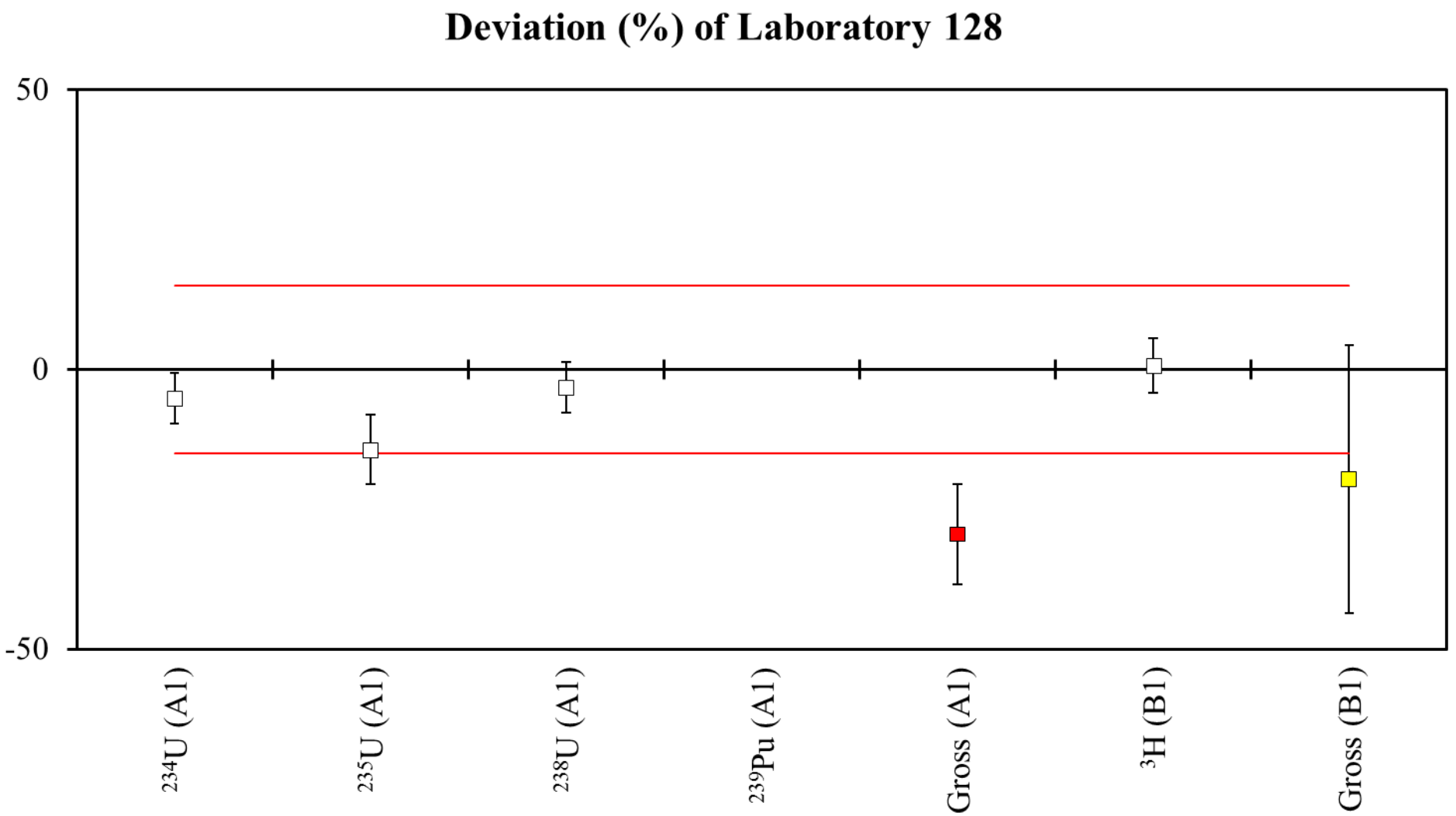
Radionuclide	Laboratory 109	NPL Assigned Value	Deviation /%	Zeta	Z Score
^{90}Sr (AB)	6.710 ± 0.6	2.418 ± 0.011	177.5	7.15	30.48
^{237}Np (AB)	6.00 ± 0.54	7.432 ± 0.074	-19.3	-2.63	-3.31
^{234}U (A1)	17.3 ± 1.6	16.50 ± 0.28	4.8	0.49	0.83
^{235}U (A1)	0.81 ± 0.07	0.788 ± 0.013	2.8	0.31	0.48
^{238}U (A1)	17.0 ± 1.5	16.50 ± 0.28	3.0	0.33	0.52
^{239}Pu (A1)	8.07 ± 0.73	20.879 ± 0.039	-61.3	-17.52	-10.54
^{60}Co (GH)	4.66 ± 0.33	5.394 ± 0.012	-13.6	-2.22	-2.34
^{134}Cs (GH)	3.93 ± 0.28	4.973 ± 0.034	-21.0	-3.70	-3.60
^{137}Cs (GH)	3.78 ± 0.27	4.125 ± 0.031	-8.4	-1.27	-1.44
^{154}Eu (GH)	4.02 ± 0.40	4.600 ± 0.037	-12.6	-1.44	-2.17
^{60}Co (GL)	11.1 ± 1.1	12.490 ± 0.062	-11.1	-1.26	-1.91
^{137}Cs (GL)	2.15 ± 0.22	2.259 ± 0.020	-4.8	-0.49	-0.83
^{152}Eu (GL)	16.14 ± 0.16	20.00 ± 0.15	-19.3	-17.60	-3.31
^{241}Am (GL)	1.98 ± 0.18	1.8124 ± 0.0039	9.2	0.93	1.59


Deviation (%) of Laboratory 111
50
0
-50
^{60}Co (GL)
^{137}Cs (GL)
^{152}Eu (GL)
^{241}Am (GL)

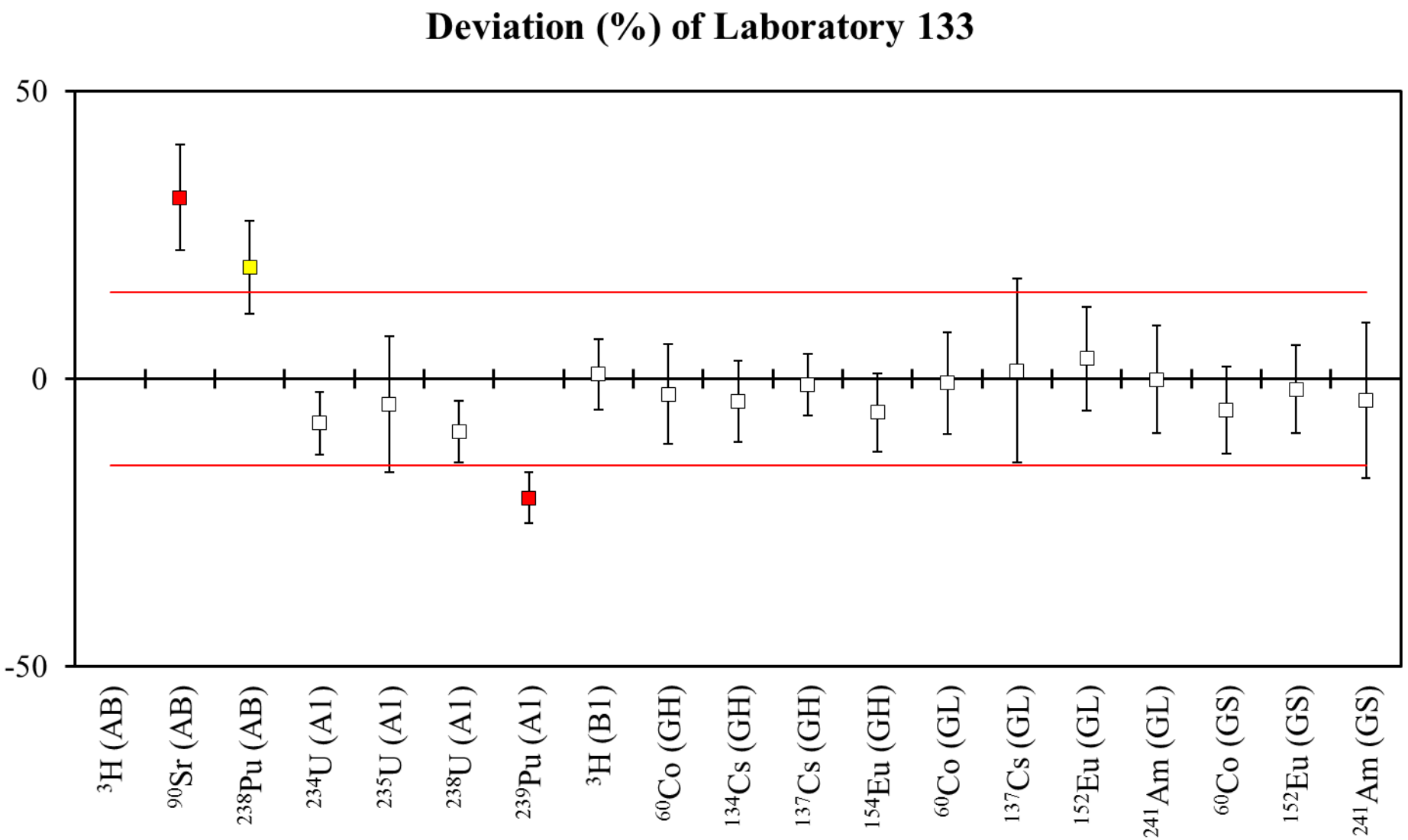
Radionuclide	Laboratory 111	NPL Assigned Value	Deviation /%	Zeta	Z Score
^{60}Co (GL)	13.20 ± 0.36	12.490 ± 0.062	5.7	1.94	0.98
^{137}Cs (GL)	2.57 ± 0.16	2.259 ± 0.020	13.8	1.93	2.36
^{152}Eu (GL)	20.30 ± 0.64	20.00 ± 0.15	1.5	0.46	0.26
^{241}Am (GL)	1.88 ± 0.22	1.8124 ± 0.0039	3.7	0.31	0.64


Deviation (%) of Laboratory 120
50
0
-50
^{3}H (AB)
^{90}Sr (AB)
^{238}Pu (AB)
^{3}H (B1)
^{14}C (B1)
^{60}Co (GH)
^{134}Cs (GH)
^{137}Cs (GH)
^{154}Eu (GH)
^{60}Co (GS)
^{152}Eu (GS)
^{241}Am (GS)

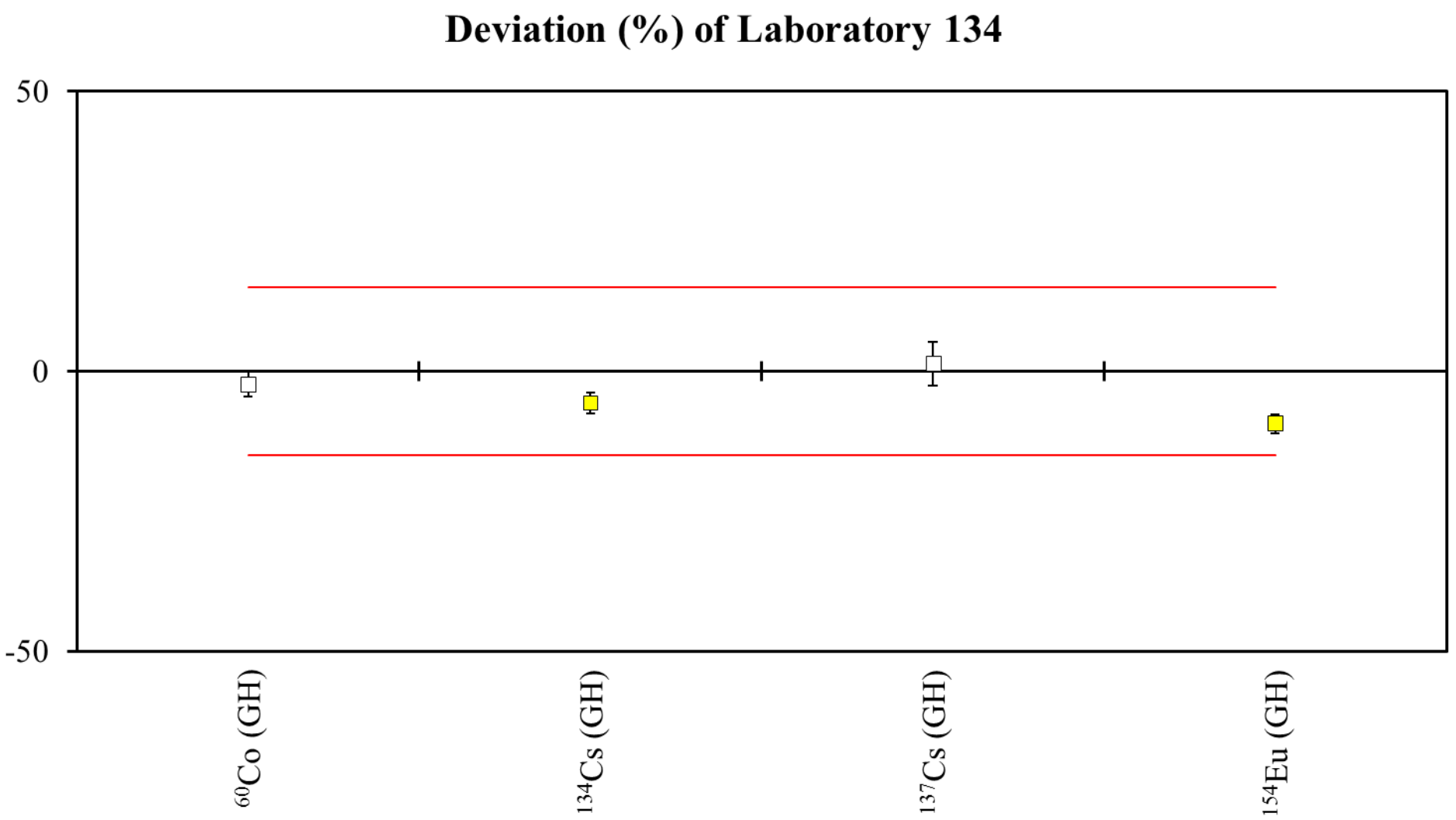
Radionuclide	Laboratory 120	NPL Assigned Value	Deviation /%	Zeta	Z Score
^{3}H (AB)	5.83 ± 0.26	6.037 ± 0.043	-3.4	-0.79	-0.59
^{90}Sr (AB)	2.62 ± 0.25	2.418 ± 0.011	8.4	0.81	1.43
^{238}Pu (AB)	8.68 ± 0.43	8.666 ± 0.020	0.2	0.03	0.03
^{3}H (B1)	0.70 ± 0.03	0.7400 ± 0.0052	-5.4	-1.31	-0.93
^{14}C (B1)	0.41 ± 0.03	0.4254 ± 0.0028	-3.6	-0.51	-0.62
^{60}Co (GH)	5.15 ± 0.16	5.394 ± 0.012	-4.5	-1.52	-0.78
^{134}Cs (GH)	4.84 ± 0.13	4.973 ± 0.034	-2.7	-0.99	-0.46
^{137}Cs (GH)	4.06 ± 0.16	4.125 ± 0.031	-1.6	-0.40	-0.27
^{154}Eu (GH)	4.55 ± 0.12	4.600 ± 0.037	-1.1	-0.40	-0.19
^{60}Co (GS)	1.490 ± 0.080	1.470 ± 0.017	1.4	0.24	0.23
^{152}Eu (GS)	0.76 ± 0.06	0.769 ± 0.012	-1.2	-0.15	-0.20
^{241}Am (GS)	2.80 ± 0.14	2.40 ± 0.20	16.7	1.64	2.86


Deviation (%) of Laboratory 128
50
0
-50
234U (A1)
235U (A1)
238U (A1)
239Pu (A1)
Gross (A1)
3H (B1)
Gross (B1)

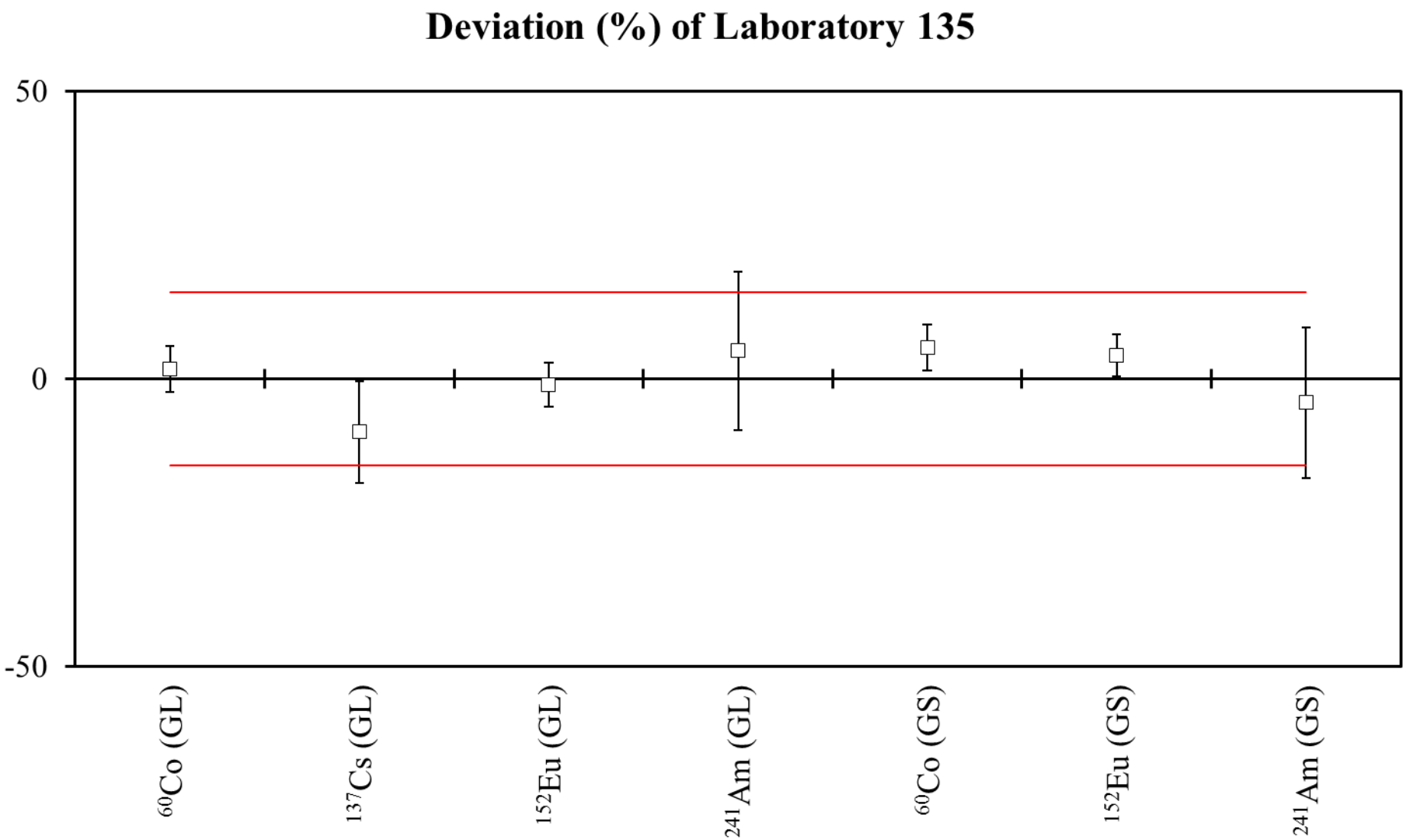
Radionuclide	Laboratory 128	NPL Assigned Value	Deviation /%	Zeta	Z Score
^{234}U (A1)	15.64 ± 0.69	16.50 ± 0.28	-5.2	-1.15	-0.90
^{235}U (A1)	0.675 ± 0.048	0.788 ± 0.013	-14.3	-2.27	-2.46
^{238}U (A1)	15.960 ± 0.7	16.50 ± 0.28	-3.3	-0.72	-0.56
^{239}Pu (A1)	1.01 ± 0.07	20.879 ± 0.039	-95.2	-247.96	-16.34
Gross Alpha (A1)	33.0 ± 3.0	46.8 ± 4.2	-29.5	-2.67	-5.06
^{3}H (B1)	0.745 ± 0.036	0.7400 ± 0.0052	0.7	0.14	0.12
Gross Beta (B1)	0.755 ± 0.018	0.94 ± 0.28	-19.7	-0.66	-3.38


Deviation (%) of Laboratory 133
50
0
-50
^{3}H (AB)
^{90}Sr (AB)
^{238}Pu (AB)
^{234}U (A1)
^{235}U (A1)
^{238}U (A1)
^{239}Pu (A1)
^{3}H (B1)
^{60}Co (GH)
^{134}Cs (GH)
^{137}Cs (GH)
^{154}Eu (GH)
^{60}Co (GL)
^{137}Cs (GL)
^{152}Eu (GL)
^{241}Am (GL)
^{60}Co (GS)
^{152}Eu (GS)
^{241}Am (GS)

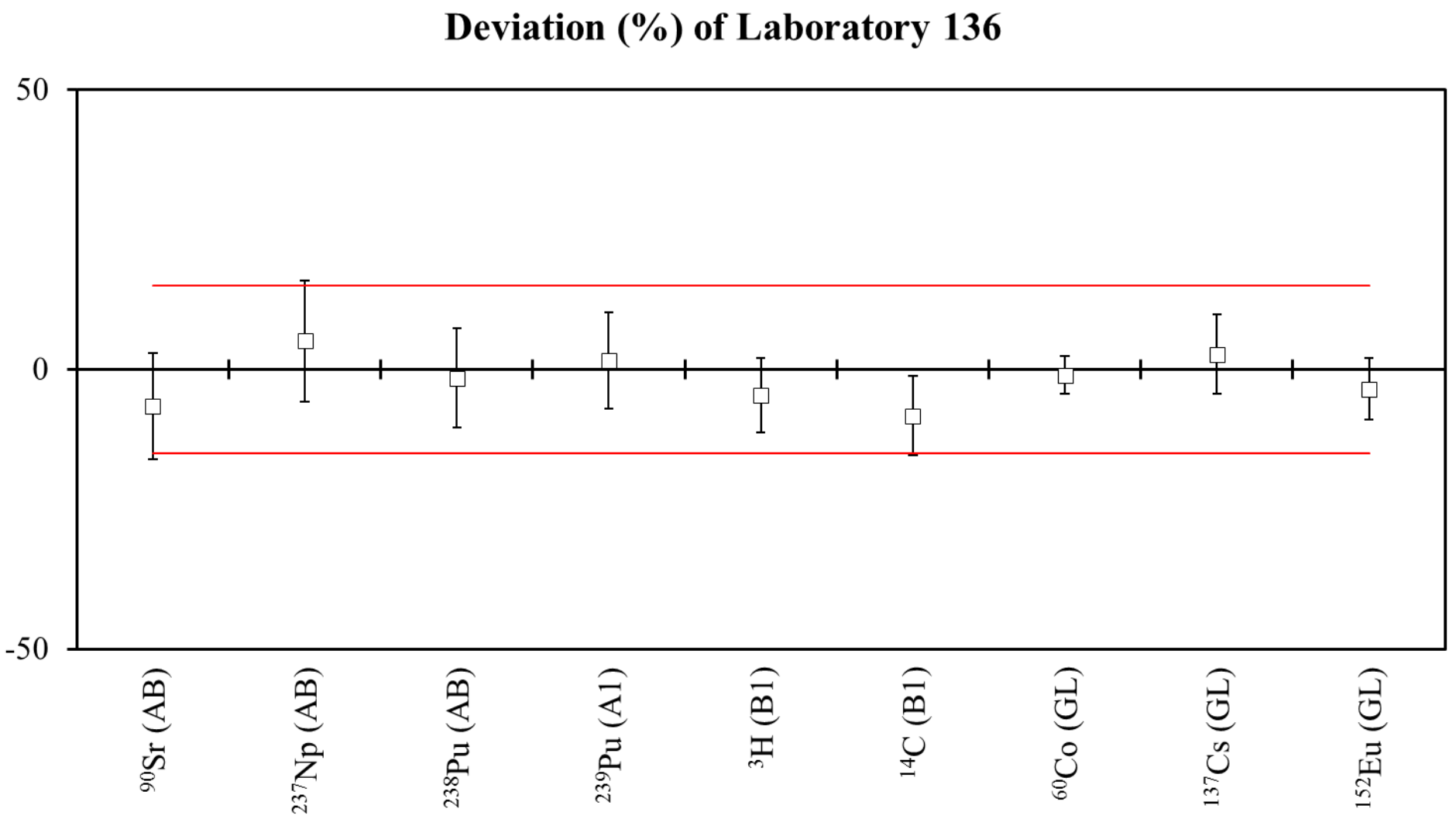
Radionuclide	Laboratory 133	NPL Assigned Value	Deviation /%	Zeta	Z Score
^{3}H (AB)	2.190 ± 0.083	6.037 ± 0.043	-63.7	-41.15	-10.94
^{90}Sr (AB)	3.18 ± 0.22	2.418 ± 0.011	31.5	3.46	5.41
^{238}Pu (AB)	10.340 ± 0.7	8.666 ± 0.020	19.3	2.39	3.32
^{234}U (A1)	15.23 ± 0.86	16.50 ± 0.28	-7.7	-1.40	-1.32
^{235}U (A1)	0.753 ± 0.092	0.788 ± 0.013	-4.4	-0.38	-0.76
^{238}U (A1)	14.98 ± 0.85	16.50 ± 0.28	-9.2	-1.70	-1.58
^{239}Pu (A1)	16.56 ± 0.92	20.879 ± 0.039	-20.7	-4.69	-3.55
^{3}H (B1)	0.746 ± 0.045	0.7400 ± 0.0052	0.8	0.13	0.14
^{60}Co (GH)	5.25 ± 0.47	5.394 ± 0.012	-2.7	-0.31	-0.46
^{134}Cs (GH)	4.78 ± 0.35	4.973 ± 0.034	-3.9	-0.55	-0.67
^{137}Cs (GH)	4.08 ± 0.22	4.125 ± 0.031	-1.1	-0.20	-0.19
^{154}Eu (GH)	4.33 ± 0.31	4.600 ± 0.037	-5.9	-0.86	-1.01
^{60}Co (GL)	12.4 ± 1.1	12.490 ± 0.062	-0.7	-0.08	-0.12
^{137}Cs (GL)	2.29 ± 0.36	2.259 ± 0.020	1.4	0.09	0.24
^{152}Eu (GL)	20.7 ± 1.8	20.00 ± 0.15	3.5	0.39	0.60
^{241}Am (GL)	1.81 ± 0.17	1.8124 ± 0.0039	-0.1	-0.01	-0.02
^{60}Co (GS)	1.39 ± 0.11	1.470 ± 0.017	-5.4	-0.72	-0.93
^{152}Eu (GS)	0.755 ± 0.058	0.769 ± 0.012	-1.8	-0.24	-0.31
^{241}Am (GS)	2.31 ± 0.26	2.40 ± 0.20	-3.7	-0.27	-0.64


Deviation (%) of Laboratory 134
50
0
-50
^{60}Co (GH)
^{134}Cs (GH)
^{137}Cs (GH)
^{154}Eu (GH)

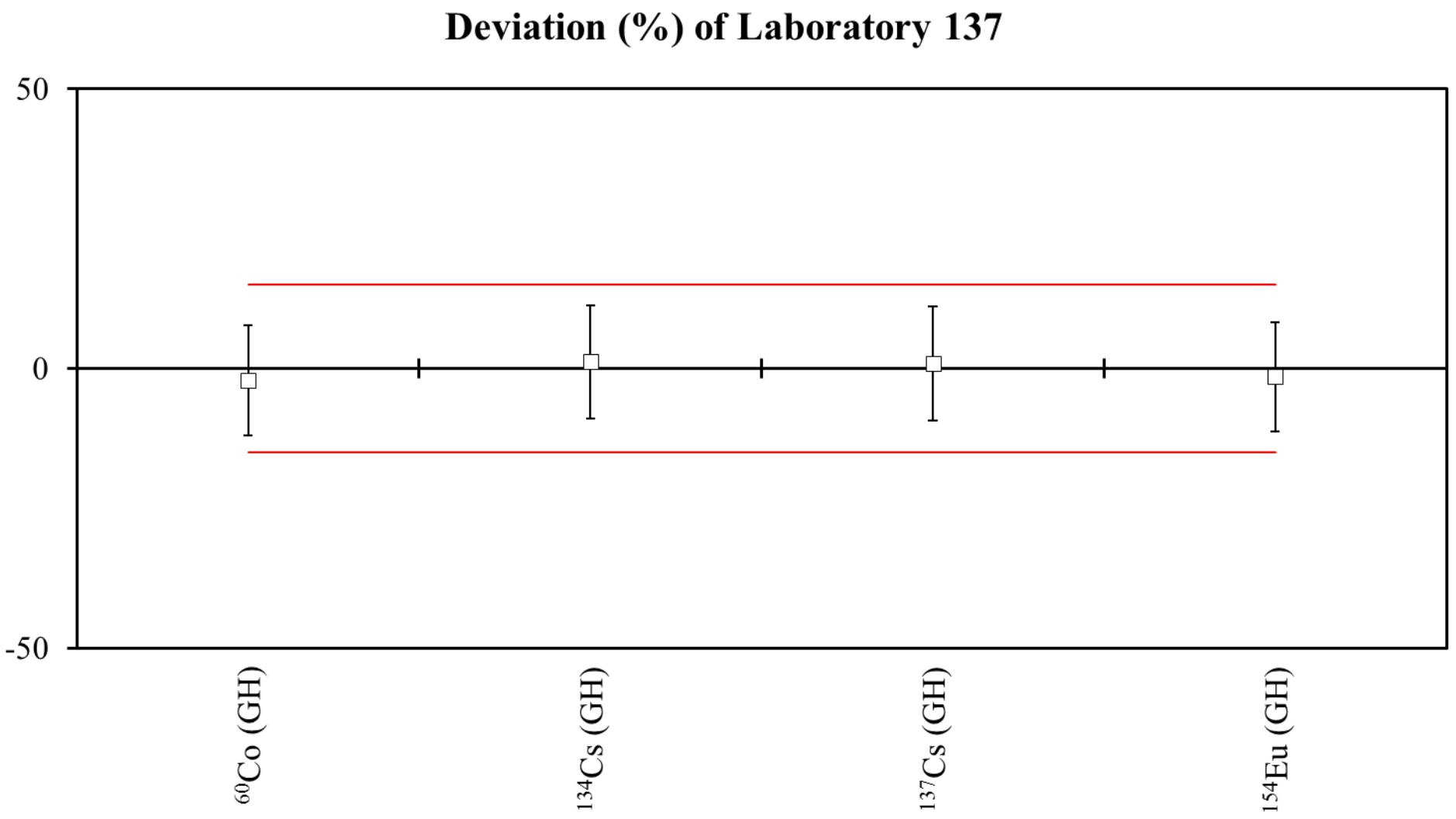
Radionuclide	Laboratory 134	NPL Assigned Value	Deviation /%	Zeta	Z Score
^{60}Co (GH)	5.27 ± 0.12	5.394 ± 0.012	-2.3	-1.03	-0.39
^{134}Cs (GH)	4.69 ± 0.09	4.973 ± 0.034	-5.7	-2.94	-0.98
^{137}Cs (GH)	4.18 ± 0.16	4.125 ± 0.031	1.3	0.34	0.23
^{154}Eu (GH)	4.17 ± 0.07	4.600 ± 0.037	-9.3	-5.43	-1.61


Deviation (%) of Laboratory 135
50
0
-50
60Co (GL)
137Cs (GL)
152Eu (GL)
241Am (GL)
60Co (GS)
152Eu (GS)
241Am (GS)

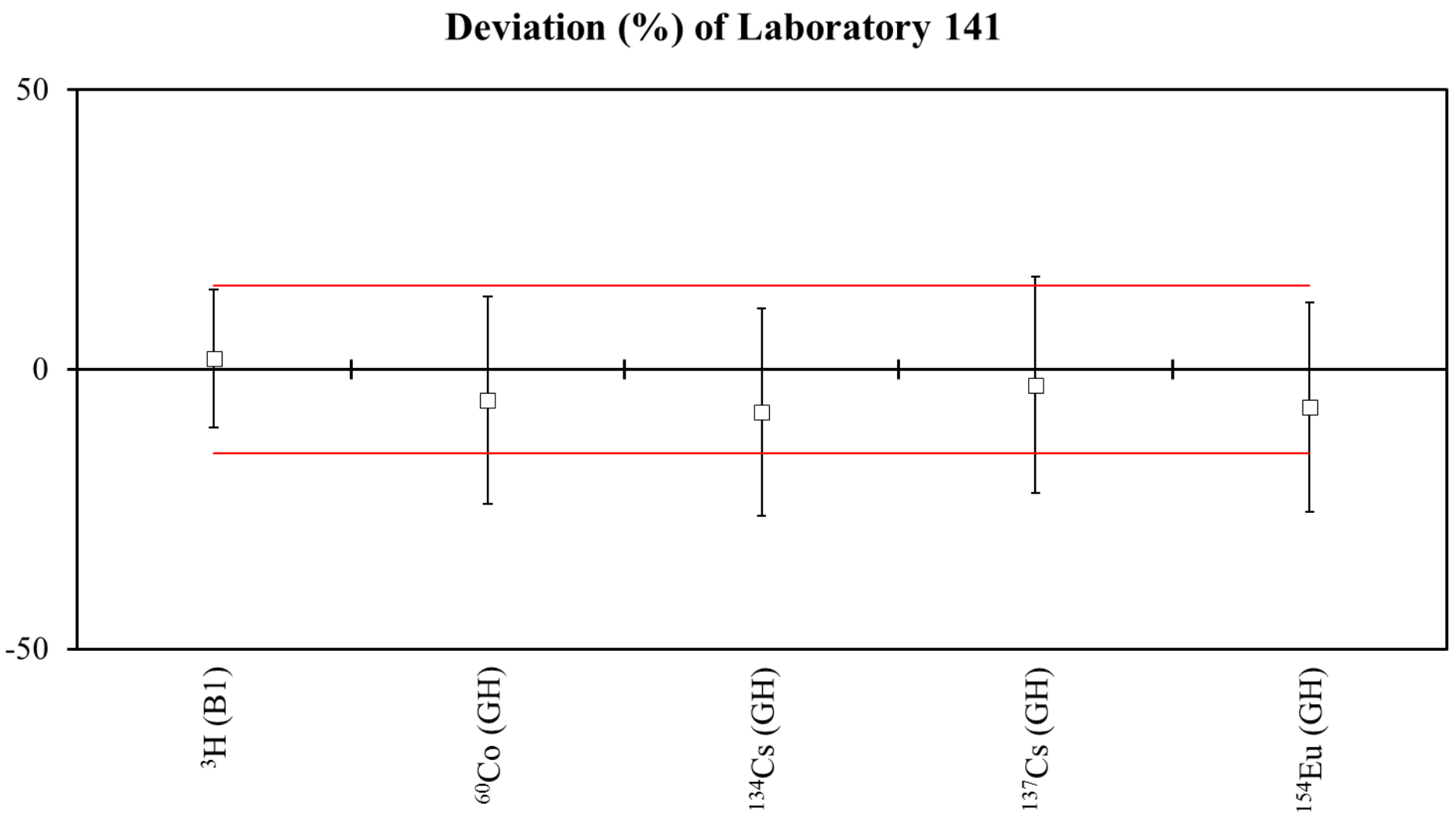
Radionuclide	Laboratory 135	NPL Assigned Value	Deviation /%	Zeta	Z Score
^{60}Co (GL)	12.70 ± 0.50	12.490 ± 0.062	1.7	0.42	0.29
^{137}Cs (GL)	2.05 ± 0.20	2.259 ± 0.020	-9.3	-1.04	-1.59
^{152}Eu (GL)	19.80 ± 0.75	20.00 ± 0.15	-1.0	-0.26	-0.17
^{241}Am (GL)	1.90 ± 0.25	1.8124 ± 0.0039	4.8	0.35	0.83
^{60}Co (GS)	1.550 ± 0.055	1.470 ± 0.017	5.4	1.39	0.93
^{152}Eu (GS)	0.800 ± 0.025	0.769 ± 0.012	4.0	1.12	0.69
^{241}Am (GS)	2.30 ± 0.25	2.40 ± 0.20	-4.2	-0.31	-0.72


Deviation (%) of Laboratory 136
50
0
-50
90Sr (AB)
237Np (AB)
238Pu (AB)
239Pu (A1)
3H (B1)
14C (B1)
60Co (GL)
137Cs (GL)
152Eu (GL)

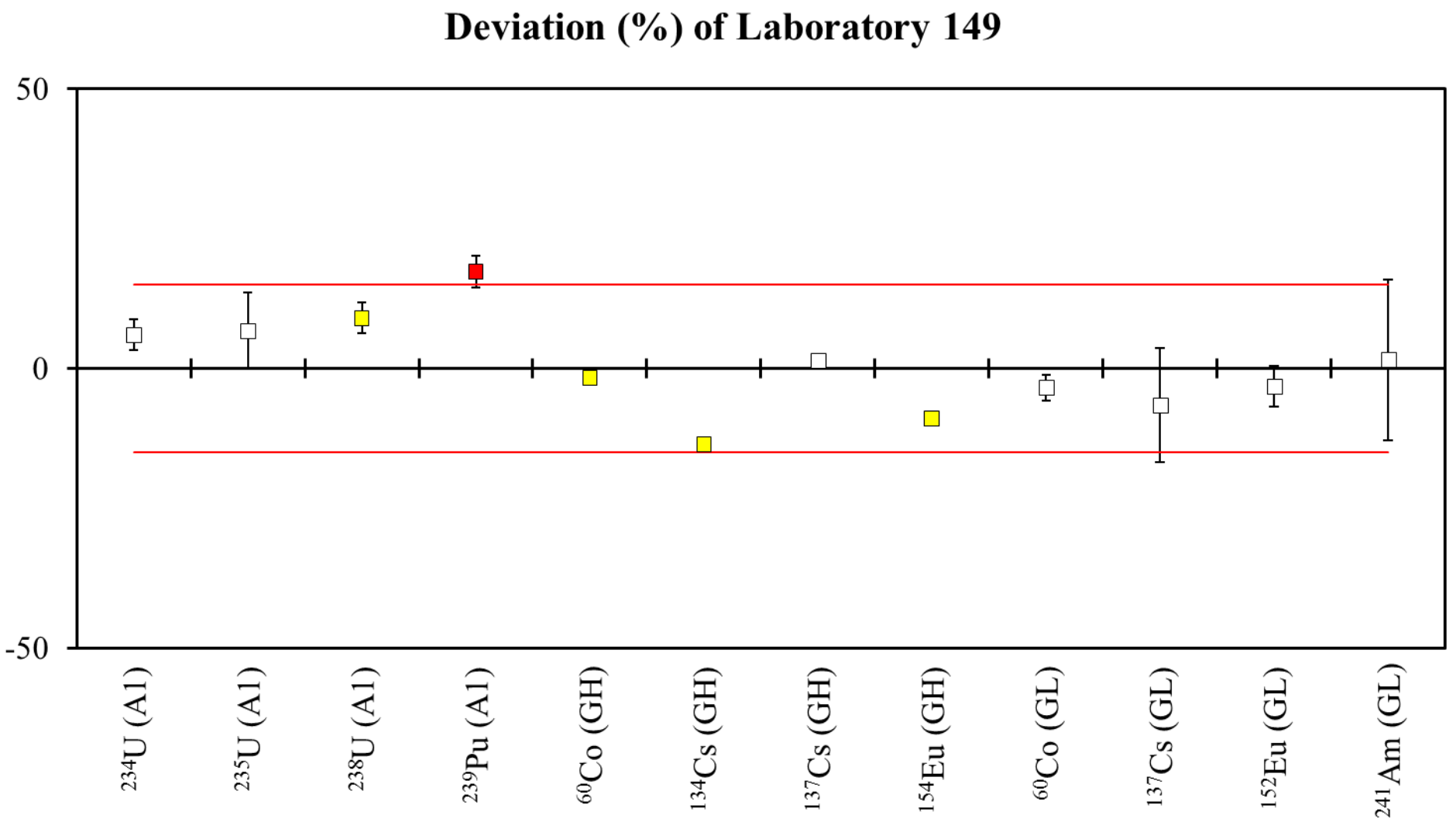
Radionuclide	Laboratory 136	NPL Assigned Value	Deviation /%	Zeta	Z Score
^{90}Sr (AB)	2.26 ± 0.23	2.418 ± 0.011	-6.5	-0.69	-1.12
^{237}Np (AB)	7.81 ± 0.80	7.432 ± 0.074	5.1	0.47	0.87
^{238}Pu (AB)	8.53 ± 0.77	8.666 ± 0.020	-1.6	-0.18	-0.27
^{239}Pu (A1)	21.2 ± 1.8	20.879 ± 0.039	1.5	0.18	0.26
^{3}H (B1)	0.706 ± 0.049	0.7400 ± 0.0052	-4.6	-0.69	-0.79
^{14}C (B1)	0.39 ± 0.03	0.4254 ± 0.0028	-8.3	-1.17	-1.43
^{60}Co (GL)	12.36 ± 0.42	12.490 ± 0.062	-1.0	-0.31	-0.18
^{137}Cs (GL)	2.32 ± 0.16	2.259 ± 0.020	2.7	0.38	0.46
^{152}Eu (GL)	19.3 ± 1.1	20.00 ± 0.15	-3.5	-0.63	-0.60


Deviation (%) of Laboratory 137
50
0
-50
^{60}Co (GH)
^{134}Cs (GH)
^{137}Cs (GH)
^{154}Eu (GH)

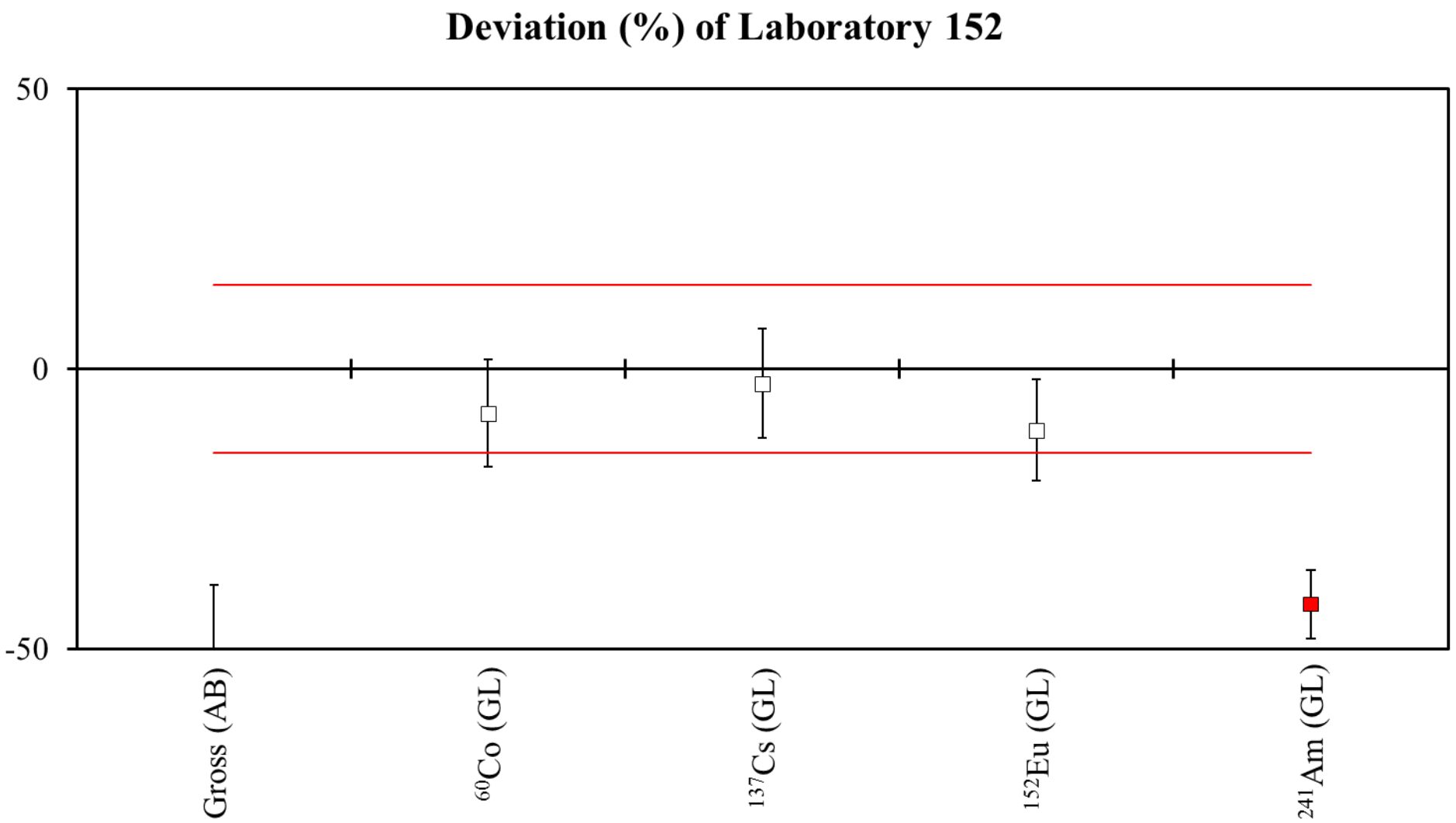
Radionuclide	Laboratory 137	NPL Assigned Value	Deviation /%	Zeta	Z Score
^{60}Co (GH)	5.28 ± 0.53	5.394 ± 0.012	-2.1	-0.22	-0.36
^{134}Cs (GH)	5.03 ± 0.50	4.973 ± 0.034	1.1	0.11	0.20
^{137}Cs (GH)	4.16 ± 0.42	4.125 ± 0.031	0.8	0.08	0.15
^{154}Eu (GH)	4.53 ± 0.45	4.600 ± 0.037	-1.5	-0.16	-0.26


Deviation (%) of Laboratory 141
50
0
-50
^{3}H (B1)
^{60}Co (GH)
^{134}Cs (GH)
^{137}Cs (GH)
^{154}Eu (GH)

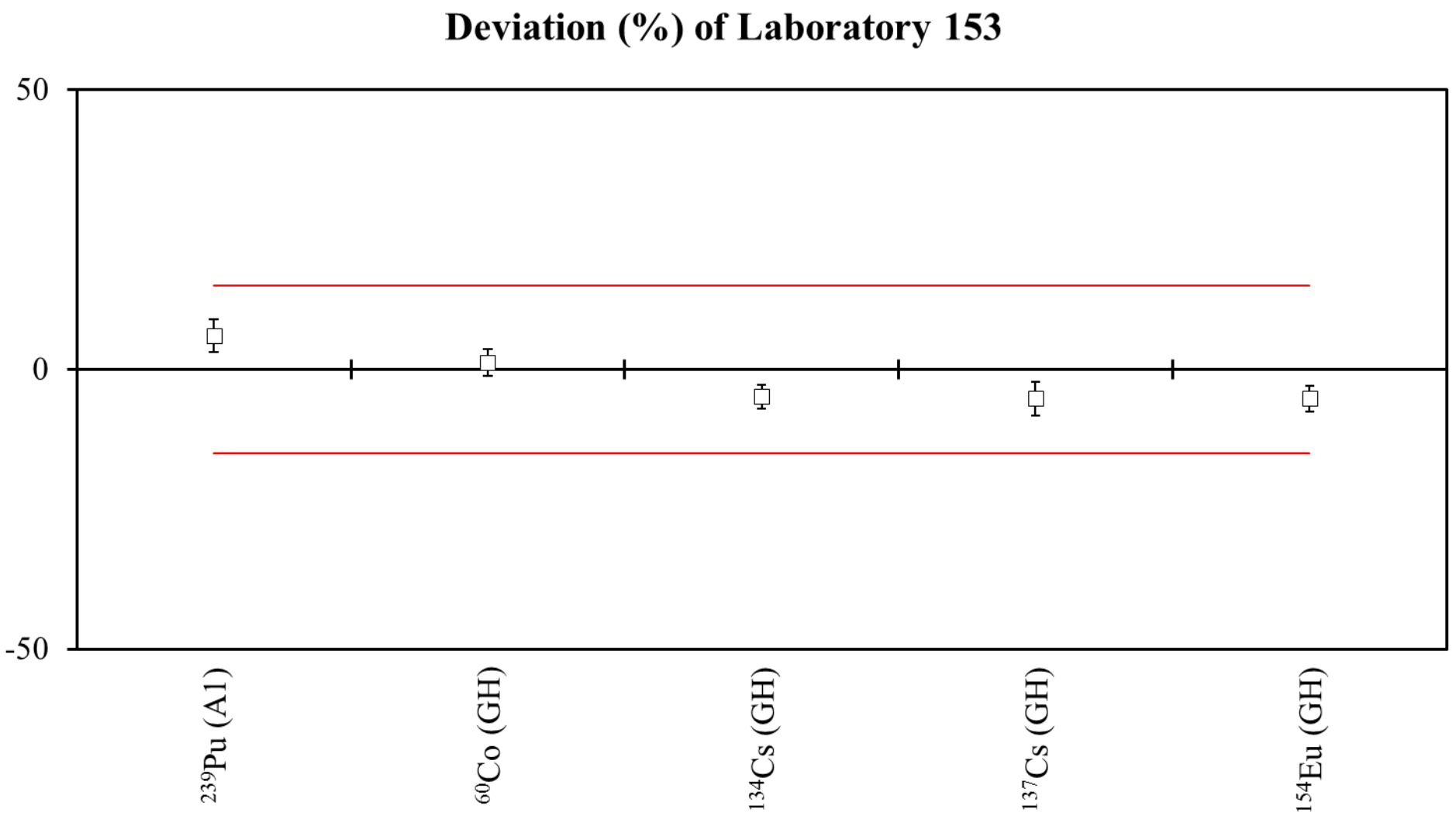
Radionuclide	Laboratory 141	NPL Assigned Value	Deviation /%	Zeta	Z Score
^{3}H (B1)	0.754 ± 0.091	0.7400 ± 0.0052	1.9	0.15	0.32
^{60}Co (GH)	5.1 ± 1.0	5.394 ± 0.012	-5.5	-0.29	-0.94
^{134}Cs (GH)	4.59 ± 0.92	4.973 ± 0.034	-7.7	-0.42	-1.32
^{137}Cs (GH)	4.01 ± 0.80	4.125 ± 0.031	-2.8	-0.14	-0.48
^{154}Eu (GH)	4.29 ± 0.86	4.600 ± 0.037	-6.7	-0.36	-1.16


Deviation (%) of Laboratory 149
50
0
-50
234U (A1)
235U (A1)
238U (A1)
239Pu (A1)
60Co (GH)
134Cs (GH)
137Cs (GH)
154Eu (GH)
60Co (GL)
137Cs (GL)
152Eu (GL)
241Am (GL)

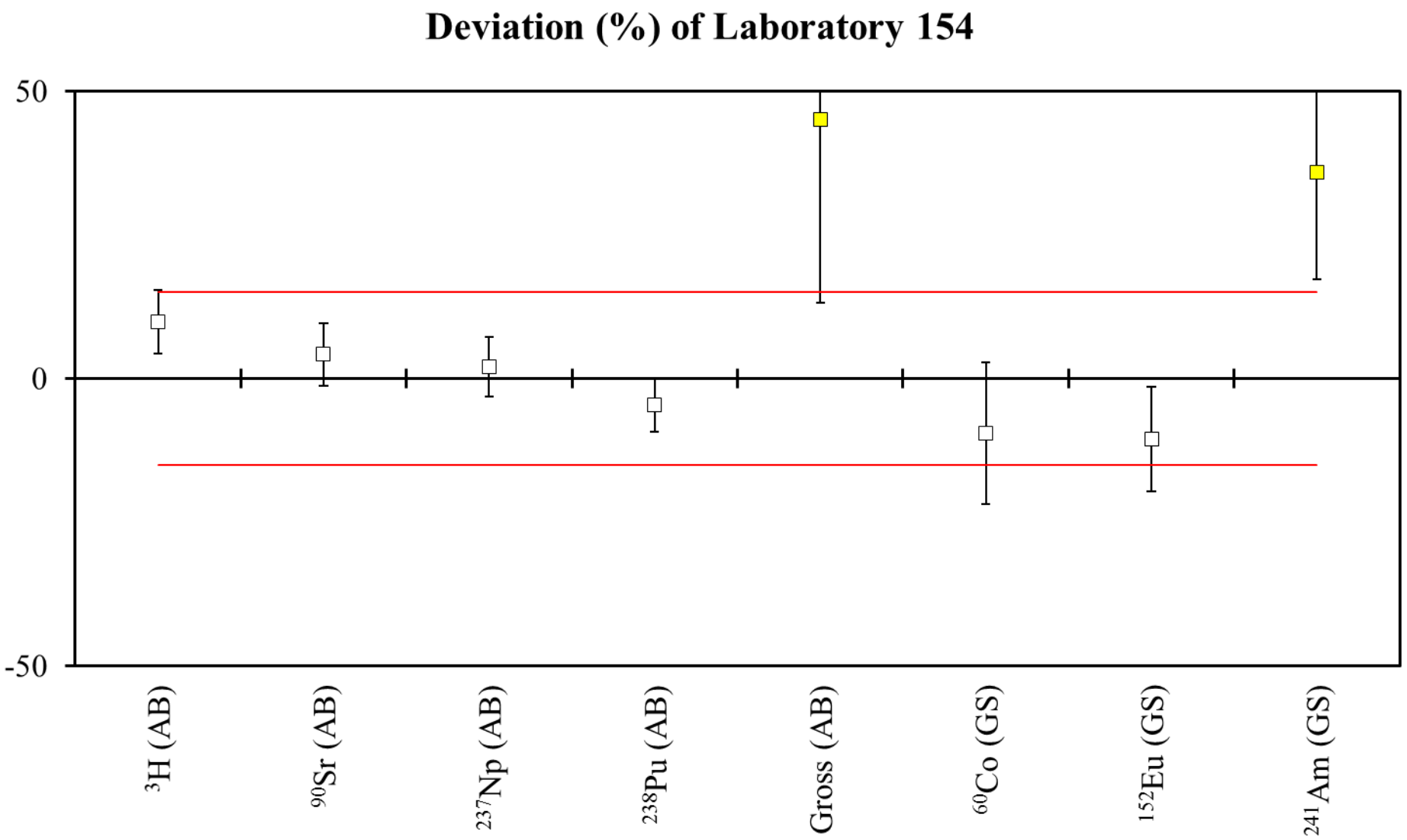
Radionuclide	Laboratory 149	NPL Assigned Value	Deviation /%	Zeta	Z Score
^{234}U (A1)	17.49 ± 0.34	16.50 ± 0.28	6.0	2.25	1.03
^{235}U (A1)	0.841 ± 0.052	0.788 ± 0.013	6.7	0.99	1.16
^{238}U (A1)	17.98 ± 0.34	16.50 ± 0.28	9.0	3.36	1.54
^{239}Pu (A1)	24.480 ± 0.6	20.879 ± 0.039	17.2	5.99	2.96
^{60}Co (GH)	5.304 ± 0.019	5.394 ± 0.012	-1.7	-4.00	-0.29
^{134}Cs (GH)	4.297 ± 0.018	4.973 ± 0.034	-13.6	-17.57	-2.33
^{137}Cs (GH)	4.182 ± 0.025	4.125 ± 0.031	1.4	1.43	0.24
^{154}Eu (GH)	4.185 ± 0.015	4.600 ± 0.037	-9.0	-10.39	-1.55
^{60}Co (GL)	12.06 ± 0.28	12.490 ± 0.062	-3.4	-1.50	-0.59
^{137}Cs (GL)	2.11 ± 0.23	2.259 ± 0.020	-6.6	-0.65	-1.13
^{152}Eu (GL)	19.37 ± 0.71	20.00 ± 0.15	-3.2	-0.87	-0.54
^{241}Am (GL)	1.84 ± 0.26	1.8124 ± 0.0039	1.5	0.11	0.26


Deviation (%) of Laboratory 152
50
0
-50
Gross (AB)
60Co (GL)
137Cs (GL)
152Eu (GL)
241Am (GL)

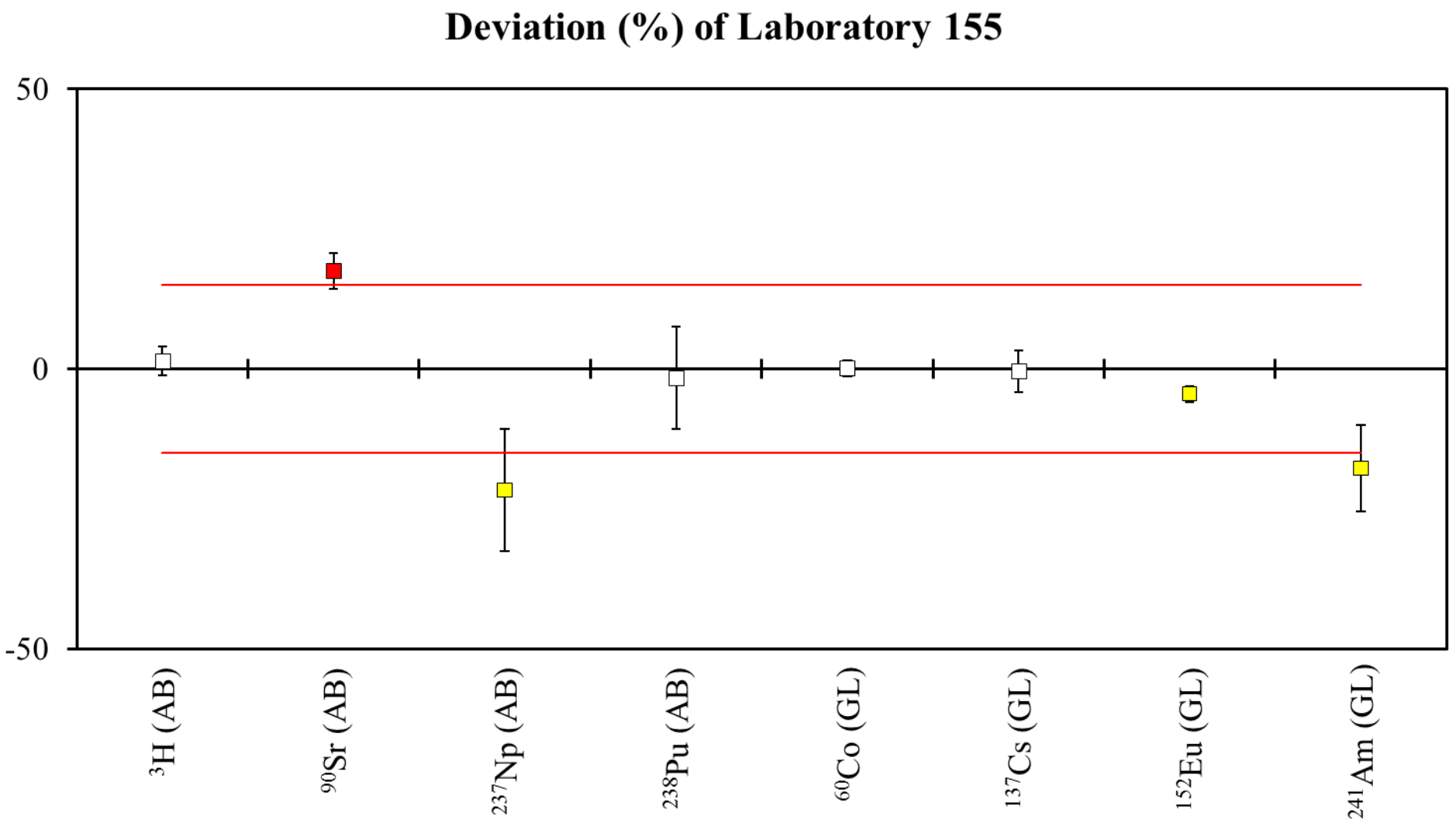
Radionuclide	Laboratory 152	NPL Assigned Value	Deviation /%	Zeta	Z Score
Gross Alpha-Beta (AB)	13.5 ± 1.7	27.1 ± 5.3	-50.2	-2.44	-8.62
^{60}Co (GL)	11.5 ± 1.2	12.490 ± 0.062	-7.9	-0.82	-1.36
^{137}Cs (GL)	2.20 ± 0.22	2.259 ± 0.020	-2.6	-0.27	-0.45
^{152}Eu (GL)	17.8 ± 1.8	20.00 ± 0.15	-11.0	-1.22	-1.89
^{241}Am (GL)	1.05 ± 0.11	1.8124 ± 0.0039	-42.1	-6.93	-7.22


Deviation (%) of Laboratory 153
50
0
-50
239Pu (A1)
60Co (GH)
134Cs (GH)
137Cs (GH)
154Eu (GH)

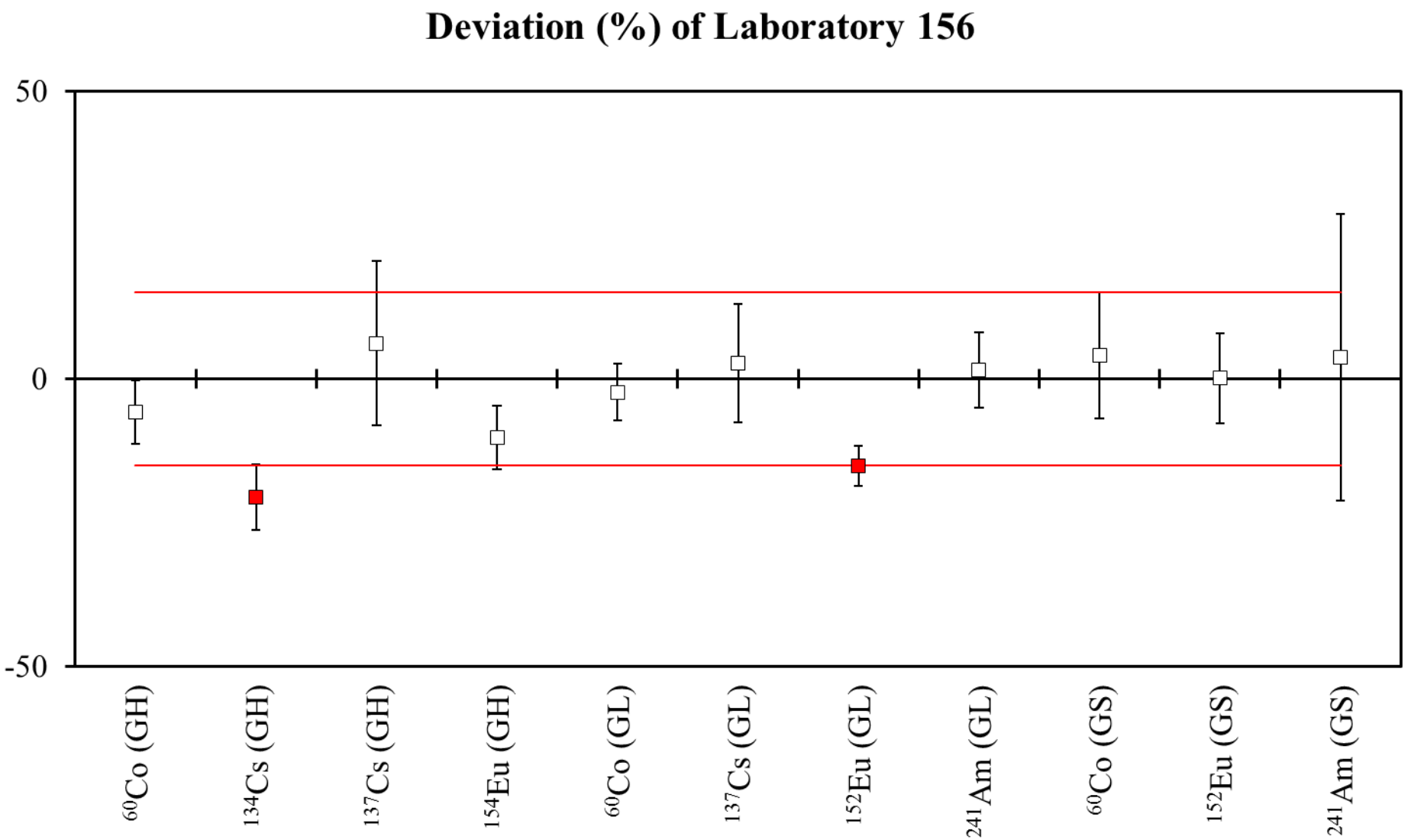
Radionuclide	Laboratory 153	NPL Assigned Value	Deviation /%	Zeta	Z Score
^{239}Pu (A1)	22.12 ± 0.61	20.879 ± 0.039	5.9	2.03	1.02
^{60}Co (GH)	5.46 ± 0.13	5.394 ± 0.012	1.2	0.51	0.21
^{134}Cs (GH)	4.729 ± 0.099	4.973 ± 0.034	-4.9	-2.33	-0.84
^{137}Cs (GH)	3.91 ± 0.12	4.125 ± 0.031	-5.2	-1.73	-0.90
^{154}Eu (GH)	4.36 ± 0.10	4.600 ± 0.037	-5.2	-2.25	-0.90


Deviation (%) of Laboratory 154
50
0
-50
^{3}H (AB)
^{90}Sr (AB)
^{237}Np (AB)
^{238}Pu (AB)
Gross (AB)
^{60}Co (GS)
^{152}Eu (GS)
^{241}Am (GS)

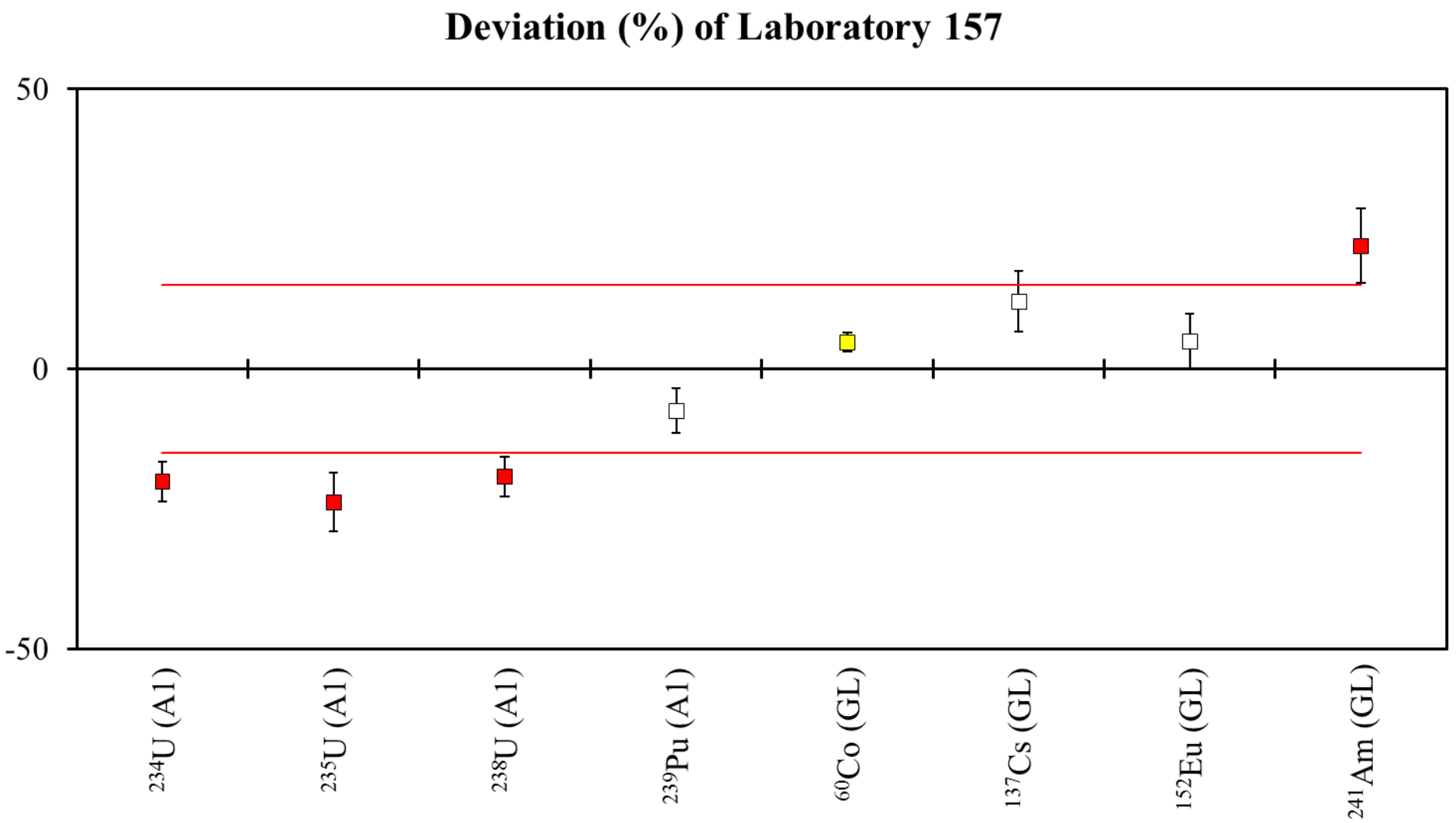
Radionuclide	Laboratory 154	NPL Assigned Value	Deviation /%	Zeta	Z Score
^{3}H (AB)	6.63 ± 0.33	6.037 ± 0.043	9.8	1.78	1.69
^{90}Sr (AB)	2.52 ± 0.13	2.418 ± 0.011	4.2	0.78	0.72
^{237}Np (AB)	7.59 ± 0.38	7.432 ± 0.074	2.1	0.41	0.37
^{238}Pu (AB)	8.27 ± 0.41	8.666 ± 0.020	-4.6	-0.96	-0.78
Gross Alpha-Beta (AB)	39.3 ± 3.9	27.1 ± 5.3	45.0	1.85	7.73
^{60}Co (GS)	1.33 ± 0.18	1.470 ± 0.017	-9.5	-0.77	-1.64
^{152}Eu (GS)	0.688 ± 0.069	0.769 ± 0.012	-10.5	-1.16	-1.81
^{241}Am (GS)	3.26 ± 0.35	2.40 ± 0.20	35.8	2.13	6.15


Deviation (%) of Laboratory 155
50
0
-50
^{3}H (AB)
^{90}Sr (AB)
^{237}Np (AB)
^{238}Pu (AB)
^{60}Co (GL)
^{137}Cs (GL)
^{152}Eu (GL)
^{241}Am (GL)

Radionuclide	Laboratory 155	NPL Assigned Value	Deviation /%	Zeta	Z Score
^{3}H (AB)	6.12 ± 0.15	6.037 ± 0.043	1.4	0.53	0.24
^{90}Sr (AB)	2.840 ± 0.076	2.418 ± 0.011	17.5	5.50	3.00
^{237}Np (AB)	5.82 ± 0.81	7.432 ± 0.074	-21.7	-1.98	-3.72
^{238}Pu (AB)	8.53 ± 0.79	8.666 ± 0.020	-1.6	-0.17	-0.27
^{60}Co (GL)	12.50 ± 0.16	12.490 ± 0.062	0.1	0.06	0.01
^{137}Cs (GL)	2.250 ± 0.082	2.259 ± 0.020	-0.4	-0.11	-0.07
^{152}Eu (GL)	19.10 ± 0.25	20.00 ± 0.15	-4.5	-3.09	-0.77
^{241}Am (GL)	1.49 ± 0.14	1.8124 ± 0.0039	-17.8	-2.30	-3.05


Deviation (%) of Laboratory 156
50
0
-50
^{60}Co (GH)
^{134}Cs (GH)
^{137}Cs (GH)
^{154}Eu (GH)
^{60}Co (GL)
^{137}Cs (GL)
^{152}Eu (GL)
^{241}Am (GL)
^{60}Co (GS)
^{152}Eu (GS)
^{241}Am (GS)

Radionuclide	Laboratory 156	NPL Assigned Value	Deviation /%	Zeta	Z Score
^{60}Co (GH)	5.080 ± 0.3	5.394 ± 0.012	-5.8	-1.05	-1.00
^{134}Cs (GH)	3.95 ± 0.28	4.973 ± 0.034	-20.6	-3.63	-3.53
^{137}Cs (GH)	4.38 ± 0.59	4.125 ± 0.031	6.2	0.43	1.06
^{154}Eu (GH)	4.13 ± 0.25	4.600 ± 0.037	-10.2	-1.86	-1.75
^{60}Co (GL)	12.20 ± 0.61	12.490 ± 0.062	-2.3	-0.47	-0.40
^{137}Cs (GL)	2.32 ± 0.23	2.259 ± 0.020	2.7	0.26	0.46
^{152}Eu (GL)	16.97 ± 0.69	20.00 ± 0.15	-15.2	-4.29	-2.60
^{241}Am (GL)	1.84 ± 0.12	1.8124 ± 0.0039	1.5	0.23	0.26
^{60}Co (GS)	1.53 ± 0.16	1.470 ± 0.017	4.1	0.37	0.70
^{152}Eu (GS)	0.770 ± 0.059	0.769 ± 0.012	0.1	0.02	0.02
^{241}Am (GS)	2.49 ± 0.56	2.40 ± 0.20	3.7	0.15	0.64


Deviation (%) of Laboratory 157
50
0
-50
234U (A1)
235U (A1)
238U (A1)
239Pu (A1)
60Co (GL)
137Cs (GL)
152Eu (GL)
241Am (GL)

Radionuclide	Laboratory 157	NPL Assigned Value	Deviation /%	Zeta	Z Score
^{234}U (A1)	13.17 ± 0.54	16.50 ± 0.28	-20.2	-5.47	-3.47
^{235}U (A1)	0.600 ± 0.040	0.788 ± 0.013	-23.9	-4.47	-4.10
^{238}U (A1)	13.32 ± 0.55	16.50 ± 0.28	-19.3	-5.15	-3.31
^{239}Pu (A1)	19.32 ± 0.82	20.879 ± 0.039	-7.5	-1.90	-1.28
^{60}Co (GL)	13.08 ± 0.20	12.490 ± 0.062	4.7	2.82	0.81
^{137}Cs (GL)	2.53 ± 0.12	2.259 ± 0.020	12.0	2.23	2.06
^{152}Eu (GL)	20.98 ± 0.96	20.00 ± 0.15	4.9	1.01	0.84
^{241}Am (GL)	2.21 ± 0.12	1.8124 ± 0.0039	21.9	3.31	3.77

11. DISCUSSION

11.1 Tritium in AB and B1

A total of 20 results were submitted for tritium provided in Sample Type AB, with 75% being in agreement with the Assigned Value; 25 results were submitted for this nuclide provided in B1, with 92% being in agreement with NPL. These levels of performance are similar to those observed in 2013.

In most cases, the nuclide was separated from the mixture by distillation and subsequently assayed using liquid scintillation counting; some participants used pyrolysis or combustion of the sample or used 'Internal methods' for tritium analysis. In most cases, LSC efficiencies were based on internal standards, from organisations including Eckert and Ziegler, NIST, NPL or Perkin Elmer. Other methods included the use of an LSC external standard or an assumption of constant levels of quench in samples.

11.2 ^{90}Sr in AB

A total of 23 results were submitted for this nuclide, with 74% in agreement with NPL, again similar to the 2013 performance level. Various separation methods were used, including precipitation, ion exchange chromatography, extraction chromatography and solvent extraction. The nuclide was measured mostly by LSC, although gas-flow proportional counting, Cerenkov counting and ICPMS were also used. Standards used were from centres including CMI, Eckert and Ziegler and NPL. Yield tracers were used by some laboratories (^{85}Sr, ^{88}Sr and stable strontium).

11.3 ^{237}Np in AB

In all, 14 results were submitted for ^{237}Np; 71% agreed with NPL, and again this is comparable to the levels of performance seen in the previous PTE. Gamma and alpha spectrometry were the techniques used by most participants (with ICPMS and LSC being used by some). A range of standards and tracers were used including mixed radionuclide standards, ^{237}Np, ^{239}Np, ^{242}Pu and ^{243}Am.

11.4 ^{238}Pu in AB

A total of 21 results were submitted, with 81% in agreement with the Assigned Value, a significantly higher proportion than in 2013. Most laboratories used ion exchange chromatography as the separation technique (extraction chromatography was also used). Nearly all laboratories used alpha spectrometry (with one using LSC). Standards used included ^{242}Pu, ^{236}Pu and ^{243}Am.

11.5 ^{234}U, ^{235}U and ^{238}U in A1

The numbers of results submitted for these nuclides were 20, 19 and 22 respectively. The level of performance for all the nuclides combined (87%) was higher than that seen in 2013. Again, ion exchange chromatography was used by most analysts with a few opting for extraction chromatography. Alpha spectrometry was again the main measurement technique although some laboratories used ICPMS. The nuclide ^{232}U was used as the standard in most cases, other standards used including ^{233}U, ^{238}U, natural uranium, mixed radionuclide standards and NPL PTE samples from previous exercises.

11.6 ^{239}Pu in A1

The comments for this nuclide are similar to those for ^{238}Pu above; 19 results were submitted (74% being in agreement with NPL) with ion exchange chromatography being the predominant separation method with all participants using alpha spectrometry. Standards of ^{242}Pu, ^{236}Pu, ^{239}Pu and ^{243}Am were used.

11.7 ^{14}C in B1

A total of 16 results were submitted, with 94% agreeing with NPL – a marked improvement on the previous exercise. Pyrolysis, oxidation, evaporation, combustion and chemical separation were cited as separation methods. All participants used LSC and a ^{14}C internal standard.

11.8 ^{36}Cl in B1

Only 6 results were submitted for this nuclide (4 agreeing with NPL). Some cited LSC as the measurement technique and used a ^{36}Cl internal standard.

11.9 Sample Types GH, GL and GS

The numbers of sets of results submitted for these sample types were 31, 32 and 15 respectively. Almost all measurements were carried out using high-resolution gamma spectrometry (alpha spectrometry and ICPMS were also used). Most laboratories used mixed radionuclide standards from Eckert and Ziegler, CERCA LEA or NPL.

Most of results submitted for the nuclides in these sample types were in agreement with the Assigned Values. There were true coincidence summing issues evident for ^{134}Cs and ^{154}Eu. The results for ^{241}Am exhibited a high bias and a large spread; the shape of the gamma calibration curve at low energies may be an issue here, as may density corrections for the ^{241}Am in the GS sample type.

12. POST-EXERCISE WORKSHOP OUTCOMES

A workshop was held after the exercise to present the results formally and to allow participants to discuss them and to provide feedback for future exercises in terms of nuclides and sample types required. The following feedback was obtained, with the number of delegates expressing the preference in brackets:

Preferred alpha and beta emitters: ^{55}Fe (5), ^{63}Ni (5), ^{99}Tc (4), U nuclides (3), ^{241}Am, ^{14}C, ^{3}H, ^{210}Po, ^{241}Pu, ^{226}Ra, ^{89}Sr, ^{90}Sr (all 2 each), ^{35}S, ^{129}I, ^{237}Np, ^{32}P, ^{238}Pu, ^{239}Pu and ^{35}S (all 1 each).

Other preferences: Mixture of ^{90}Sr + ^{239}Pu + ^{238}Pu + ^{241}Am + ^{242}Cm or ^{244}Cm (1), ^{3}H and ^{14}C in wood or soil (3), samples with ‘non-natural’ isotopic ratios (e.g. depleted U or processed Th) (1).

Preferred gamma emitters: ^{7}Be, ^{40}K, ^{22}Na, ^{210}Pb (all 2 each), ^{59}Fe, ^{60}Co, ^{137}Cs, ^{133}Ba, ^{54}Mn, ^{65}Zn, ^{110m}Ag, ^{134}Cs, ^{125}I, ^{129}I, ^{126}Sn, ^{125}Sb, ^{124}I, ^{155}Eu and ^{241}Am (all 1 each).

Other preferences: Activation products (1), interfering nuclides (e.g. ^{106}Ru and ^{110m}Ag, ^{226}Ra and ^{235}U) (1).

Preferred matrices: Soil (7), concrete or cement (5), ASFP or HVAS filters (3), variable density soil or glass (2), NORM (2), volatile substance in glass, refractory substance in glass, ^{226}Ra, ^{228}Ac or ^{210}Pb in soil or glass, brick, metal, vegetation or seafood and milk (all 1 each).

Some delegates (5) wanted a sample with the nuclides undisclosed (i.e. a blind test).

NPL will consider this feedback in planning its 2015 PTE.

13. REFERENCES

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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).

14. 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, Paris Aitken-Smith, Arzu Arinc, Kelley Ferreira, Peter Ivanov, Lynsey Keightley and Cyrus Larijani for their work on preparing, measuring and dispatching the samples. Finally, they thank Steven Judge for reviewing this report.