

NPL REPORT IR 28

**Environmental Radioactivity
Proficiency Test Exercise 2012**

JULIAN DEAN, SEAN COLLINS AND GEORGE HAM

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Environmental Radioactivity Proficiency Test Exercise 2012

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ABSTRACT

The results of NPL's eighteenth Environmental Radioactivity Proficiency Test Exercise are reported. Seven different sample types were offered: an aqueous mixture of five alpha emitters (designated 'AL'), a second aqueous mixture of five alpha emitters (AH), an aqueous mixture of four beta emitters (B1), a second aqueous mixture of four beta emitters (B2), an aqueous mixture of five gamma emitters (GL), a second aqueous mixture of five gamma emitters (GH) and a solid sewage sludge sample containing five radionuclides (S). A total of 672 results were submitted, of which 74 % of the results were in agreement with the assigned values.

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Approved on behalf of NPLML by Bajram Zeqiri, Knowledge Leader AIR

Assigned Values

Nuclide (AH)	Assigned Values (Bq g⁻¹)
Am-241	4.449 ± 0.020 (± 0.48 %)
Cm-244	19.51 ± 0.14 (± 0.8 %)
Np-237	14.65 ± 0.30 (± 2.0 %)
Pu-238	14.950 ± 0.100 (± 0.6 %)
Ra-226	1.461 ± 0.038 (± 2.6 %)
gross alpha	56.7 ± 4.8 (± 10 %)

Nuclide (AL)	Assigned Values (Bq kg⁻¹)
Pu-239	12.1 ± 0.6 (± 5.0 %)
Th-232	2.52 ± 0.12 (± 4.8 %)
U-234	15.0 ± 0.8 (± 6 %)
U-235	0.718 ± 0.038 (± 6 %)
U-238	15.0 ± 0.8 (± 6 %)
gross alpha	45 ± 8 (± 16 %)

Nuclide (B1)	Assigned Values (Bq g⁻¹)
H-3	1.046 ± 0.016 (± 1.4 %)
C-14	0.968 ± 0.016 (± 1.6 %)
Cl-36	0.4900 ± 0.0040 (± 0.8 %)
Tc-99	0.1434 ± 0.0026 (± 1.8 %)

Nuclide (B2)	Assigned Values (Bq g⁻¹)
H-3	1.076 ± 0.016 (± 1.4 %)
Pm-147	0.435 ± 0.008 (± 1.8 %)
Pu-241	0.942 ± 0.020 (± 2.2 %)
Sr-90	0.1429 ± 0.0006 (± 0.40 %)
gross beta (PC)	0.2857 ± 0.0012 (± 0.40 %)
gross beta (LSC)	2.739 ± 0.028 (± 1.0 %)

Nuclide (GH)	Assigned Values (Bq g⁻¹)
Ba-133	7.410 ± 0.100 (± 1.4 %)
Eu-152	15.26 ± 0.20 (± 1.4 %)
Co-60	5.229 ± 0.022 (± 0.44 %)
Cs-134	2.800 ± 0.038 (± 1.4 %)
Cs-137	15.41 ± 0.12 (± 0.8 %)

Nuclide (GL)	Assigned Values (Bq kg⁻¹)
Co-60	17.68 ± 0.16 (± 1.0 %)
Cs-134	2.190 ± 0.034 (± 1.6 %)
Cs-137	4.12 ± 0.08 (± 1.8 %)
K-40	16.4 ± 1.6 (± 10 %)
Pb-210	19.46 ± 0.44 (± 2.2 %)

Consensus Values

Nuclide (S)	Consensus Values
H-3	77.1 ± 3.4 (4.4 %) Bq g ⁻¹
C-14	1.91 ± 0.10 (5.0 %) Bq g ⁻¹
K-40	181 ± 12 (6 %) Bq kg ⁻¹
Pb-210	46.5 ± 2.8 (6 %) Bq kg ⁻¹
Po-210	47.9 ± 1.4 (3.0 %) Bq kg ⁻¹

UNCERTAINTIES

The reported uncertainties above are based on standard uncertainties multiplied by a coverage factor $k = 2$, providing a level of confidence of approximately 95 %. The uncertainty evaluations have been carried out in accordance with UKAS requirements.

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1. SUMMARY

This environmental radioactivity proficiency test exercise was the eighteenth in a series of such exercises to have been conducted by NPL since 1989. The exercises are run to help analysts identify measurement problems, to support UKAS accreditations and to provide a forum for discussion and technology transfer in this area. The exercises are now run on an annual basis by NPL. A range of sample types have been available over the course of these exercises, most of which have been aqueous. In the 2012 exercise, seven types of sample were made available for analysis:

- (i) **AL:** a 'low-level' mixture of five α -emitting radionuclides
500 g of dilute nitric acid (1 – 20 Bq kg⁻¹ per radionuclide)
- (ii) **AH:** a 'high-level' mixture of five α -emitting radionuclides
20 g of dilute nitric acid (1 – 20 Bq g⁻¹ per radionuclide)
- (iii) **B1:** a mixture of four β -emitting radionuclides
500 g of very dilute NaOH solution (0.1 – 2 Bq g⁻¹ per radionuclide)
- (iv) **B2:** a mixture of four β -emitting radionuclides
500 g of dilute nitric acid (0.1 – 2 Bq g⁻¹ per radionuclide)
- (v) **GL:** a 'low-level' mixture of five γ -emitting radionuclides
500 g of dilute hydrochloric acid (1 – 20 Bq kg⁻¹ per radionuclide)
- (vi) **GH:** a 'high-level' mixture of five γ -emitting radionuclides
100 g of dilute hydrochloric acid (1 – 20 Bq g⁻¹ per radionuclide)
- (vii) **S:** a heat-treated sewage sludge sample containing five radionuclides
100 g (1 – 100 Bq g⁻¹ or 1 – 100 Bq kg⁻¹ per radionuclide, depending on the 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 assigned values (i.e. those determined by NPL) for the activity concentrations of all the radionuclides 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)).

The NPL data analysis method was similar to that used in the previous (2011) exercise (see Section 2).

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 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 – laboratory value
 N – assigned value
 u_L – standard uncertainty of the laboratory value
 u_N – standard uncertainty of the assigned value
 σ_p – standard uncertainty for proficiency assessment

unit:

(Bq kg⁻¹ or Bq g⁻¹)
 (Bq kg⁻¹ or Bq g⁻¹)
 (Bq kg⁻¹ or Bq g⁻¹)
 (Bq kg⁻¹ or Bq g⁻¹)
 (Bq kg⁻¹ or Bq g⁻¹)

The zeta and z-scores were used to determine whether the difference between the laboratory 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. 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 laboratory value is 'in agreement'. These results are plotted as dark blue points 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 laboratory 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 laboratory 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 laboratory 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 weighted mean (WM) of the participants' results for each radionuclide in the aqueous sample types were calculated in accordance with the method described previously (Harms and Gilligan, 2011) and subsequently compared with the assigned values.

Nuclide (AH)	NPL Assigned Values (Bq g ⁻¹)	WM LCS (Bq g ⁻¹)	Deviation %	Zeta	Critical Value
²⁴¹ Am	4.449 ± 0.010 (± 0.24 %)	4.50 ± 0.05 (± 1.1 %)	1.1	1.02	2.95
²⁴⁴ Cm	19.51 ± 0.07 (± 0.4 %)	19.07 ± 0.24 (± 1.3 %)	-2.2	-1.73	2.98
²³⁷ Np	14.65 ± 0.15 (± 1.0 %)	17.48 ± 0.22 (± 1.3 %)	19.3	10.67	3.11
²³⁸ Pu	14.95 ± 0.05 (± 0.3 %)	14.49 ± 0.16 (± 1.1 %)	-3.1	-2.71	3.06
²²⁶ Ra	1.461 ± 0.019 (± 1.3 %)	1.59 ± 0.05 (± 3 %)	8.7	2.61	2.98

Nuclide (AL)	NPL Assigned Values (Bq kg ⁻¹)	WM LCS (Bq kg ⁻¹)	Deviation %	Zeta	Critical Value
²³⁹ Pu	12.1 ± 0.3 (± 2.2 %)	11.34 ± 0.18 (± 1.6 %)	-6.6	-2.45	2.58
²³² Th	2.52 ± 0.06 (± 2.4 %)	2.42 ± 0.05 (± 1.9 %)	-3.9	-1.29	2.65
²³⁴ U	15.0 ± 0.4 (± 3 %)	14.28 ± 0.13 (± 0.9 %)	-5.0	-1.83	2.58
²³⁵ U	0.718 ± 0.019 (± 3 %)	0.640 ± 0.015 (± 2.3 %)	-10.9	-3.27	2.64
²³⁸ U	15.0 ± 0.4 (± 3 %)	14.06 ± 0.15 (± 1.1 %)	-6.5	-2.34	2.58

Nuclide (B1)	NPL Assigned Values (Bq g ⁻¹)	WM LCS (Bq g ⁻¹)	Deviation %	Zeta	Critical Value
³ H	1.046 ± 0.008 (± 0.7 %)	1.050 ± 0.007 (± 0.7 %)	0.4	0.38	2.58
¹⁴ C	0.968 ± 0.008 (± 0.8 %)	0.950 ± 0.015 (± 1.6 %)	-1.9	-1.08	2.86
³⁶ Cl	0.4900 ± 0.0020 (± 0.4 %)	0.460 ± 0.018 (± 4 %)	-6.1	-1.66	4.60
⁹⁹ Tc	0.1434 ± 0.0013 (± 0.9 %)	0.136 ± 0.003 (± 2.2 %)	-5.2	-2.27	2.90

Nuclide (B2)	NPL Assigned Values (Bq g ⁻¹)	WM LCS (Bq g ⁻¹)	Deviation %	Zeta	Critical Value
³ H	1.076 ± 0.008 (± 0.7 %)	1.175 ± 0.010 (± 0.9 %)	9.2	7.86	2.69
¹⁴⁷ Pm	0.435 ± 0.004 (± 0.9 %)	0.432 ± 0.008 (± 1.9 %)	-0.6	-0.29	3.36
²⁴¹ Pu	0.942 ± 0.010 (± 1.1 %)	0.893 ± 0.018 (± 2.0 %)	-5.2	-2.36	2.88
⁹⁰ Sr	0.1429 ± 0.0003 (± 0.20 %)	0.1410 ± 0.0020 (± 1.4 %)	-1.3	-0.92	2.86

Nuclide (GH)	NPL Assigned Values (Bq g ⁻¹)	WM LCS (Bq g ⁻¹)	Deviation %	Zeta	Critical Value
¹³³ Ba	7.410 ± 0.050 (± 0.7 %)	7.07 ± 0.05 (± 0.7 %)	-4.6	-4.88	2.58
¹⁵² Eu	15.26 ± 0.10 (± 0.7 %)	14.56 ± 0.09 (± 0.6 %)	-4.6	-5.22	2.58
⁶⁰ Co	5.229 ± 0.011 (± 0.22 %)	5.22 ± 0.03 (± 0.6 %)	-0.1	-0.13	2.69
¹³⁴ Cs	2.800 ± 0.019 (± 0.7 %)	2.776 ± 0.017 (± 0.6 %)	-0.9	-0.94	2.58
¹³⁷ Cs	15.41 ± 0.06 (± 0.4 %)	15.50 ± 0.10 (± 0.6 %)	0.6	0.85	2.66

Nuclide (GL)	NPL Assigned Values (Bq kg ⁻¹)	WM LCS (Bq kg ⁻¹)	Deviation %	Zeta	Critical Value
⁶⁰ Co	17.68 ± 0.08 (± 0.50 %)	18.02 ± 0.04 (± 0.23 %)	1.9	3.87	2.58
¹³⁴ Cs	2.190 ± 0.017 (± 0.8 %)	2.205 ± 0.022 (± 1.0 %)	0.7	0.55	2.63
¹³⁷ Cs	4.12 ± 0.04 (± 0.9 %)	4.21 ± 0.04 (± 0.8 %)	2.2	1.76	2.58
⁴⁰ K	16.4 ± 0.8 (± 5.0 %)	16.23 ± 0.24 (± 1.5 %)	-1.0	-0.21	2.58
²¹⁰ Pb	19.46 ± 0.22 (± 1.1 %)	21.3 ± 0.4 (± 1.6 %)	9.7	4.61	2.68

4. DEVIATION PLOTS

Figure 1 below illustrates the format of the deviation plots with some hypothetical values and uncertainties. Results 'in agreement' are represented by dark blue points whereas questionable and discrepant results are given in yellow and red respectively. The error bars represent the standard uncertainties u_D (with a coverage factor of $k=1$). The light blue lines represent z-scores of -2.576 and 2.576 (-15% or $+15\%$ deviation). The dashed line represent the standard uncertainty of the assigned value. Table 2 explains the classification of each value.

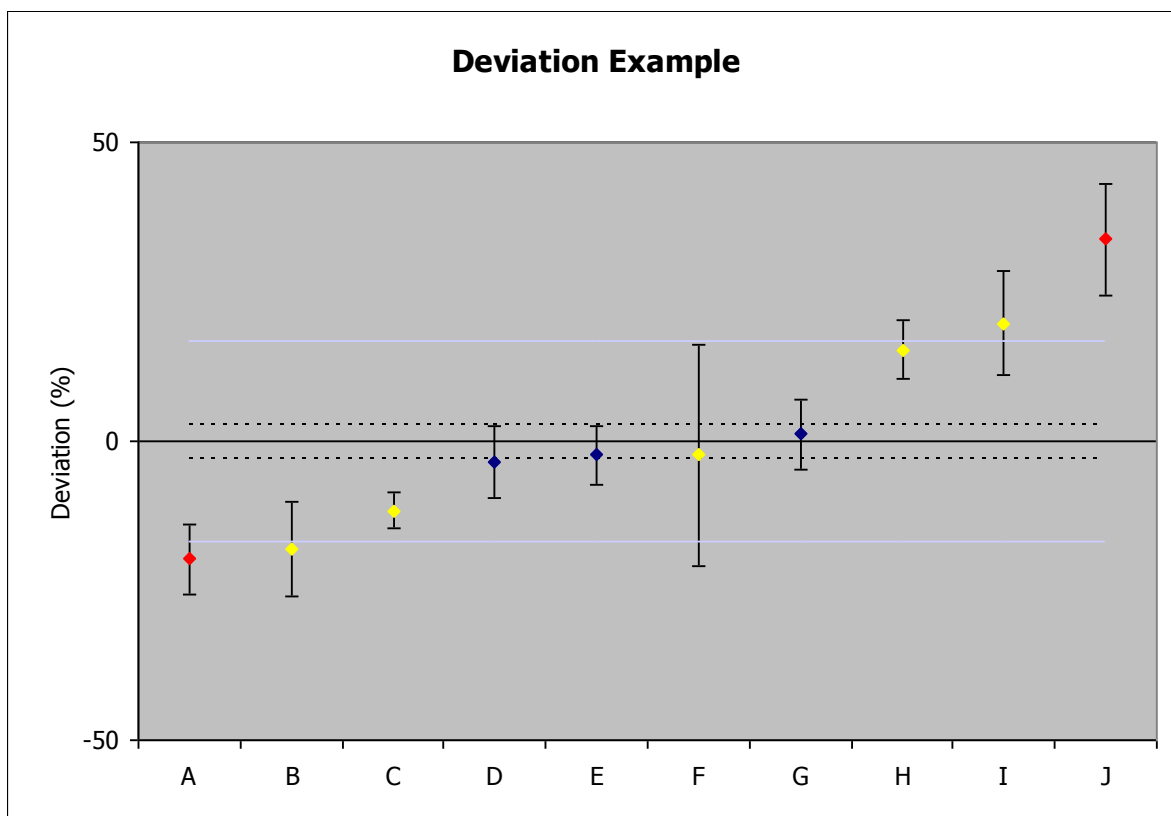


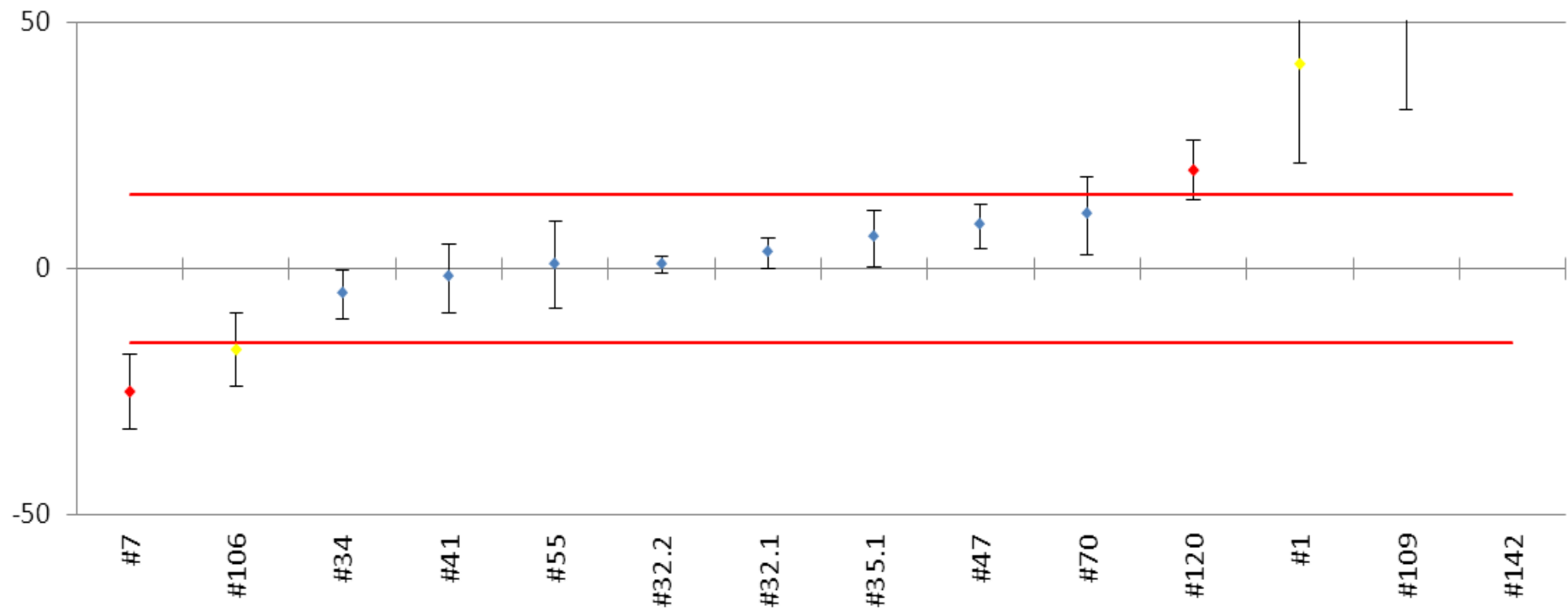
Figure 1 Deviation plot example

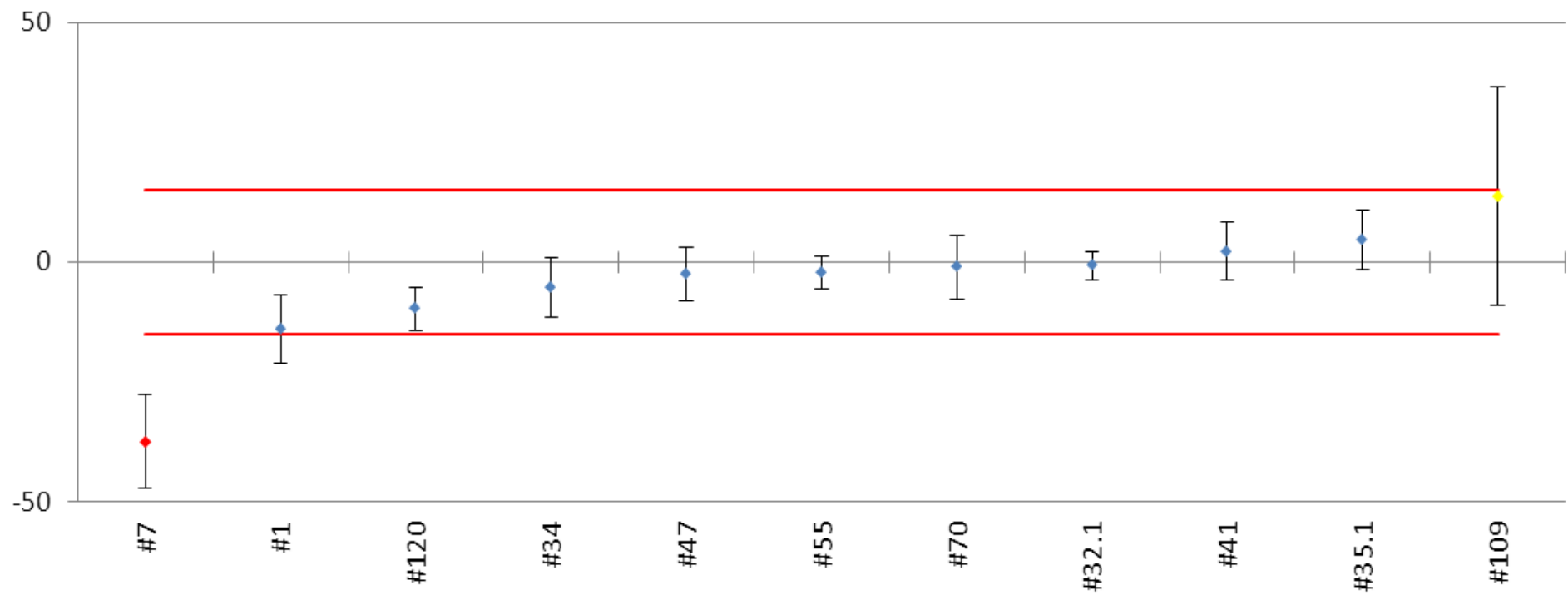
Table 2 Data classification

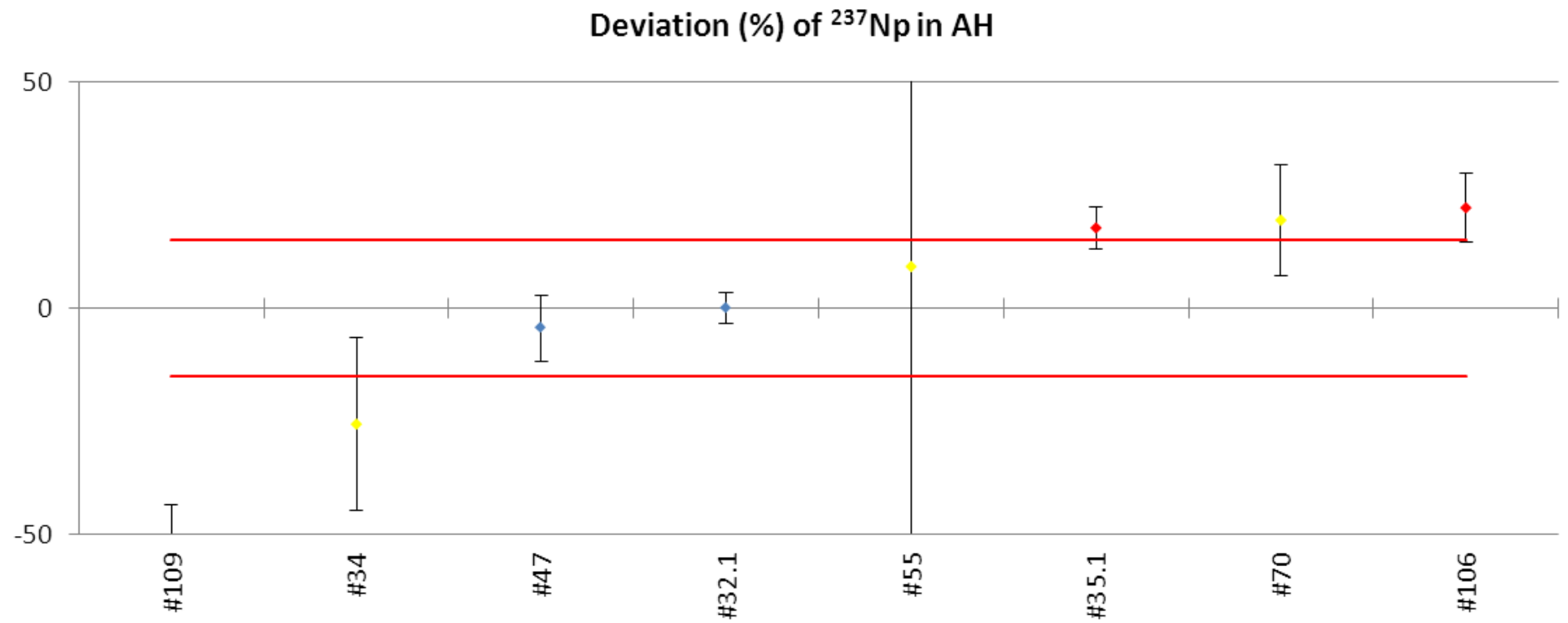
Lab	Zeta test	R_L outlier test	z test	Classification
A	fail	pass	fail	discrepant
B	pass	pass	fail	questionable
C	fail	pass	pass	questionable
D	pass	pass	pass	in agreement
E	pass	pass	pass	in agreement
F	pass	fail	pass	questionable
G	pass	pass	pass	in agreement
H	fail	pass	pass	questionable
I	pass	pass	fail	questionable
J	fail	pass	fail	discrepant

5. Alpha High (AH) Deviation Plots

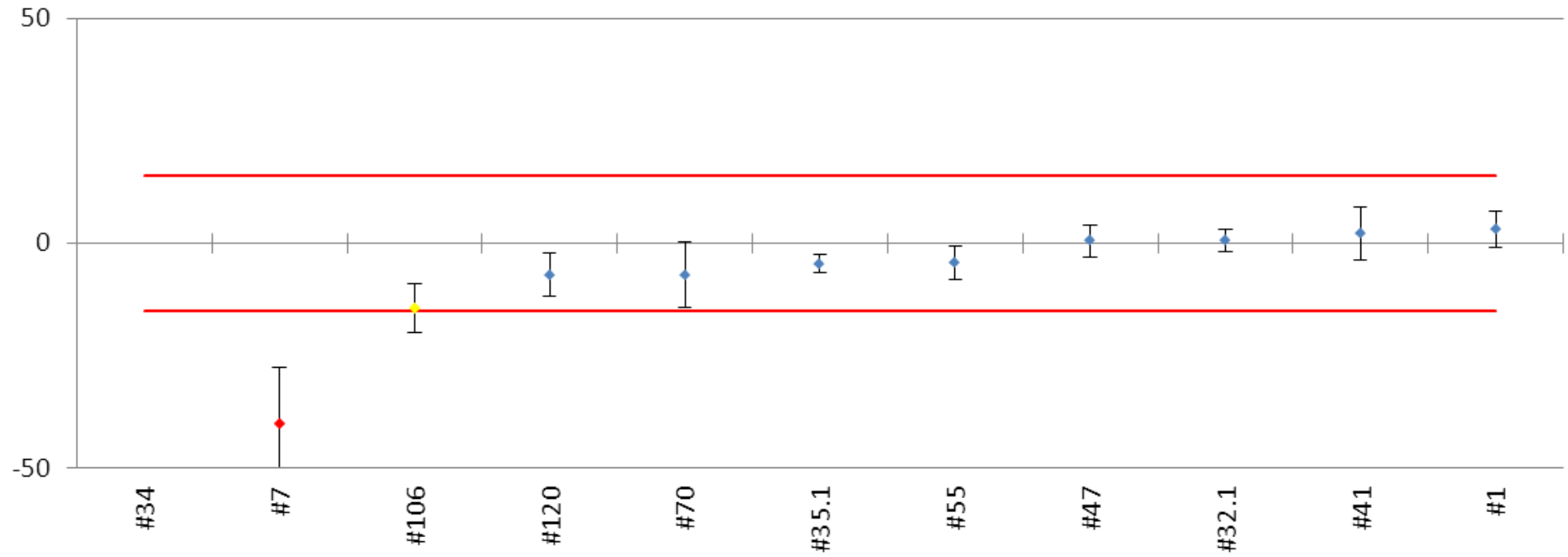
Deviation (%) of ^{241}Am in AH



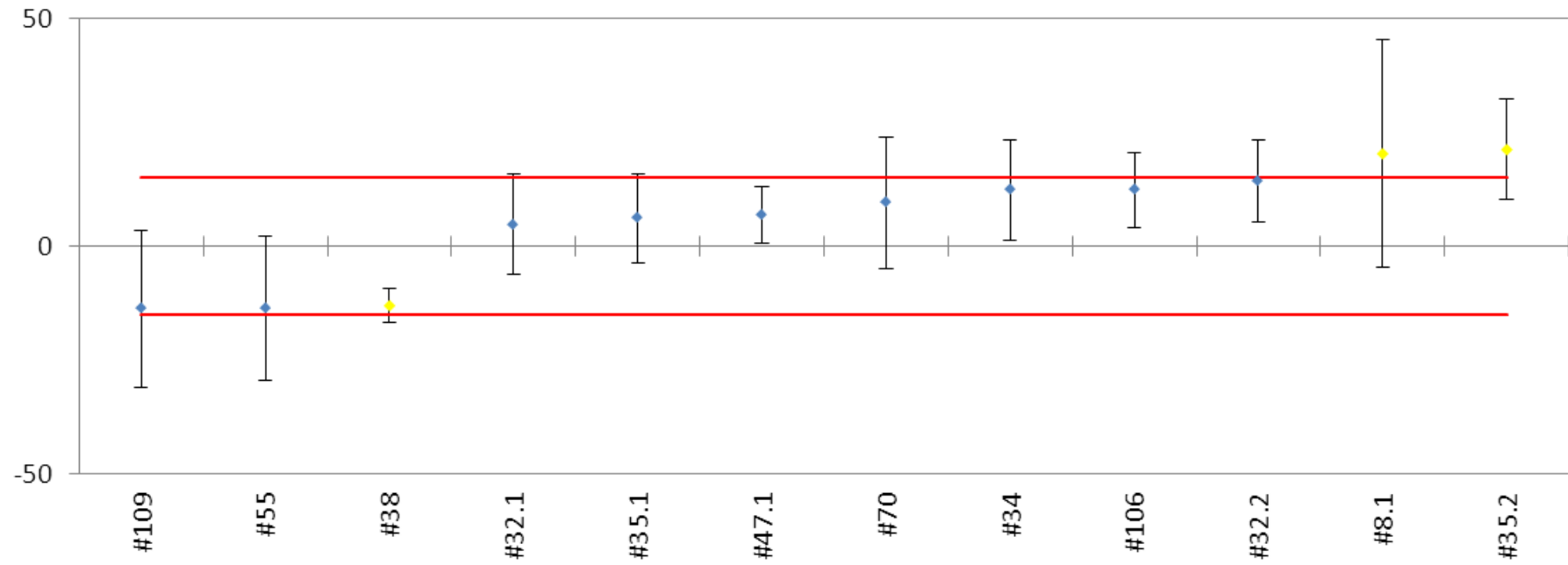
Deviation (%) of ^{244}Cm in AH



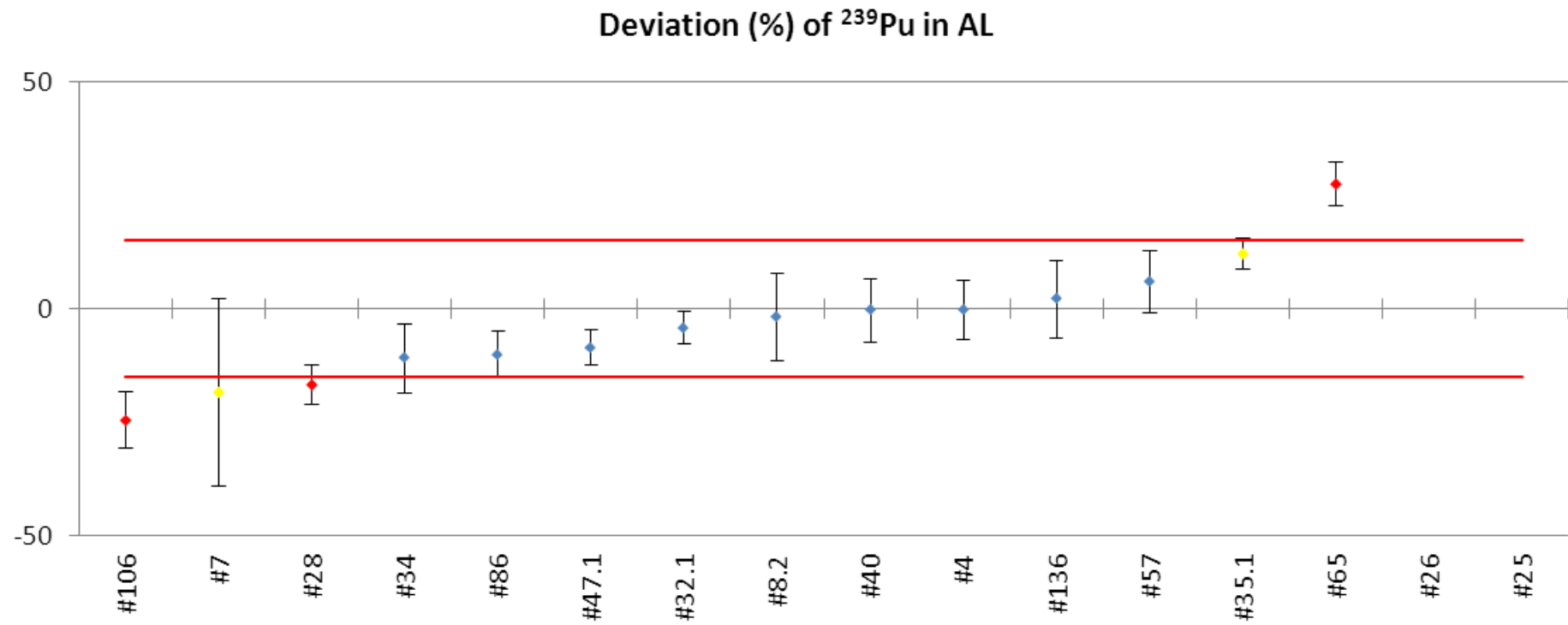
Deviation (%) of ^{238}Pu in AH



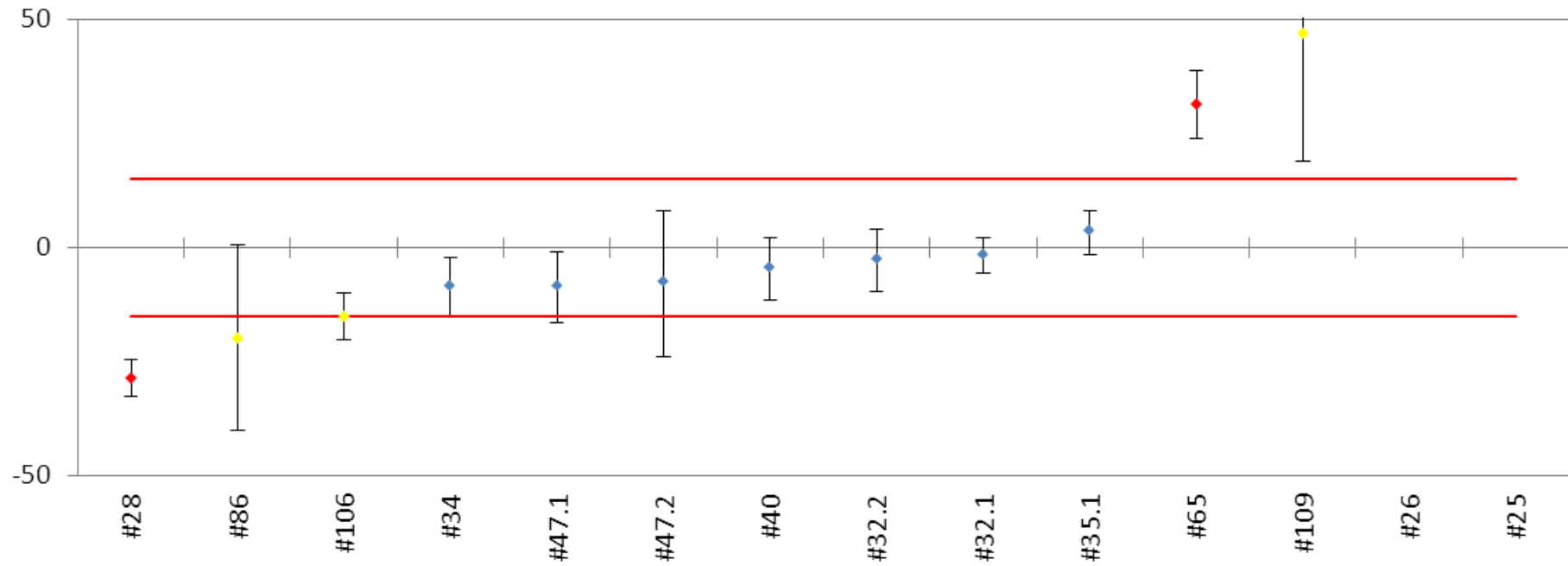
Deviation (%) of ^{226}Ra in AH

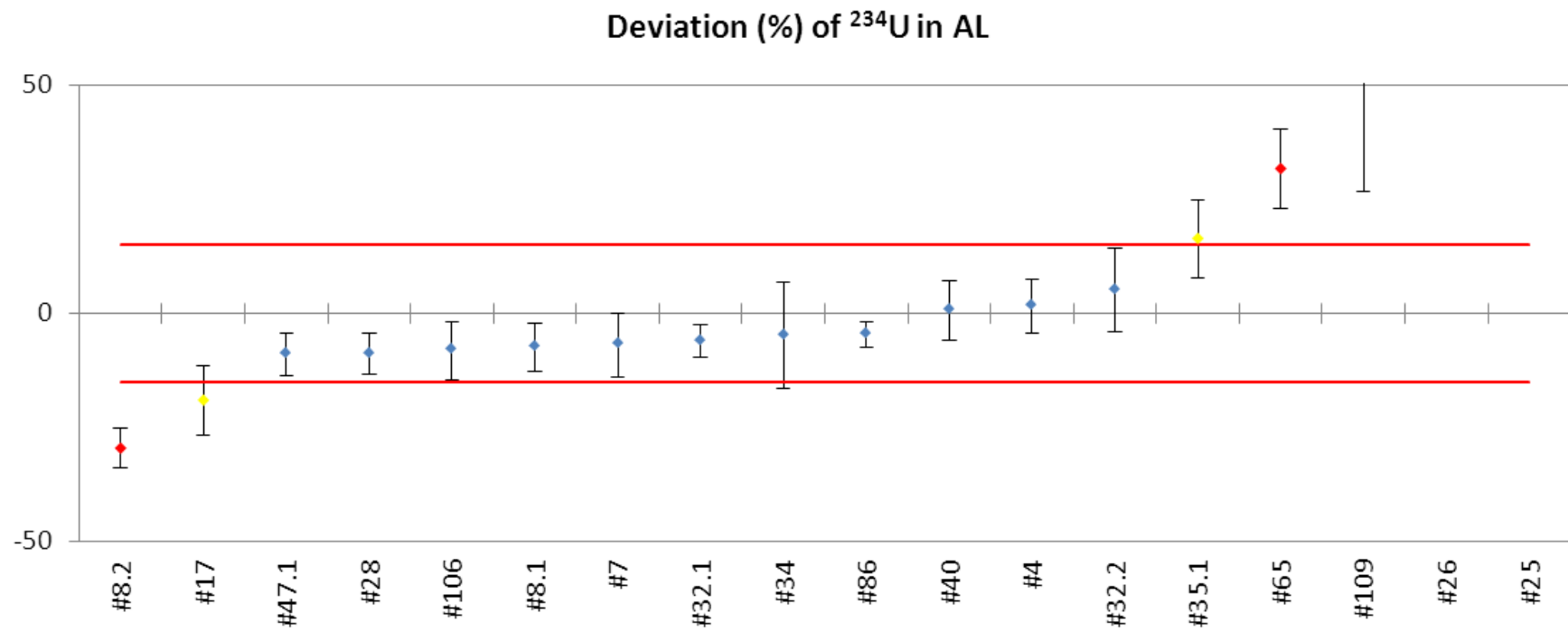


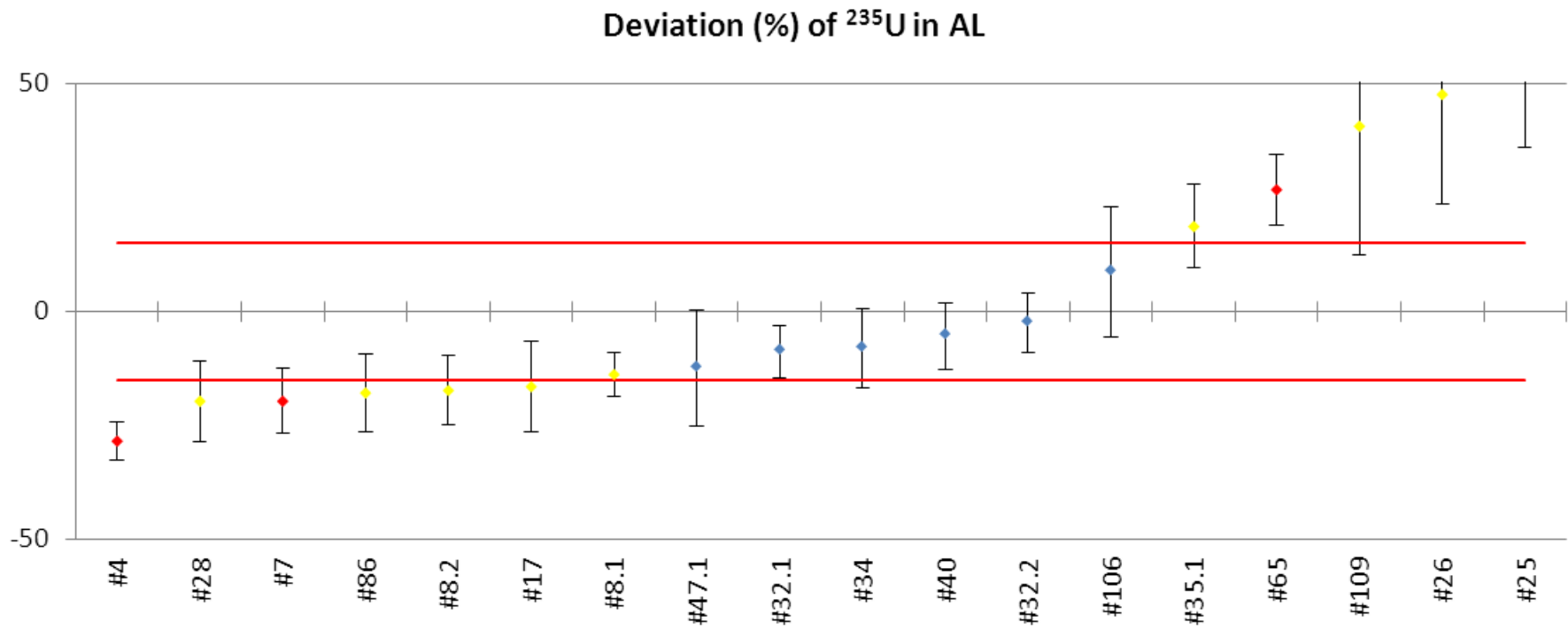
6. Alpha Low (AL) Deviation Plots

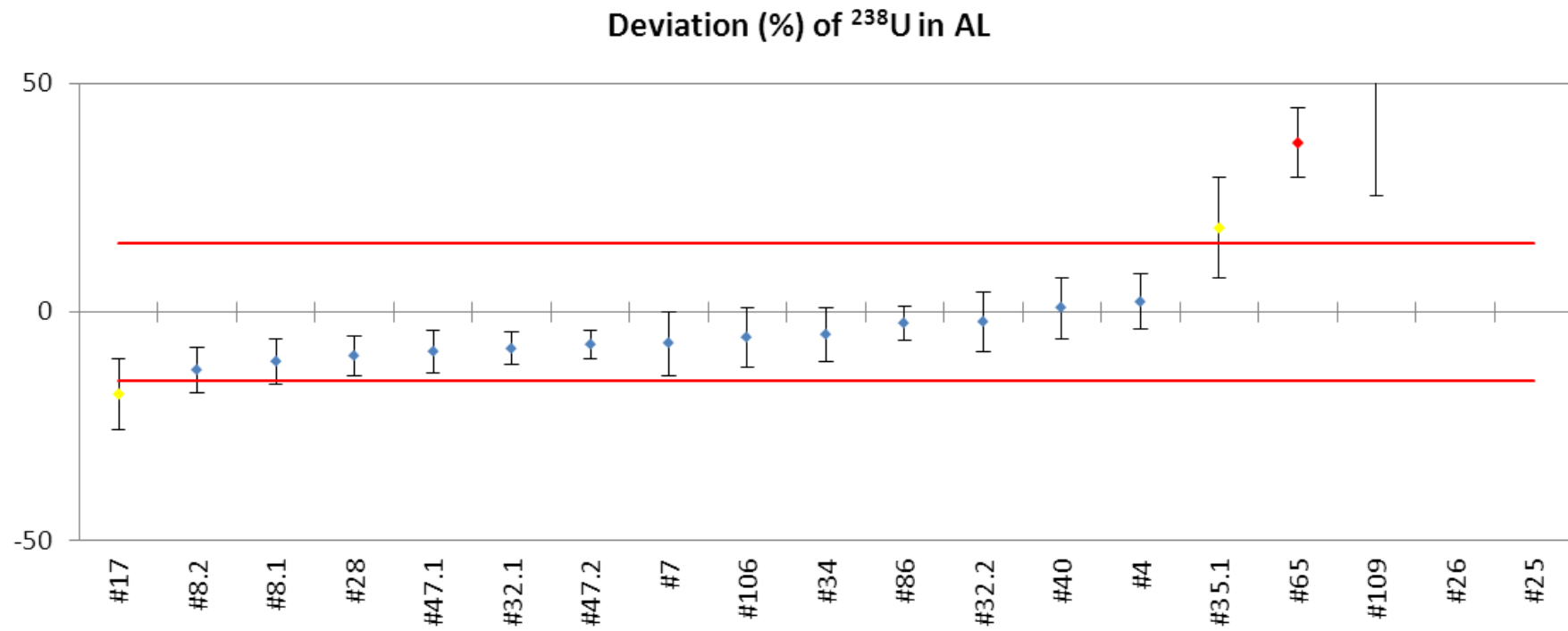


Deviation (%) of ^{232}Th in AL



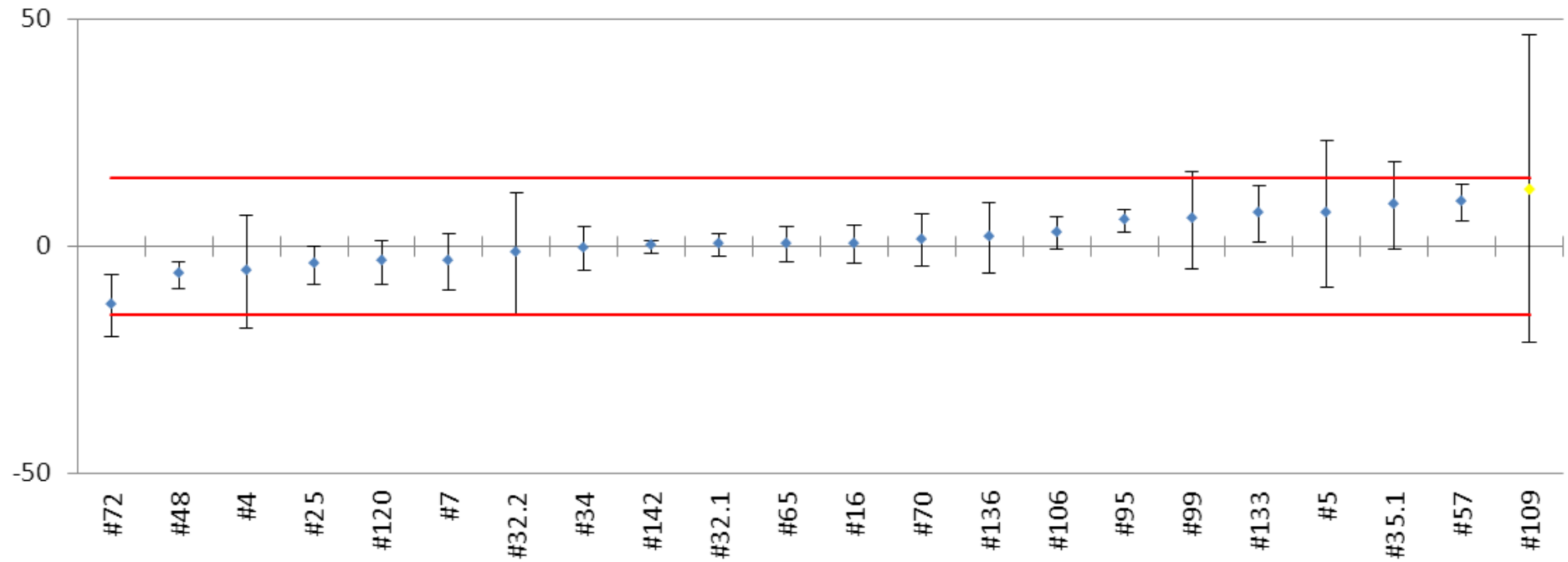




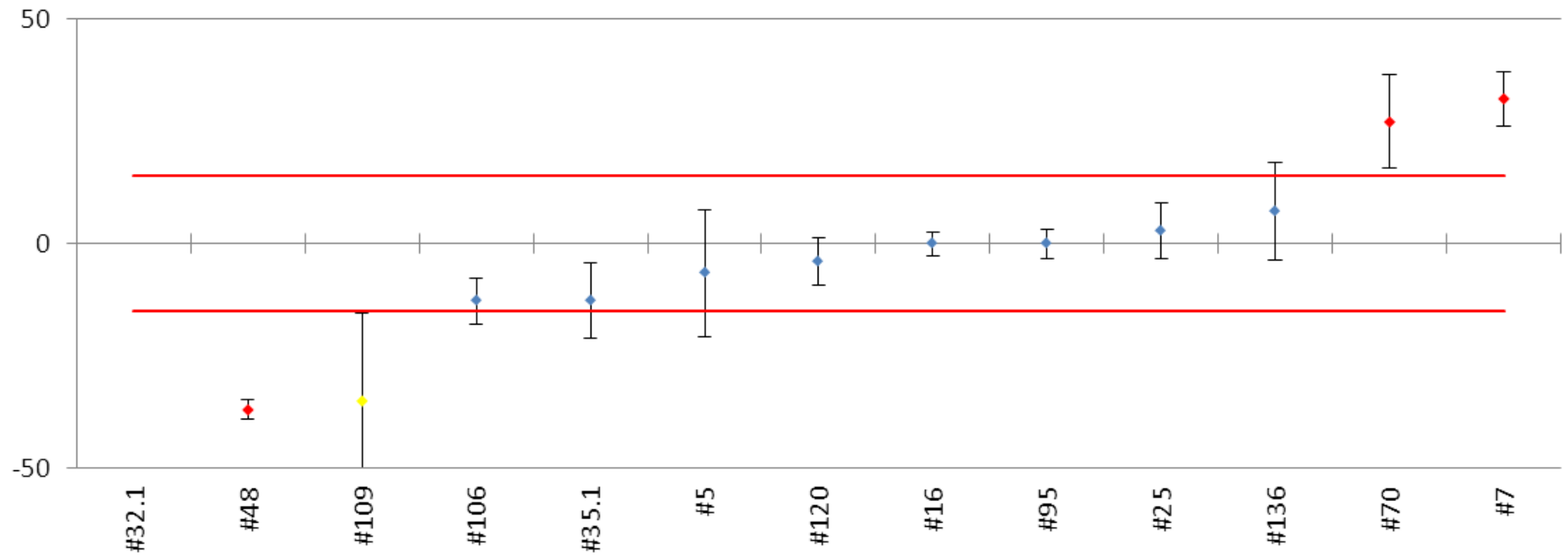


7. Beta One (B1) Deviation Plots

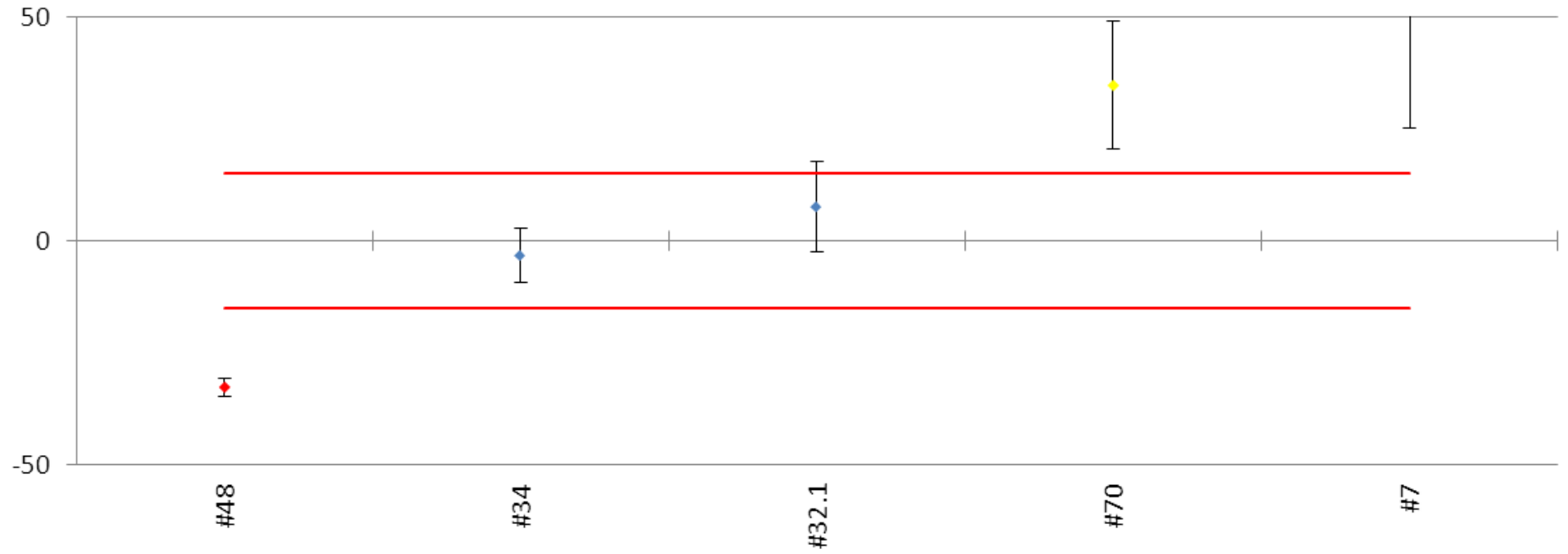
Deviation (%) of ^3H in B1

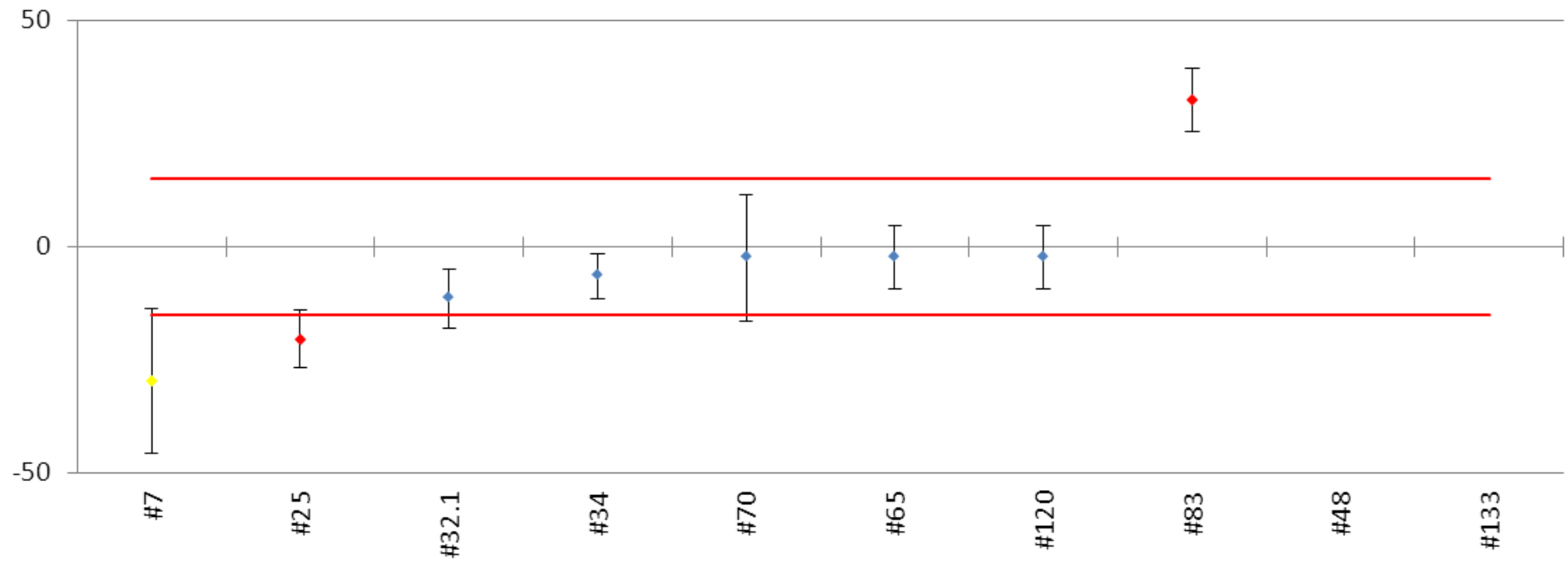


Deviation (%) of ^{14}C in B1



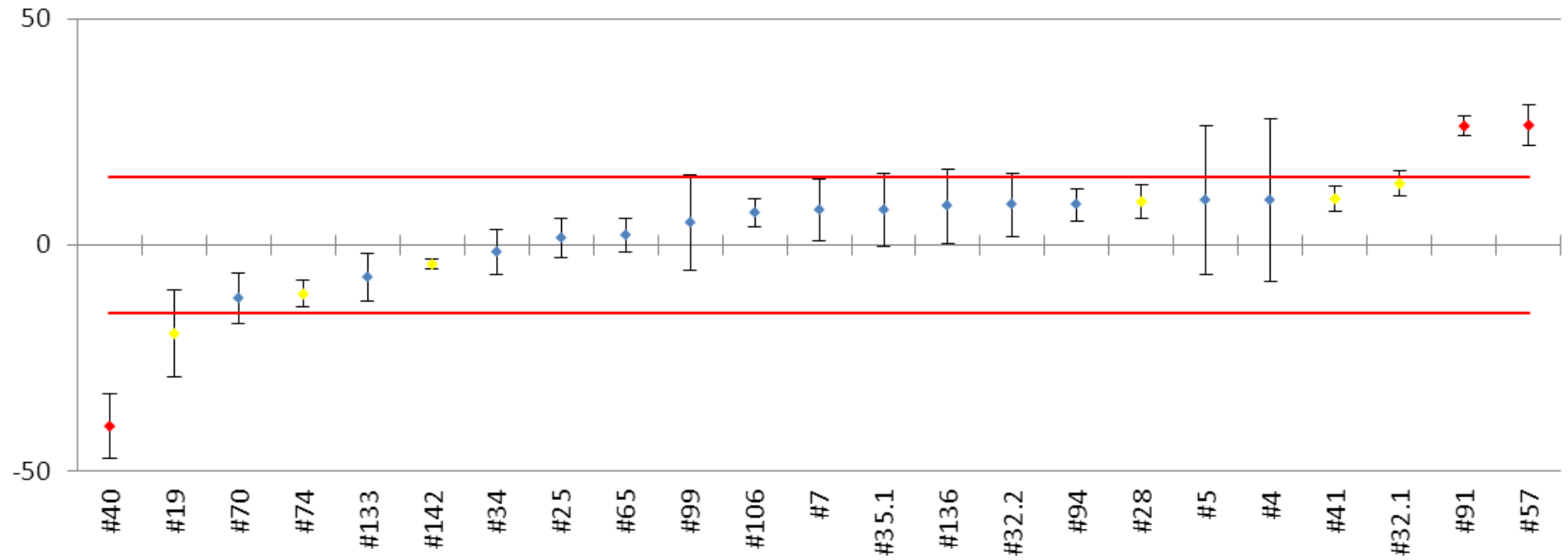
Deviation (%) of ^{36}Cl in B1



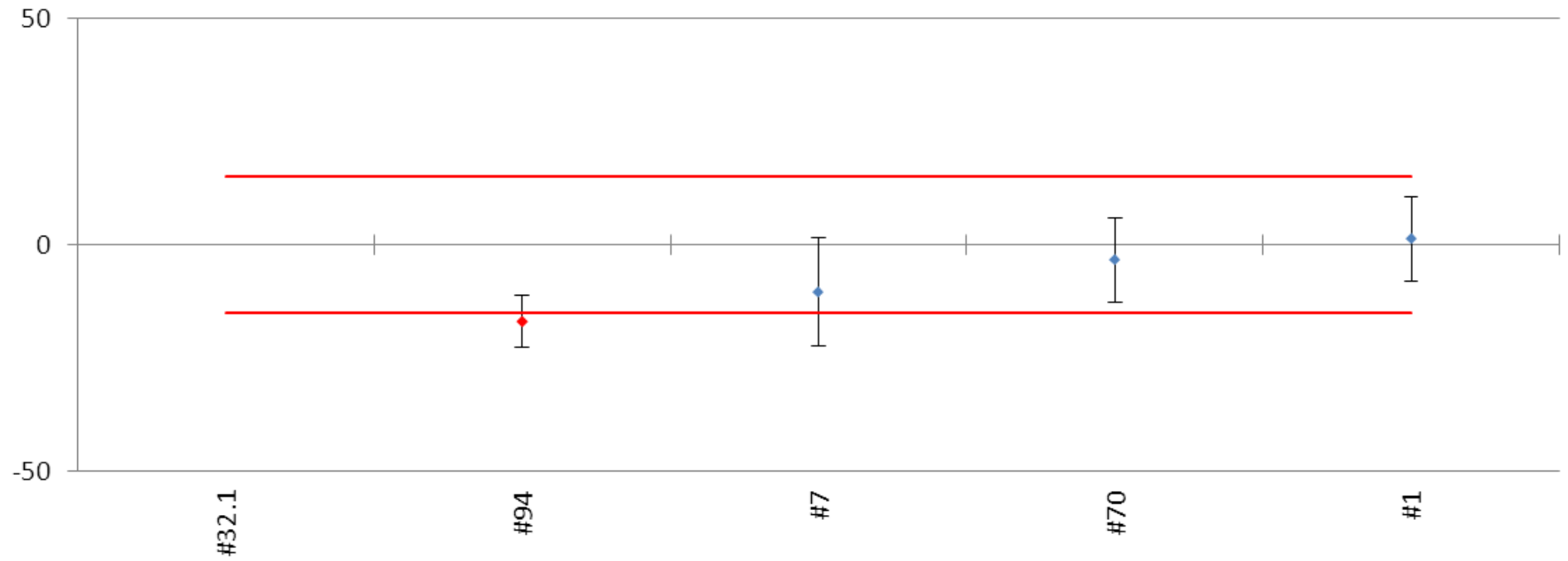
Deviation (%) of ^{99}Tc in B1

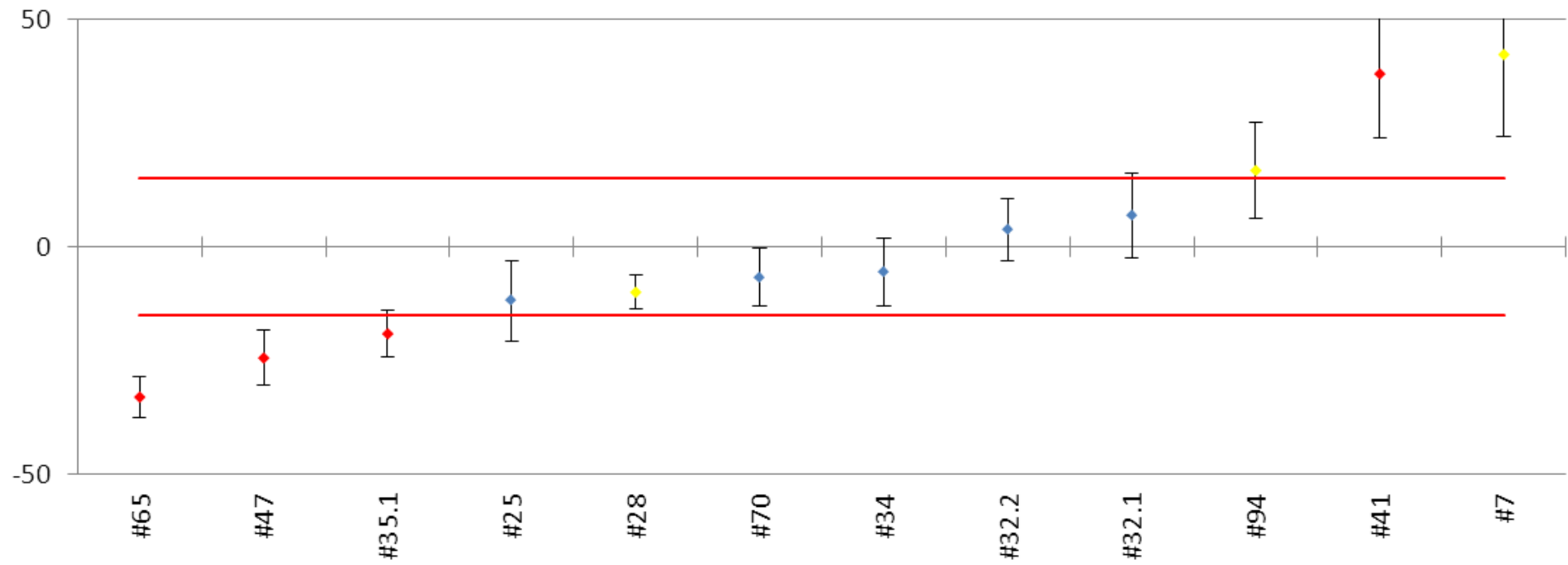
8. Beta Two (B2) Deviation Plots

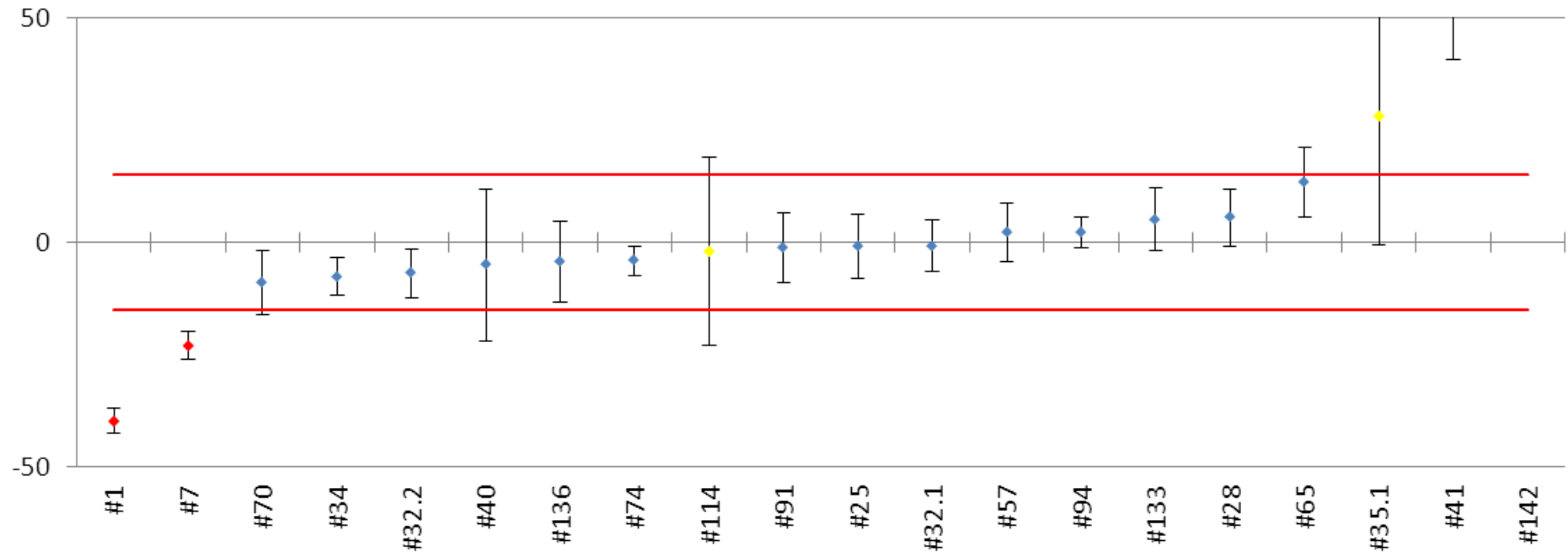
Deviation (%) of ^3H in B2



Deviation (%) of ^{147}Pm in B2

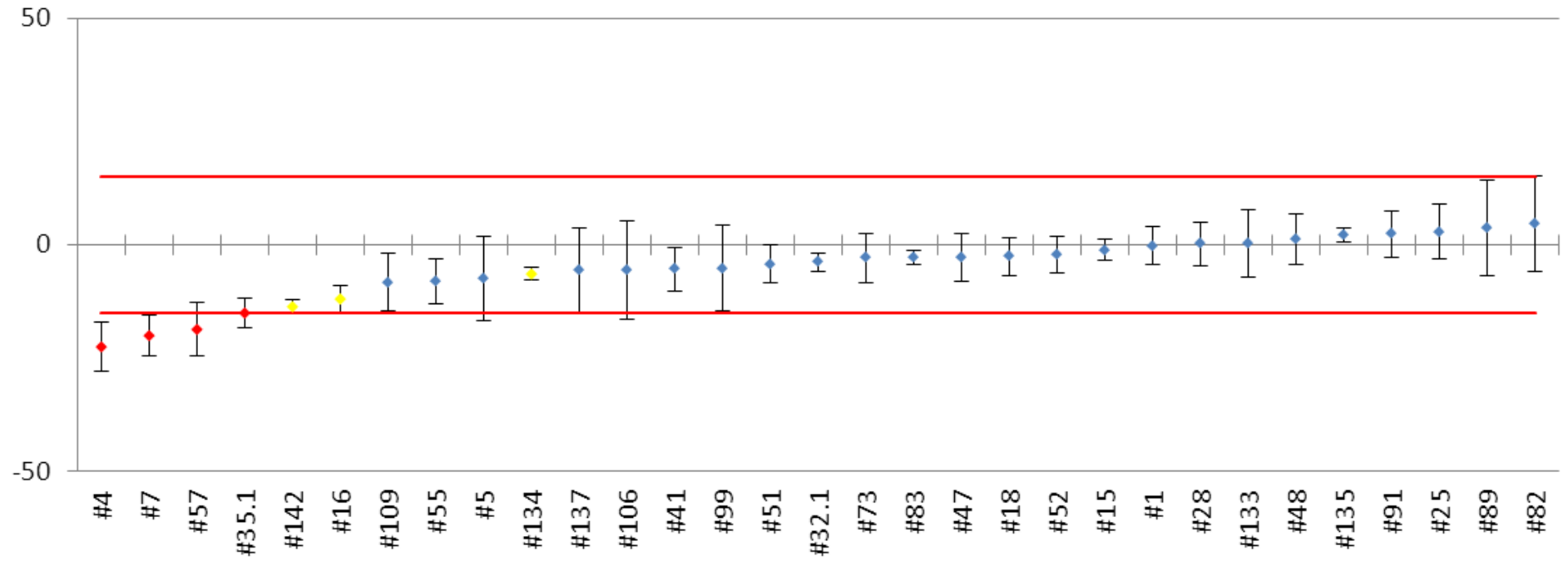


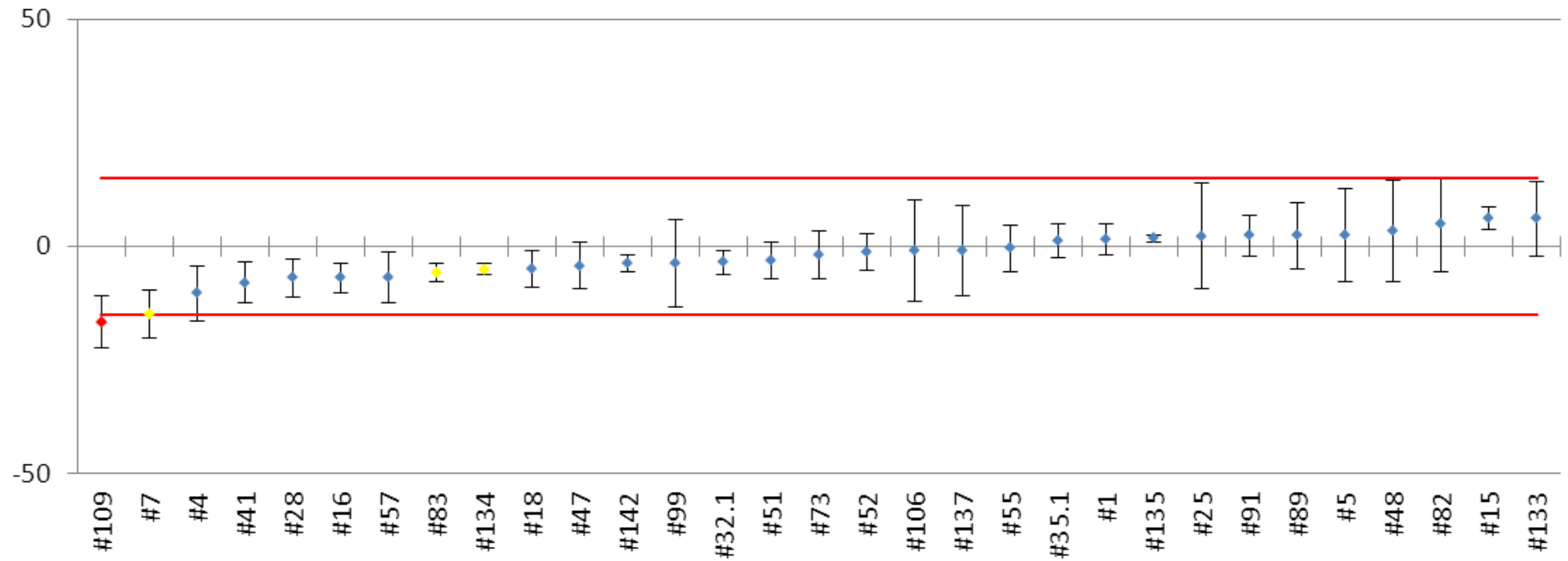
Deviation (%) of ^{241}Pu in B2

Deviation (%) of ^{90}Sr in B2

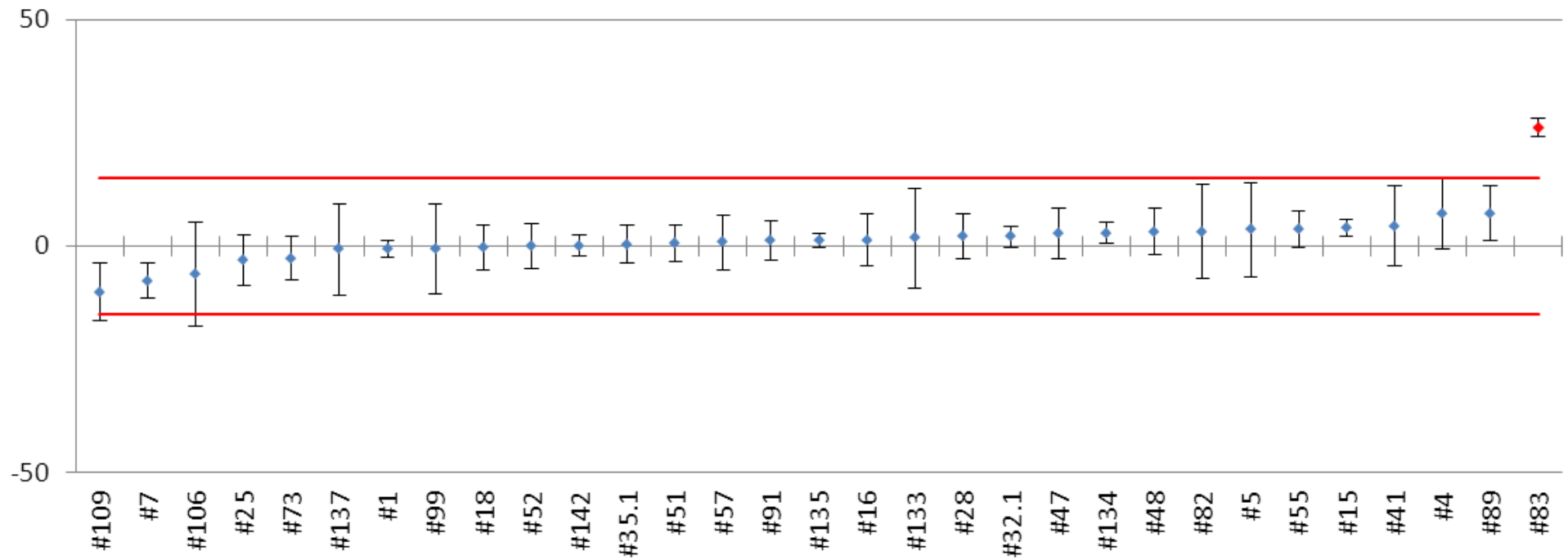
9. Gamma High (GH) Deviation Plots

Deviation (%) of ^{133}Ba in GH

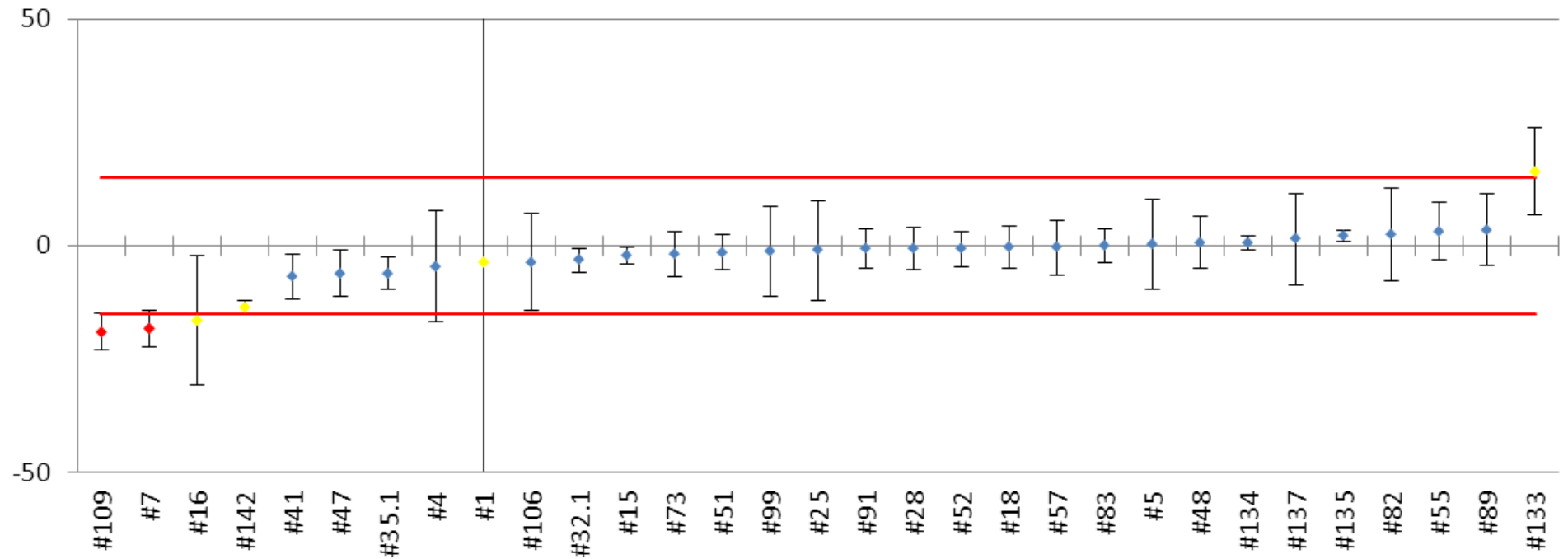


Deviation (%) of ^{152}Eu in GH

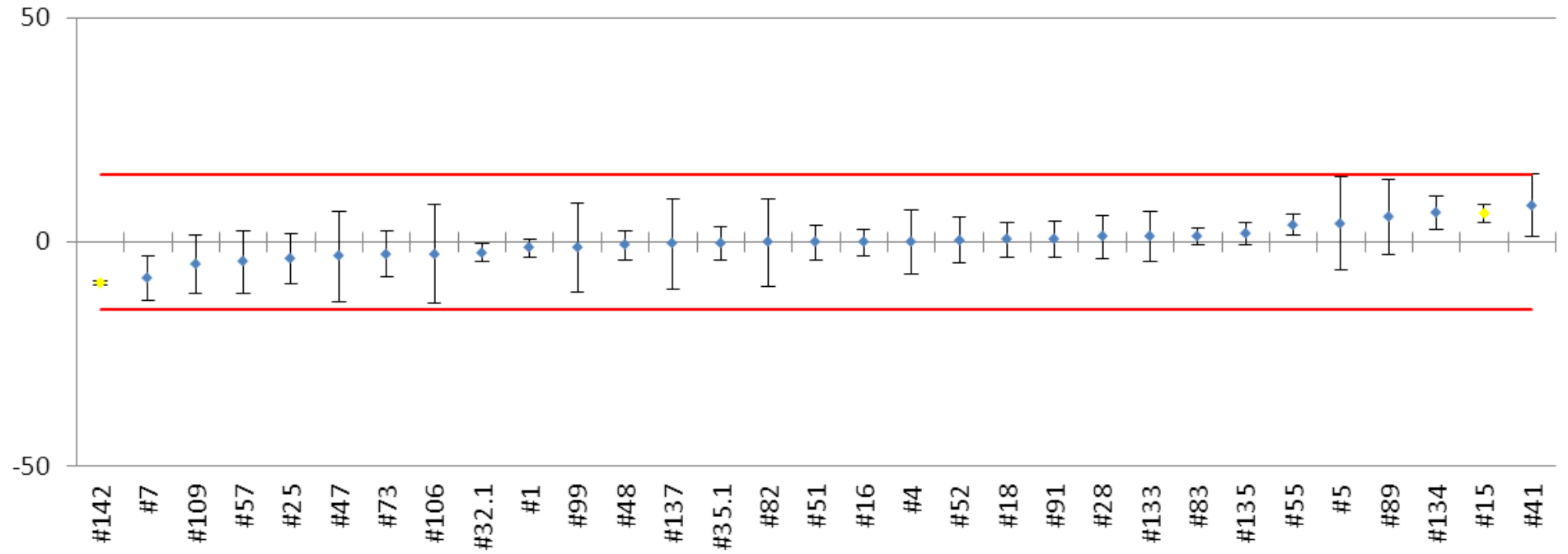
Deviation (%) of ^{60}Co in GH



Deviation (%) of ^{134}Cs in GH

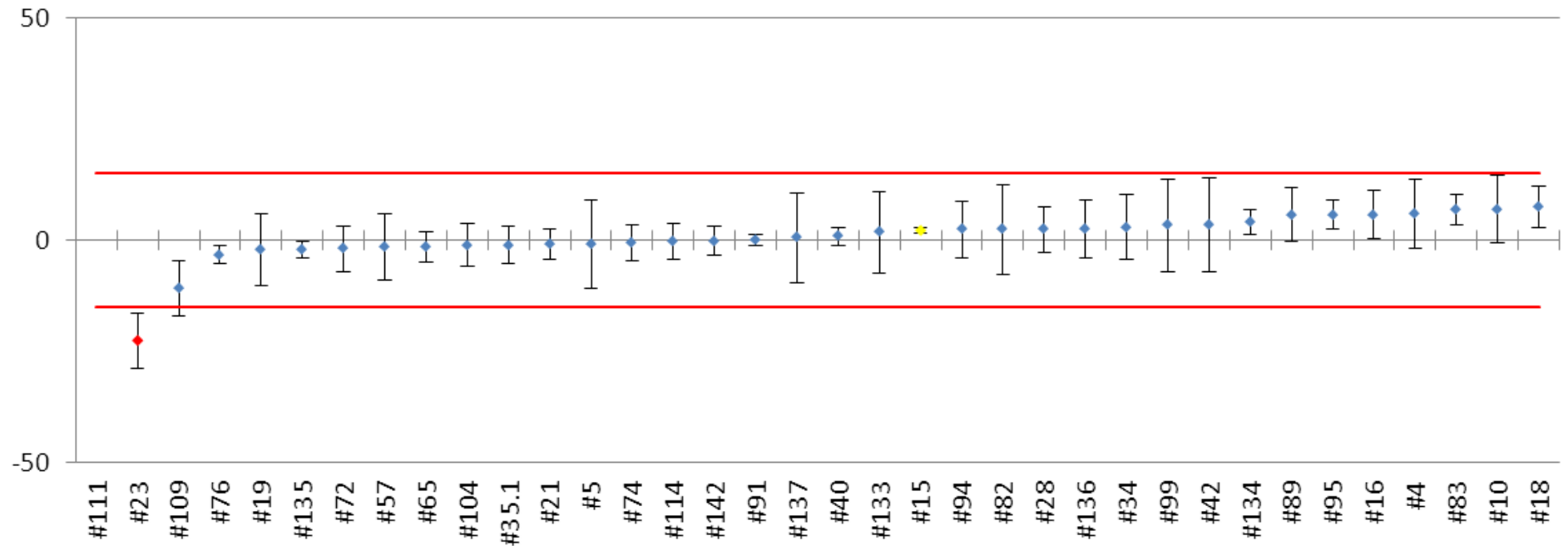


Deviation (%) of ^{137}Cs in GH

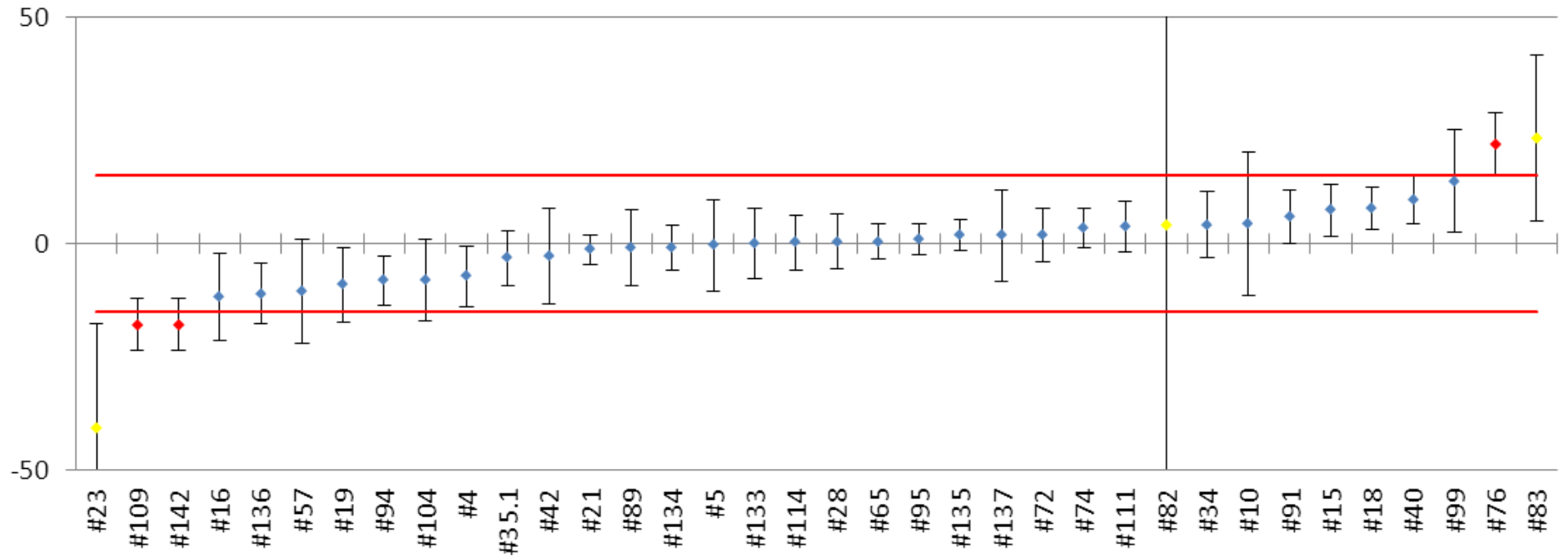


10. Gamma Low (GL) Deviation Plots

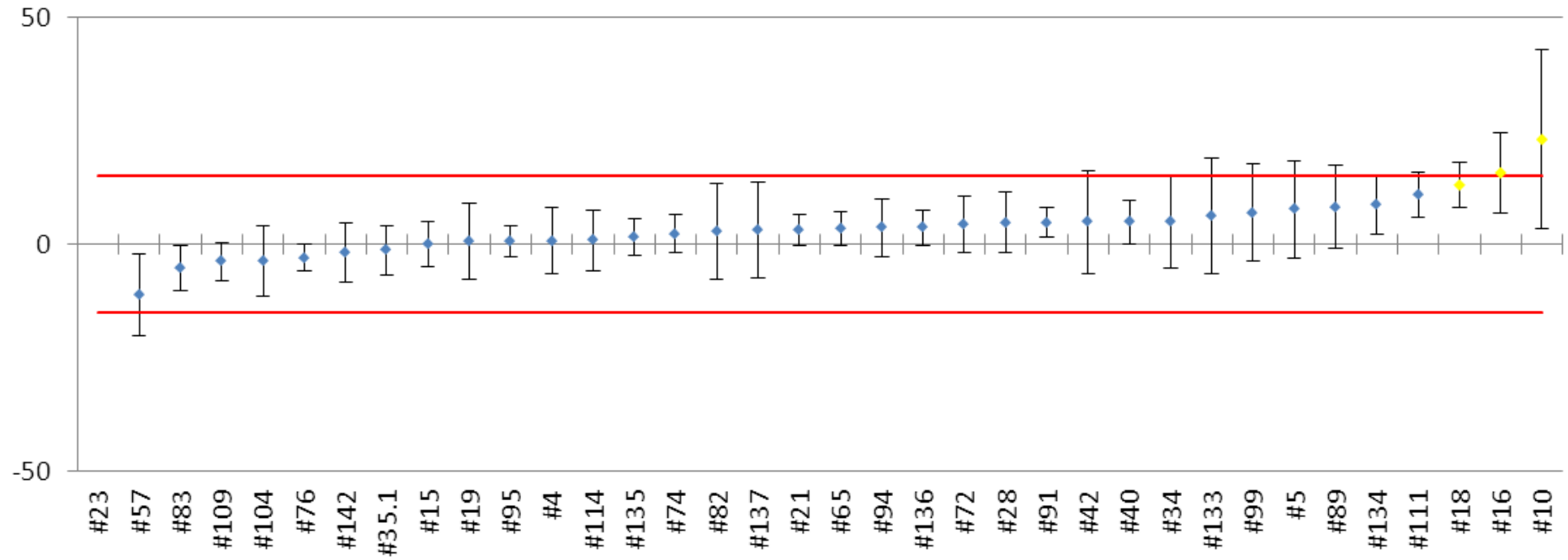
Deviation (%) of ⁶⁰Co in GL



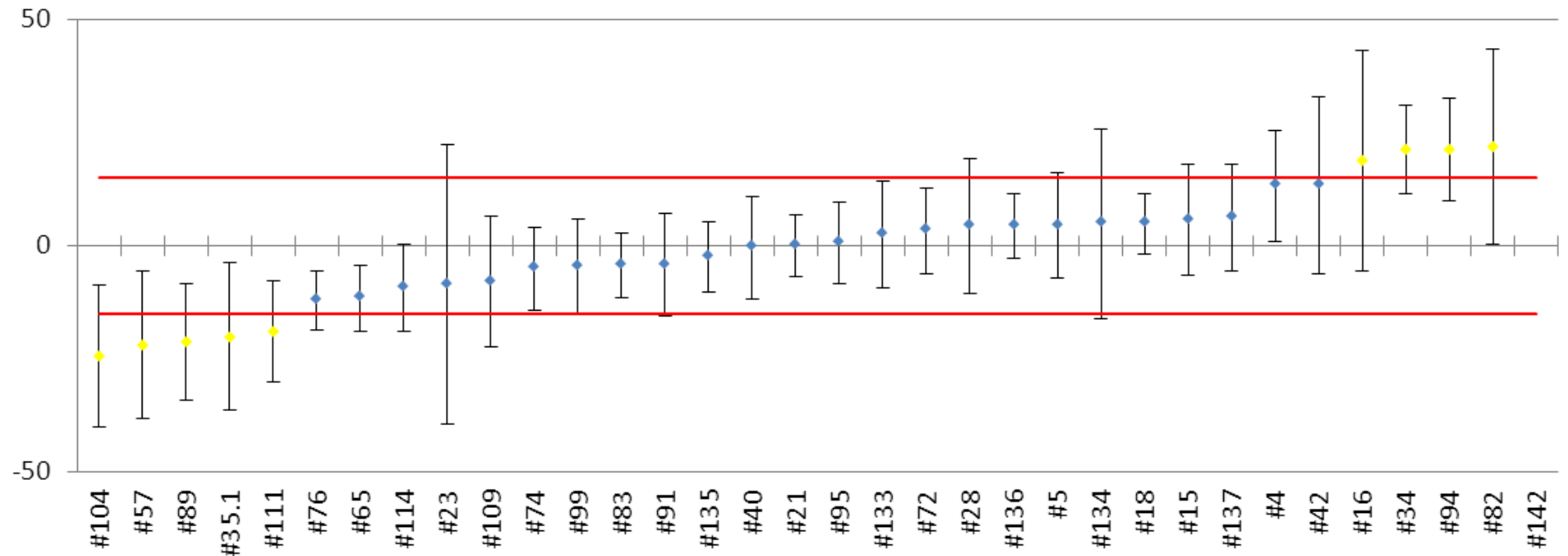
Deviation (%) of ^{134}Cs in GL

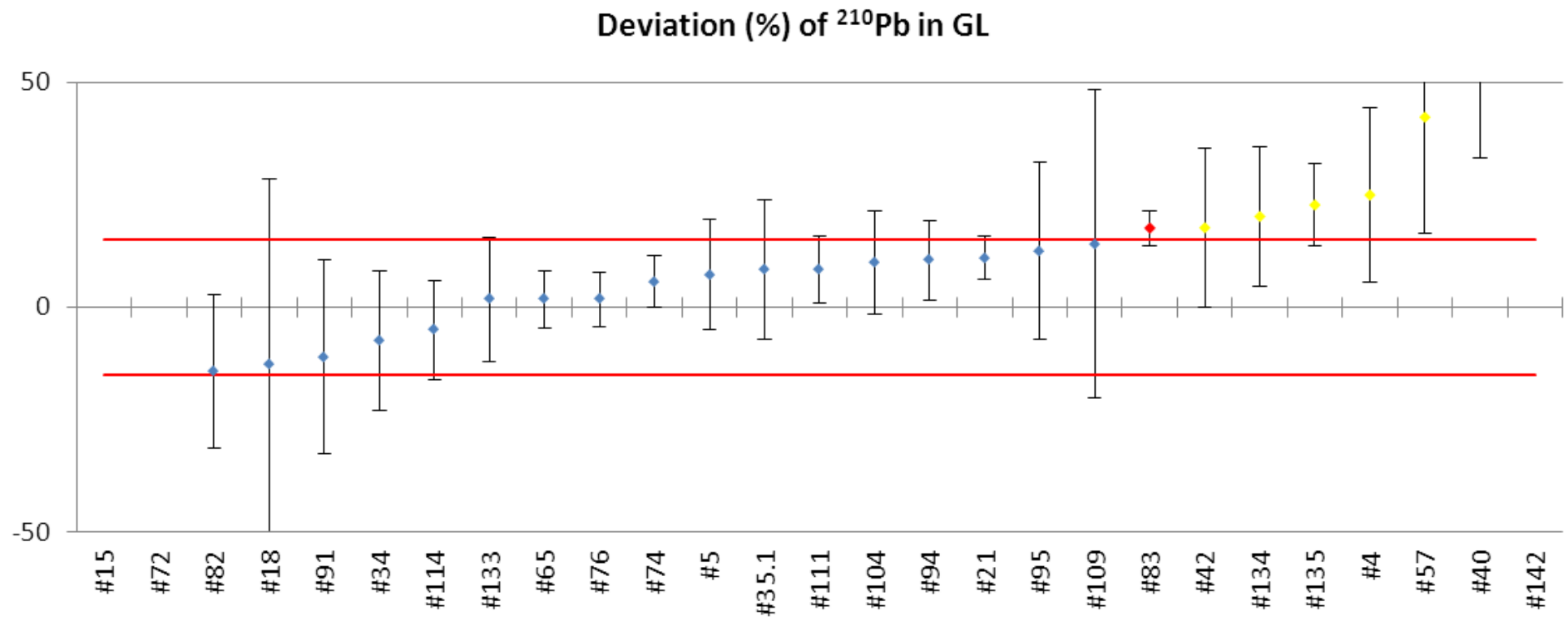


Deviation (%) of ¹³⁷Cs in GL

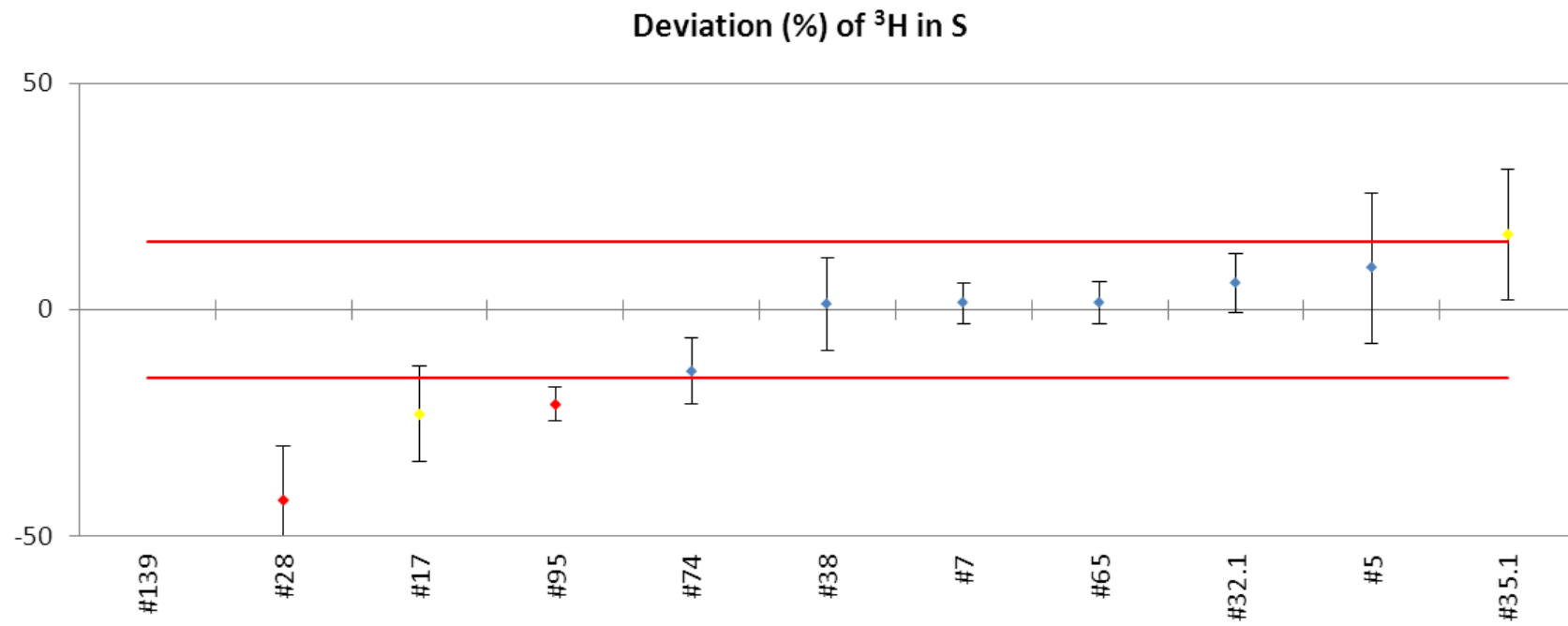


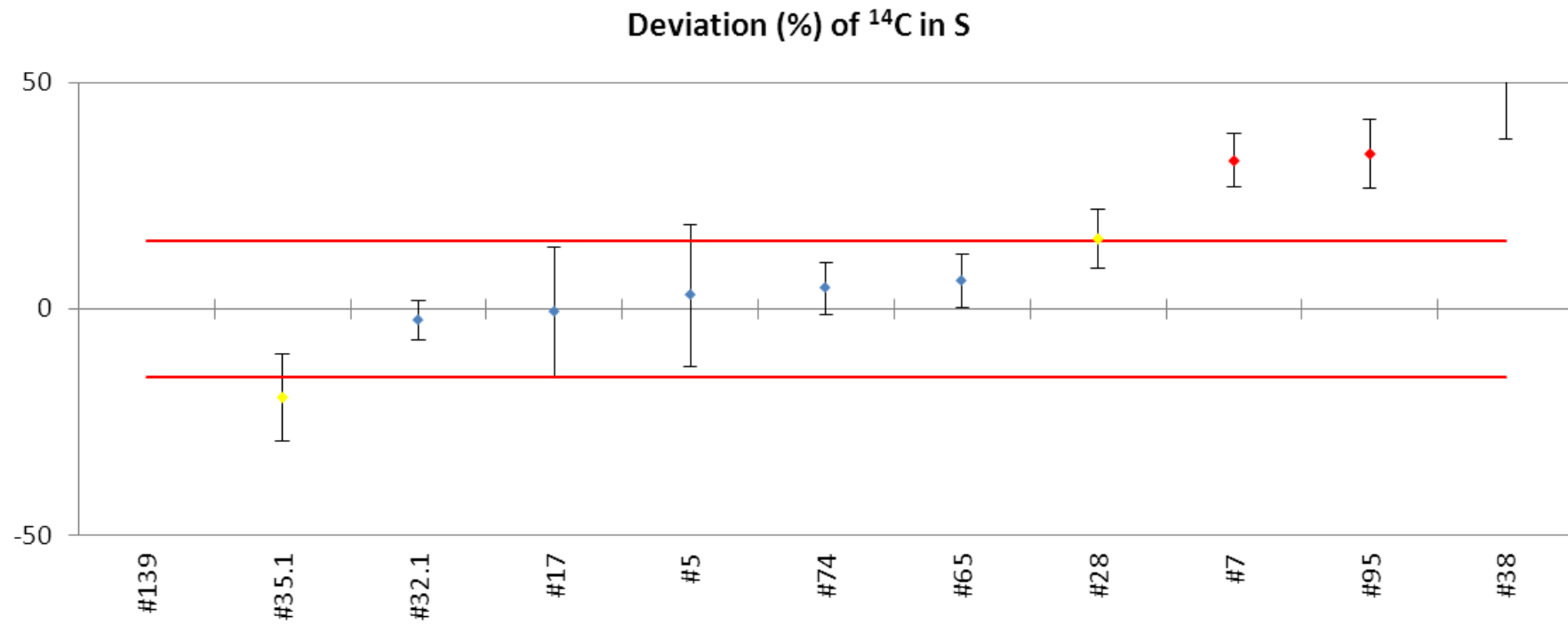
Deviation (%) of ^{40}K in GL

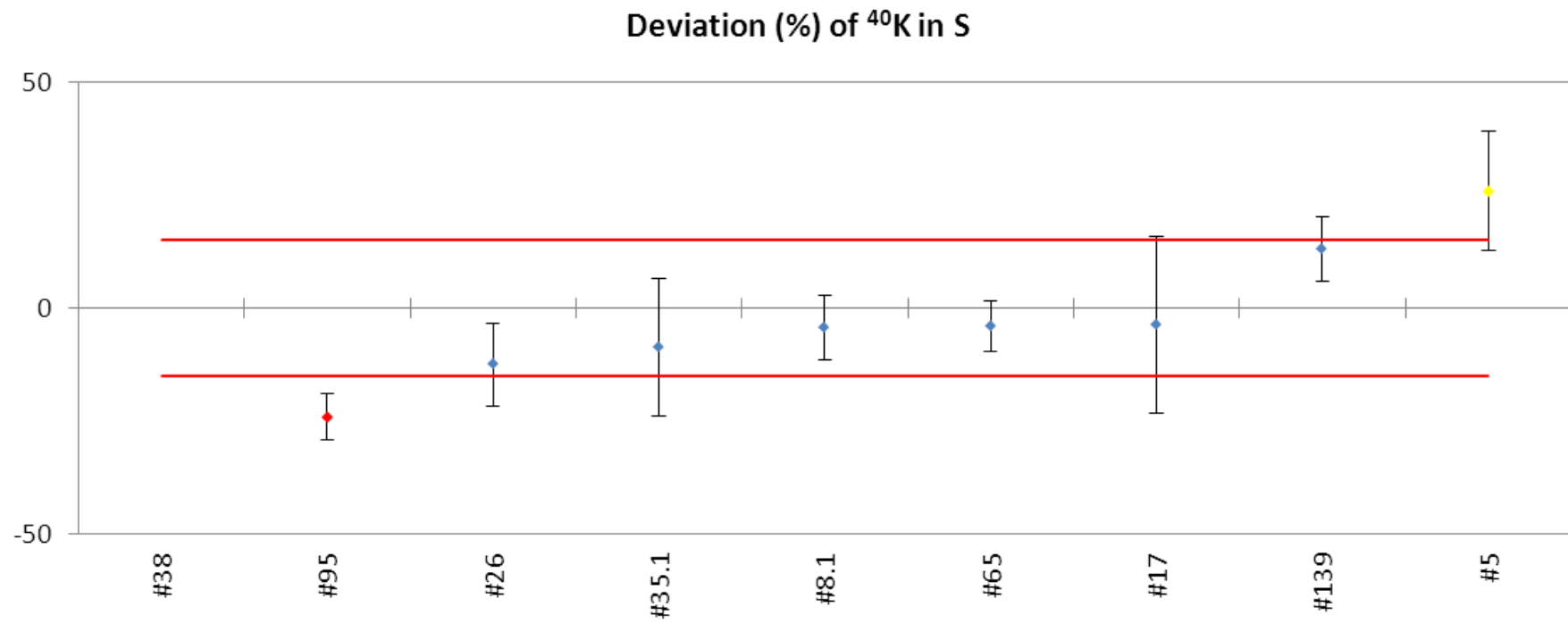


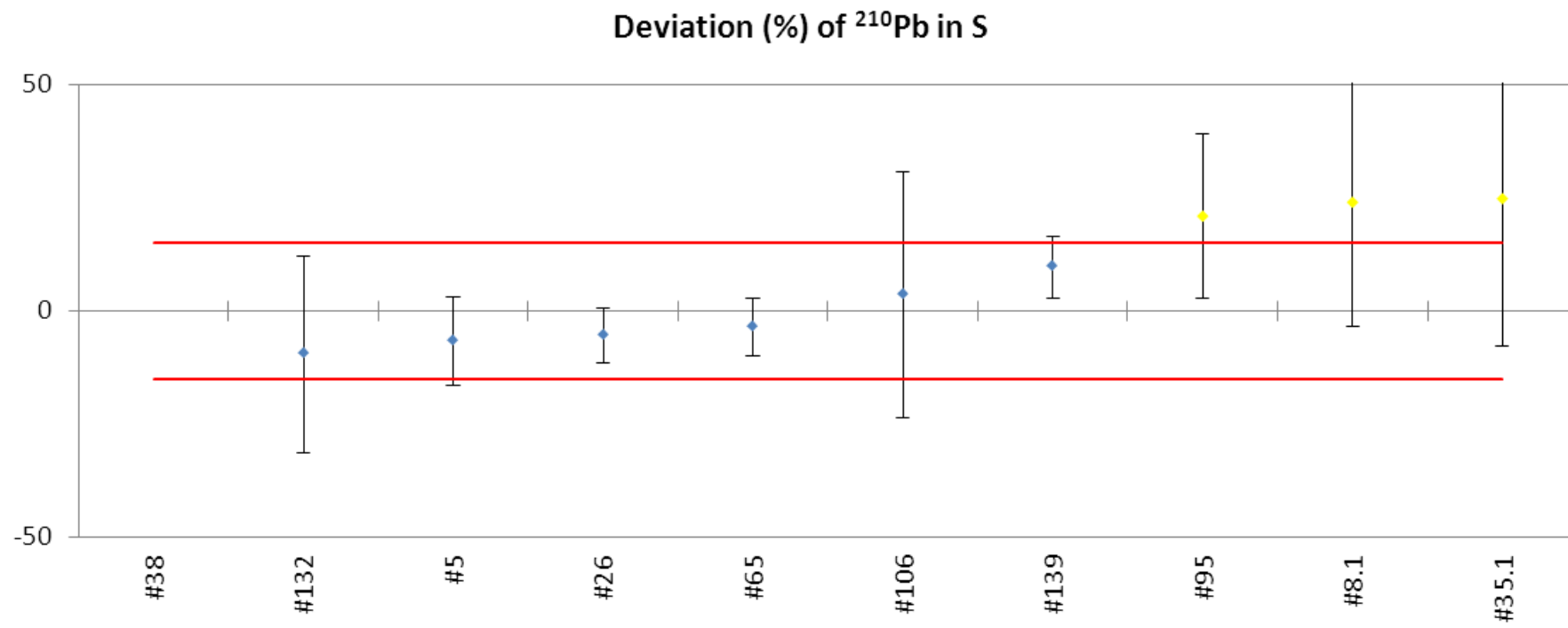


11. Solid (S) Deviation Plots

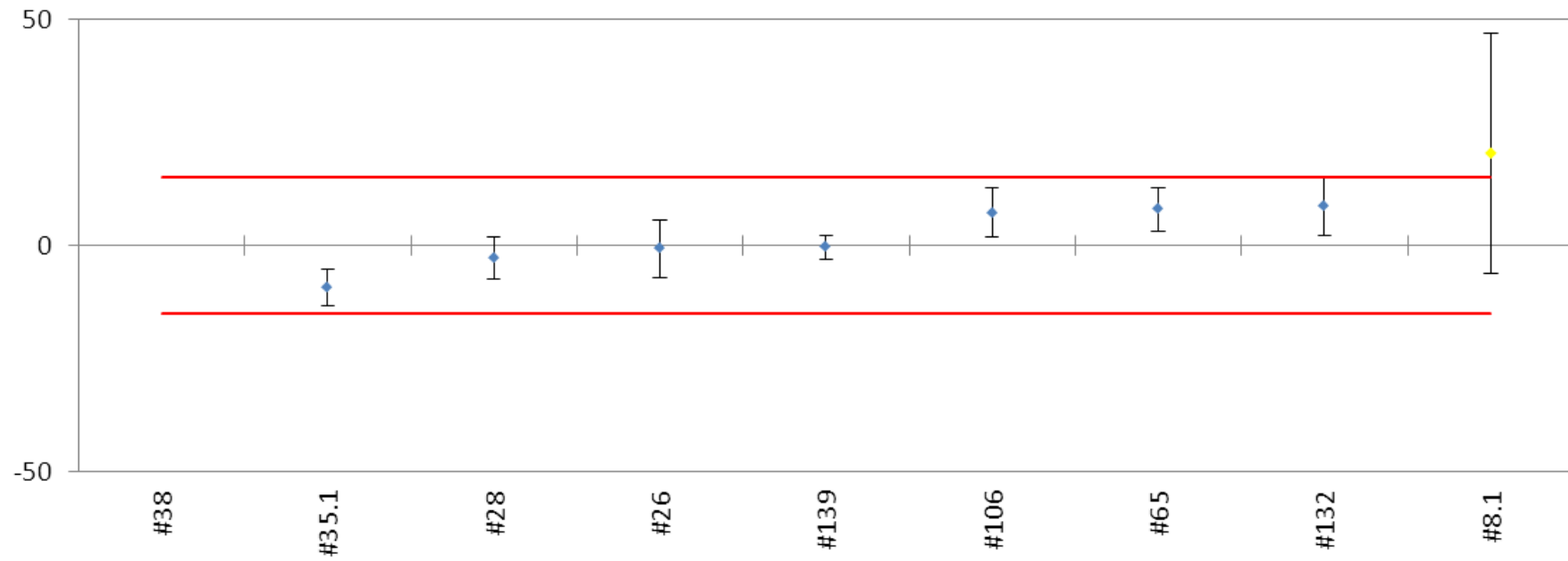






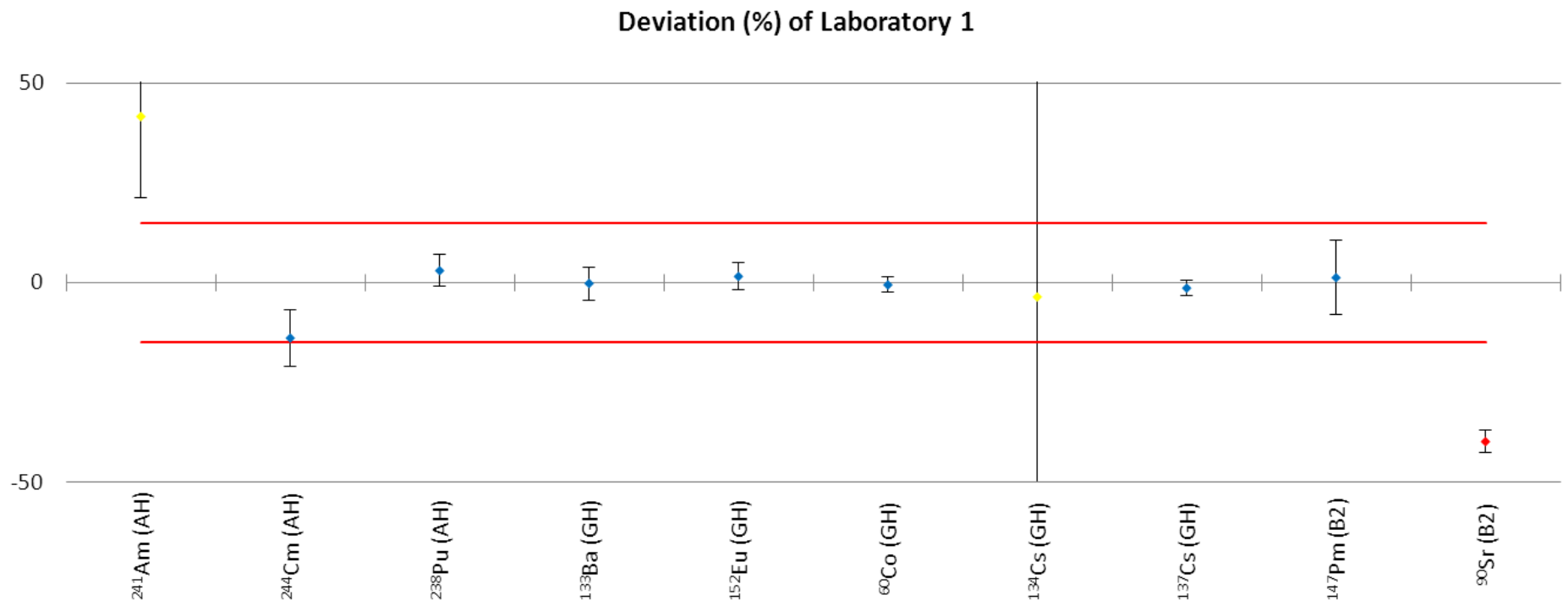


Deviation (%) of ^{210}Po in S



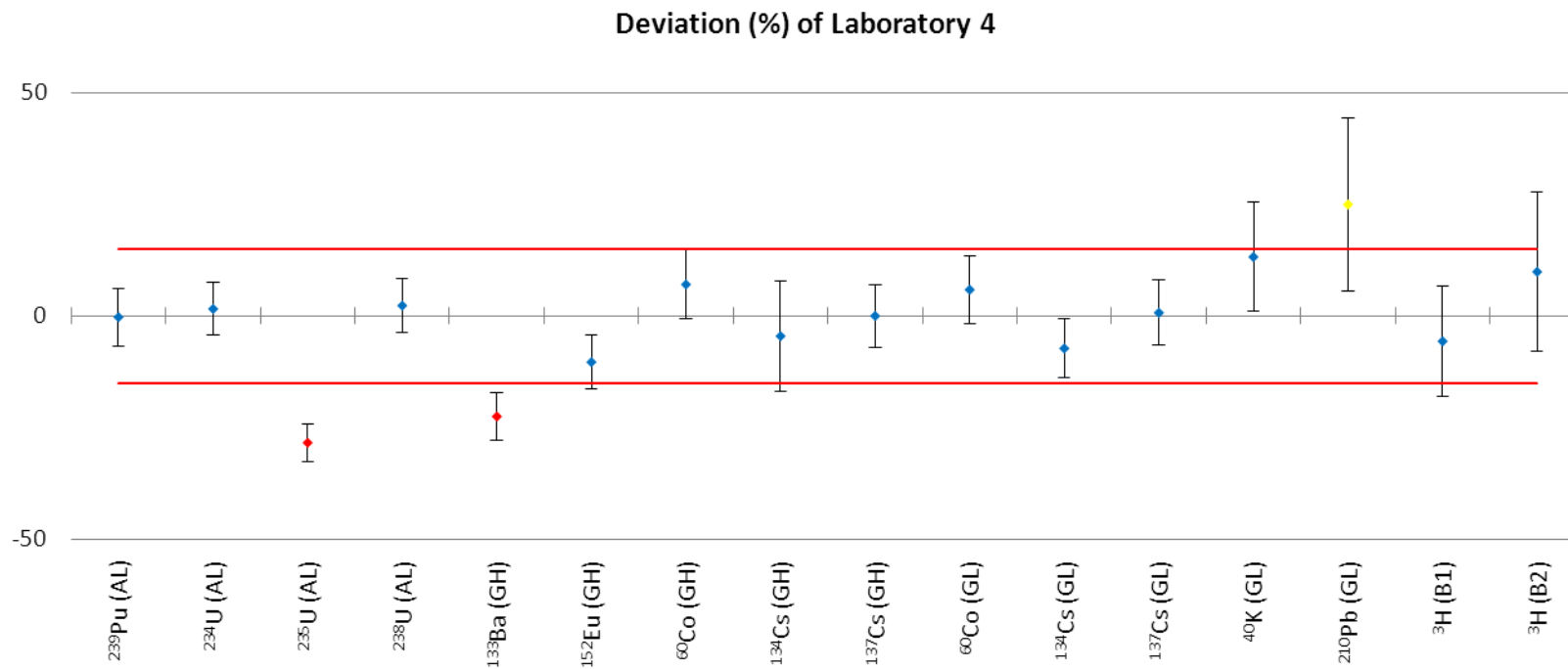
12. Deviation Plots and Tabulated Results Arranged by Lab Number

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.



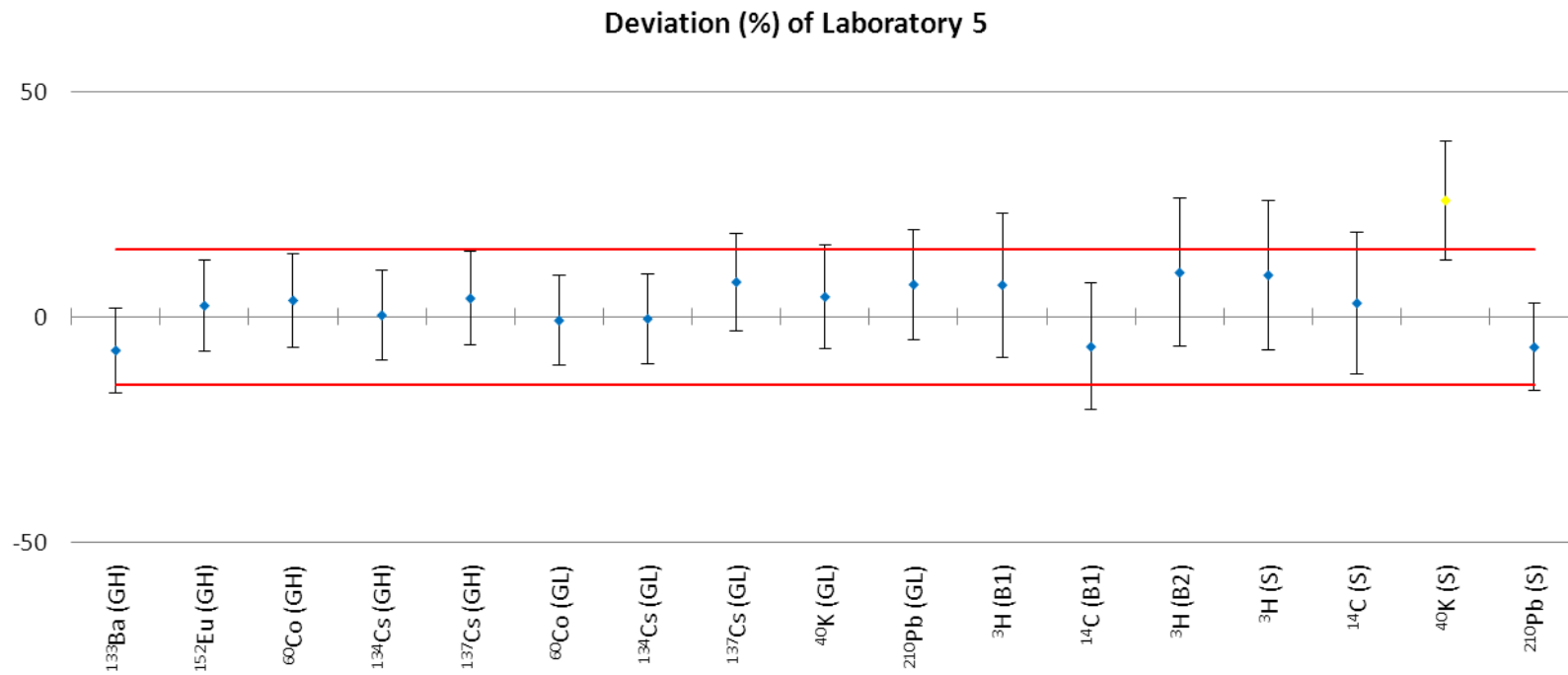
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Radionuclide	Laboratory 1	NPL Assigned Value	Deviation /%	Zeta	Z Score
²⁴¹ Am (AH)	6.3 ± 0.9 (± 14 %)	4.449 ± 0.010 (± 0.24 %)	41.6	2.06	7.14
²⁴⁴ Cm (AH)	16.8 ± 1.4 (± 8 %)	19.51 ± 0.07 (± 0.4 %)	-13.9	-1.93	-2.38
²³⁸ Pu (AH)	15.4 ± 0.6 (± 4 %)	14.950 ± 0.050 (± 0.3 %)	3.0	0.75	0.52
¹³³ Ba (GH)	7.4 ± 0.3 (± 4 %)	7.410 ± 0.050 (± 0.7 %)	-0.2	-0.05	-0.03
¹⁵² Eu (GH)	15.50 ± 0.50 (± 4 %)	15.26 ± 0.10 (± 0.7 %)	1.6	0.47	0.27
⁶⁰ Co (GH)	5.20 ± 0.10 (± 1.9 %)	5.229 ± 0.011 (± 0.22 %)	-0.6	-0.29	-0.10
¹³⁴ Cs (GH)	3 ± 3 (± 100 %)	2.800 ± 0.019 (± 0.7 %)	-3.6	-0.04	-0.61
¹³⁷ Cs (GH)	15.2 ± 0.3 (± 2.0 %)	15.41 ± 0.06 (± 0.4 %)	-1.4	-0.69	-0.23
¹⁴⁷ Pm (B2)	0.44 ± 0.04 (± 9 %)	0.435 ± 0.004 (± 0.9 %)	1.3	0.14	0.22
⁹⁰ Sr (B2)	0.086 ± 0.004 (± 5.0 %)	0.1429 ± 0.0003 (± 0.20 %)	-39.8	-14.18	-6.84



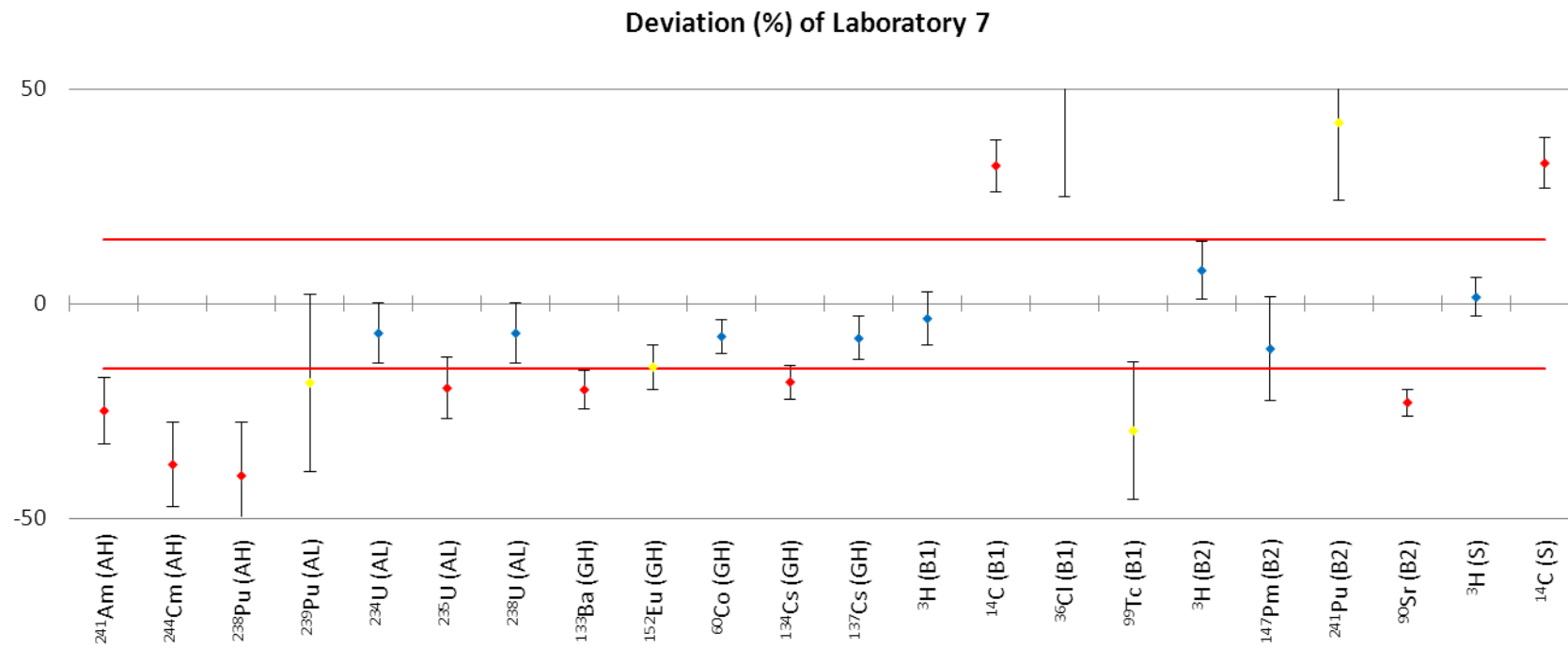
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Radionuclide	Laboratory 4	NPL Assigned Value	Deviation /%	Zeta	Z Score
²³⁹ Pu (AL)	12.1 ± 0.7 (± 6 %)	12.1 ± 0.3 (± 2.2 %)	-0.2	-0.04	-0.04
²³⁴ U (AL)	15.3 ± 0.8 (± 6 %)	15.0 ± 0.4 (± 3 %)	1.6	0.27	0.27
²³⁵ U (AL)	0.51 ± 0.03 (± 5.0 %)	0.718 ± 0.019 (± 3 %)	-28.4	-6.30	-4.88
²³⁸ U (AL)	15.4 ± 0.8 (± 6 %)	15.0 ± 0.4 (± 3 %)	2.3	0.38	0.40
¹³³ Ba (GH)	5.7 ± 0.4 (± 7 %)	7.410 ± 0.050 (± 0.7 %)	-22.5	-4.17	-3.86
¹⁵² Eu (GH)	13.7 ± 0.9 (± 7 %)	15.26 ± 0.10 (± 0.7 %)	-10.3	-1.69	-1.77
⁶⁰ Co (GH)	5.6 ± 0.4 (± 7 %)	5.229 ± 0.011 (± 0.22 %)	7.1	0.92	1.22
¹³⁴ Cs (GH)	2.7 ± 0.4 (± 13 %)	2.800 ± 0.019 (± 0.7 %)	-4.5	-0.36	-0.77
¹³⁷ Cs (GH)	15.4 ± 1.1 (± 7 %)	15.41 ± 0.06 (± 0.4 %)	0.0	0.00	0.00
⁶⁰ Co (GL)	18.7 ± 1.3 (± 7 %)	17.68 ± 0.08 (± 0.50 %)	5.9	0.77	1.01
¹³⁴ Cs (GL)	2.03 ± 0.15 (± 7 %)	2.190 ± 0.017 (± 0.8 %)	-7.3	-1.09	-1.25
¹³⁷ Cs (GL)	4.2 ± 0.3 (± 7 %)	4.12 ± 0.04 (± 0.9 %)	0.7	0.10	0.13
⁴⁰ K (GL)	18.6 ± 1.8 (± 10 %)	16.4 ± 0.8 (± 5.0 %)	13.3	1.11	2.28
²¹⁰ Pb (GL)	24 ± 4 (± 15 %)	19.46 ± 0.22 (± 1.1 %)	25.0	1.29	4.29
³ H (B1)	0.99 ± 0.13 (± 13 %)	1.046 ± 0.008 (± 0.7 %)	-5.6	-0.46	-0.97
³ H (B2)	1.18 ± 0.19 (± 16 %)	1.076 ± 0.008 (± 0.7 %)	9.9	0.55	1.70



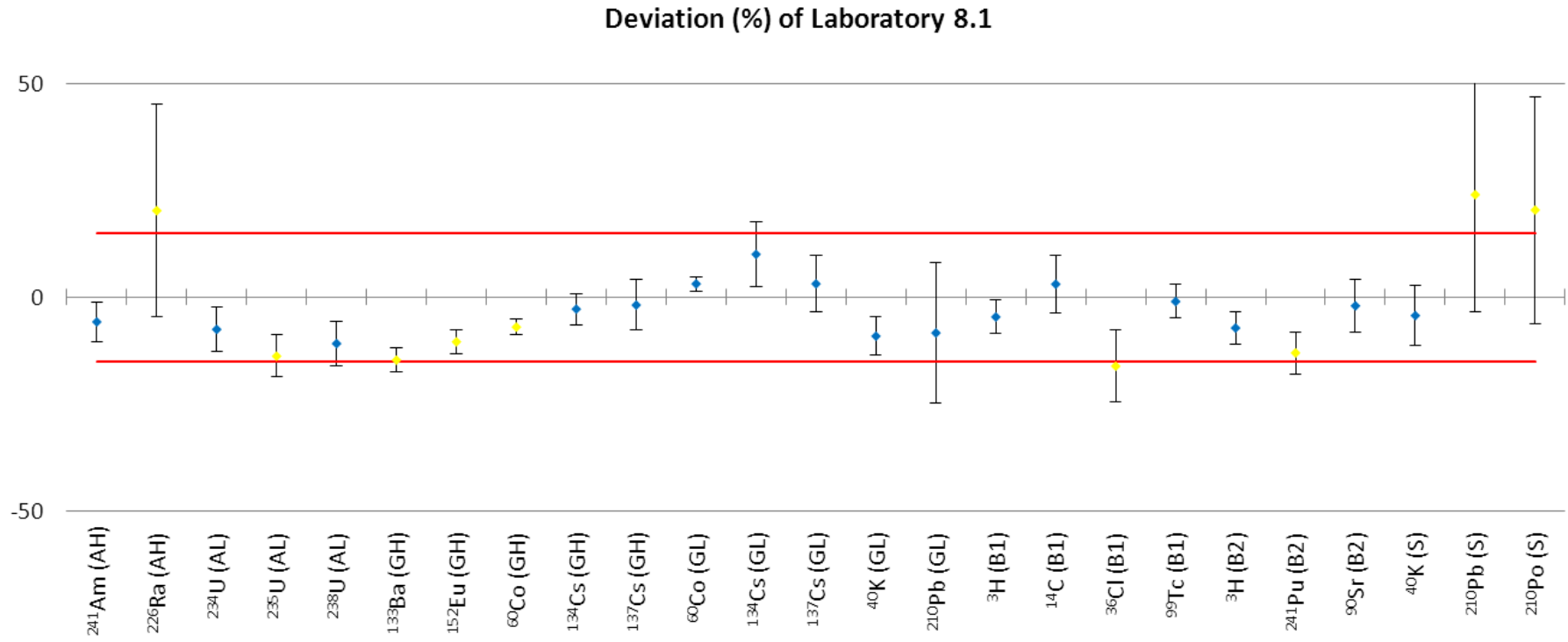
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Radionuclide	Laboratory 5	NPL Assigned Value	Deviation /%	Zeta	Z Score
¹³³ Ba (GH)	6.9 ± 0.7 (± 10 %)	7.410 ± 0.050 (± 0.7 %)	-7.5	-0.80	-1.28
¹⁵² Eu (GH)	15.6 ± 1.6 (± 10 %)	15.26 ± 0.10 (± 0.7 %)	2.5	0.24	0.43
⁶⁰ Co (GH)	5.4 ± 0.6 (± 10 %)	5.229 ± 0.011 (± 0.22 %)	3.6	0.35	0.63
¹³⁴ Cs (GH)	2.8 ± 0.3 (± 10 %)	2.800 ± 0.019 (± 0.7 %)	0.4	0.04	0.06
¹³⁷ Cs (GH)	16.0 ± 1.6 (± 10 %)	15.41 ± 0.06 (± 0.4 %)	4.1	0.39	0.70
⁶⁰ Co (GL)	17.5 ± 1.8 (± 10 %)	17.68 ± 0.08 (± 0.50 %)	-0.8	-0.08	-0.14
¹³⁴ Cs (GL)	2.18 ± 0.22 (± 10 %)	2.190 ± 0.017 (± 0.8 %)	-0.4	-0.04	-0.08
¹³⁷ Cs (GL)	4.40 ± 0.50 (± 10 %)	4.12 ± 0.04 (± 0.9 %)	7.7	0.72	1.33
⁴⁰ K (GL)	17.1 ± 1.7 (± 10 %)	16.4 ± 0.8 (± 5.0 %)	4.4	0.39	0.76
²¹⁰ Pb (GL)	20.9 ± 2.4 (± 11 %)	19.46 ± 0.22 (± 1.1 %)	7.2	0.59	1.23
³ H (B1)	1.12 ± 0.17 (± 15 %)	1.046 ± 0.008 (± 0.7 %)	7.1	0.44	1.21
¹⁴ C (B1)	0.90 ± 0.14 (± 15 %)	0.968 ± 0.008 (± 0.8 %)	-6.6	-0.47	-1.14
³ H (B2)	1.18 ± 0.18 (± 15 %)	1.076 ± 0.008 (± 0.7 %)	9.8	0.60	1.69
³ H (S)	84 ± 13 (± 15 %)	77.1 ± 1.7 (± 2.2 %)	9.2	0.56	1.59
¹⁴ C (S)	2.0 ± 0.3 (± 15 %)	1.91 ± 0.05 (± 2.5 %)	3.0	0.19	0.52
⁴⁰ K (S)	227 ± 23 (± 10 %)	181 ± 6 (± 3 %)	25.9	2.00	4.44
²¹⁰ Pb (S)	43.0 ± 5.0 (± 10 %)	46.5 ± 1.4 (± 3 %)	-6.7	-0.69	-1.16



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Radionuclide	Laboratory 7	NPL Assigned Value	Deviation /%	Zeta	Z Score
²⁴¹ Am (AH)	3.3 ± 0.4 (± 10 %)	4.449 ± 0.010 (± 0.24 %)	-24.9	-3.26	-4.28
²⁴⁴ Cm (AH)	12.2 ± 1.9 (± 16 %)	19.51 ± 0.07 (± 0.4 %)	-37.5	-3.84	-6.43
²³⁸ Pu (AH)	9.0 ± 1.9 (± 21 %)	14.950 ± 0.050 (± 0.3 %)	-40.1	-3.20	-6.88
²³⁹ Pu (AL)	9.9 ± 2.5 (± 25 %)	12.1 ± 0.3 (± 2.2 %)	-18.4	-0.89	-3.16
²³⁴ U (AL)	14.0 ± 1.0 (± 7 %)	15.0 ± 0.4 (± 3 %)	-6.8	-0.97	-1.18
²³⁵ U (AL)	0.580 ± 0.050 (± 9 %)	0.718 ± 0.019 (± 3 %)	-19.6	-2.69	-3.37
²³⁸ U (AL)	14.0 ± 1.0 (± 7 %)	15.0 ± 0.4 (± 3 %)	-6.8	-0.97	-1.18
¹³³ Ba (GH)	5.9 ± 0.4 (± 6 %)	7.410 ± 0.050 (± 0.7 %)	-20.0	-4.31	-3.44
¹⁵² Eu (GH)	13.0 ± 0.8 (± 6 %)	15.26 ± 0.10 (± 0.7 %)	-14.8	-2.79	-2.53
⁶⁰ Co (GH)	4.83 ± 0.20 (± 4 %)	5.229 ± 0.011 (± 0.22 %)	-7.6	-1.99	-1.31
¹³⁴ Cs (GH)	2.29 ± 0.11 (± 5.0 %)	2.800 ± 0.019 (± 0.7 %)	-18.2	-4.57	-3.13
¹³⁷ Cs (GH)	14.2 ± 0.8 (± 6 %)	15.41 ± 0.06 (± 0.4 %)	-8.0	-1.58	-1.38
³ H (B1)	1.01 ± 0.07 (± 7 %)	1.046 ± 0.008 (± 0.7 %)	-3.4	-0.55	-0.59
¹⁴ C (B1)	1.28 ± 0.06 (± 5.0 %)	0.968 ± 0.008 (± 0.8 %)	32.2	5.33	5.53
³⁶ Cl (B1)	0.85 ± 0.24 (± 30 %)	0.4900 ± 0.0020 (± 0.4 %)	74.1	1.51	12.72
⁹⁹ Tc (B1)	0.101 ± 0.023 (± 23 %)	0.1434 ± 0.0013 (± 0.9 %)	-29.6	-1.84	-5.08
³ H (B2)	1.16 ± 0.07 (± 6 %)	1.076 ± 0.008 (± 0.7 %)	7.8	1.14	1.34
¹⁴⁷ Pm (B2)	0.390 ± 0.050 (± 13 %)	0.435 ± 0.004 (± 0.9 %)	-10.5	-0.87	-1.80
²⁴¹ Pu (B2)	1.34 ± 0.17 (± 13 %)	0.942 ± 0.010 (± 1.1 %)	42.2	2.34	7.25
⁹⁰ Sr (B2)	0.1100 ± 0.0050 (± 4 %)	0.1429 ± 0.0003 (± 0.20 %)	-23.0	-7.45	-3.95
³ H (S)	78 ± 3 (± 4 %)	77.1 ± 1.7 (± 2.2 %)	1.5	0.34	0.26
¹⁴ C (S)	2.54 ± 0.09 (± 4 %)	1.91 ± 0.05 (± 2.5 %)	32.8	5.99	5.63

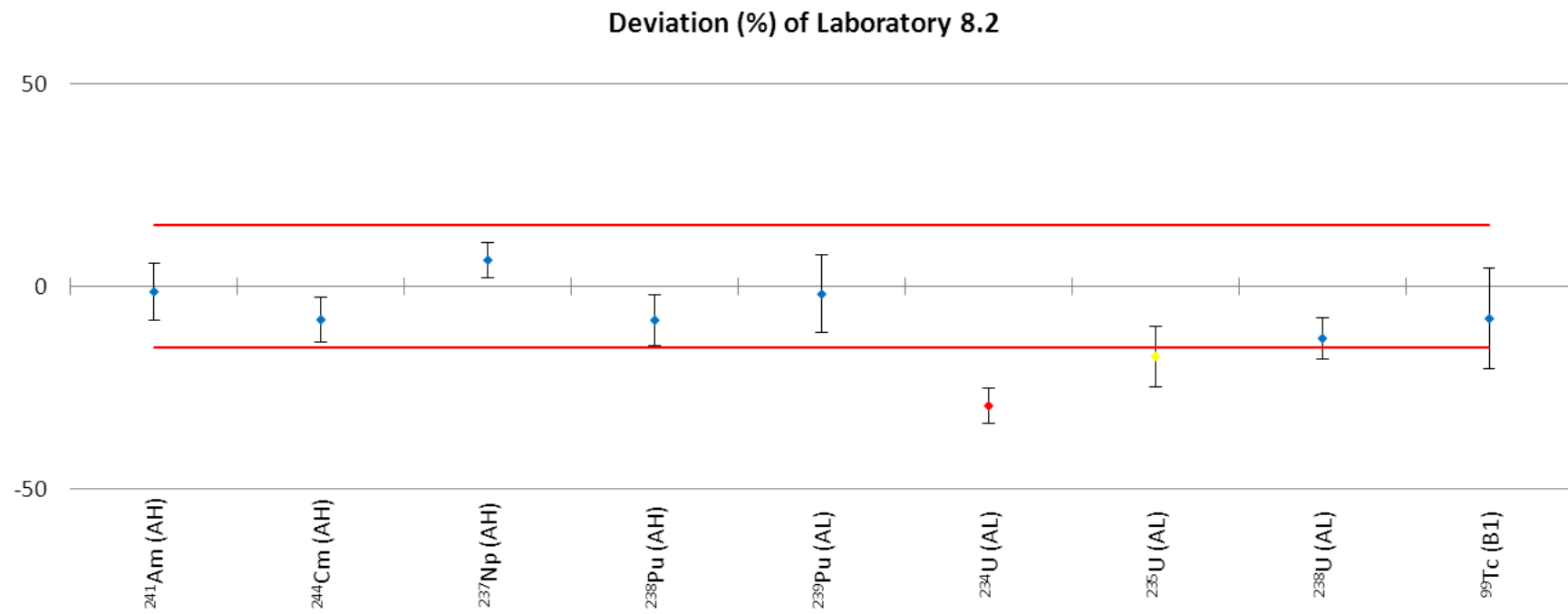


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Radionuclide	Laboratory 8.1	NPL Assigned Value	Deviation /%	Zeta	Z Score
²⁴¹ Am (AH)	4.19 ± 0.21 (± 5.0 %)	4.449 ± 0.010 (± 0.24 %)	-5.8	-1.24	-0.99
²²⁶ Ra (AH)	1.8 ± 0.4 (± 21 %)	1.461 ± 0.019 (± 1.3 %)	20.3	0.81	3.49
²³⁴ U (AL)	13.9 ± 0.7 (± 5.0 %)	15.0 ± 0.4 (± 3 %)	-7.5	-1.40	-1.29
²³⁵ U (AL)	0.62 ± 0.04 (± 5.0 %)	0.718 ± 0.019 (± 3 %)	-13.8	-2.70	-2.37
²³⁸ U (AL)	13.4 ± 0.7 (± 5.0 %)	15.0 ± 0.4 (± 3 %)	-10.8	-2.07	-1.86
¹³³ Ba (GH)	6.32 ± 0.21 (± 4 %)	7.41 ± 0.05 (± 0.7 %)	-14.7	-5.06	-2.53
¹⁵² Eu (GH)	13.7 ± 0.4 (± 3 %)	15.26 ± 0.10 (± 0.7 %)	-10.4	-3.70	-1.79
⁶⁰ Co (GH)	4.86 ± 0.09 (± 1.9 %)	5.229 ± 0.011 (± 0.22 %)	-7.0	-3.97	-1.20
¹³⁴ Cs (GH)	2.72 ± 0.10 (± 4 %)	2.800 ± 0.019 (± 0.7 %)	-2.8	-0.75	-0.47
¹³⁷ Cs (GH)	15.1 ± 0.9 (± 6 %)	15.41 ± 0.06 (± 0.4 %)	-1.8	-0.31	-0.31
⁶⁰ Co (GL)	18.2 ± 0.3 (± 1.6 %)	17.68 ± 0.08 (± 0.50 %)	3.1	1.90	0.54
¹³⁴ Cs (GL)	2.41 ± 0.17 (± 7 %)	2.190 ± 0.017 (± 0.8 %)	10.1	1.32	1.73
¹³⁷ Cs (GL)	4.3 ± 0.3 (± 7 %)	4.12 ± 0.04 (± 0.9 %)	3.2	0.47	0.54
⁴⁰ K (GL)	14.91 ± 0.15 (± 1.0 %)	16.4 ± 0.8 (± 5.0 %)	-9.1	-1.87	-1.56
²¹⁰ Pb (GL)	18 ± 4 (± 18 %)	19.46 ± 0.22 (± 1.1 %)	-8.3	-0.50	-1.43
³ H (B1)	1.00 ± 0.04 (± 4 %)	1.046 ± 0.008 (± 0.7 %)	-4.6	-1.17	-0.79
¹⁴ C (B1)	1.00 ± 0.07 (± 7 %)	0.968 ± 0.008 (± 0.8 %)	3.1	0.46	0.53
³⁶ Cl (B1)	0.41 ± 0.04 (± 10 %)	0.4900 ± 0.0020 (± 0.4 %)	-16.1	-1.92	-2.77
⁹⁹ Tc (B1)	0.142 ± 0.006 (± 4 %)	0.1434 ± 0.0013 (± 0.9 %)	-1.0	-0.25	-0.17
³ H (B2)	1.00 ± 0.04 (± 4 %)	1.076 ± 0.008 (± 0.7 %)	-7.2	-1.87	-1.23
²⁴¹ Pu (B2)	0.82 ± 0.05 (± 6 %)	0.942 ± 0.010 (± 1.1 %)	-13.0	-2.62	-2.24
⁹⁰ Sr (B2)	0.140 ± 0.009 (± 6 %)	0.1429 ± 0.0003 (± 0.20 %)	-2.0	-0.32	-0.34

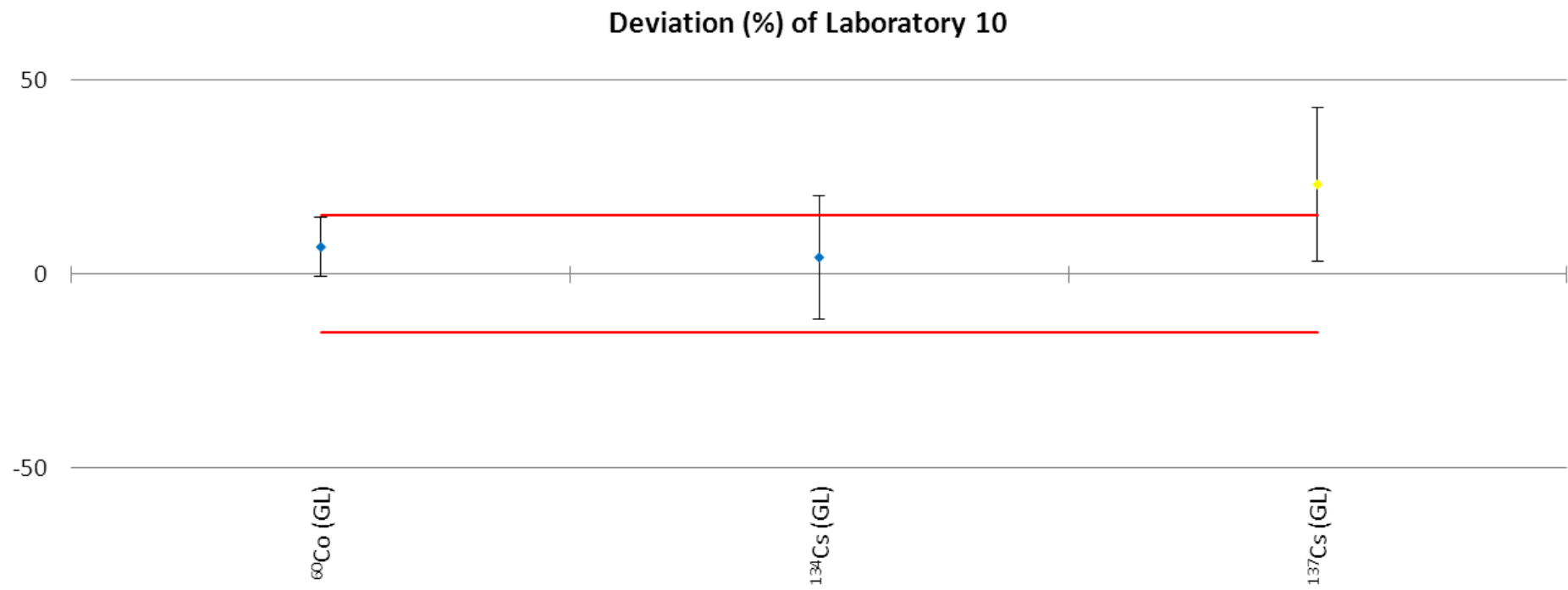
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⁴⁰ K (S)	173 ± 12 (± 7 %)	181 ± 6 (± 3 %)	-4.3	-0.60	-0.74
²¹⁰ Pb (S)	58 ± 13 (± 22 %)	46.5 ± 1.4 (± 3 %)	24.0	0.88	4.13
²¹⁰ Po (S)	58 ± 13 (± 22 %)	47.9 ± 0.7 (± 1.5 %)	20.4	0.77	3.51



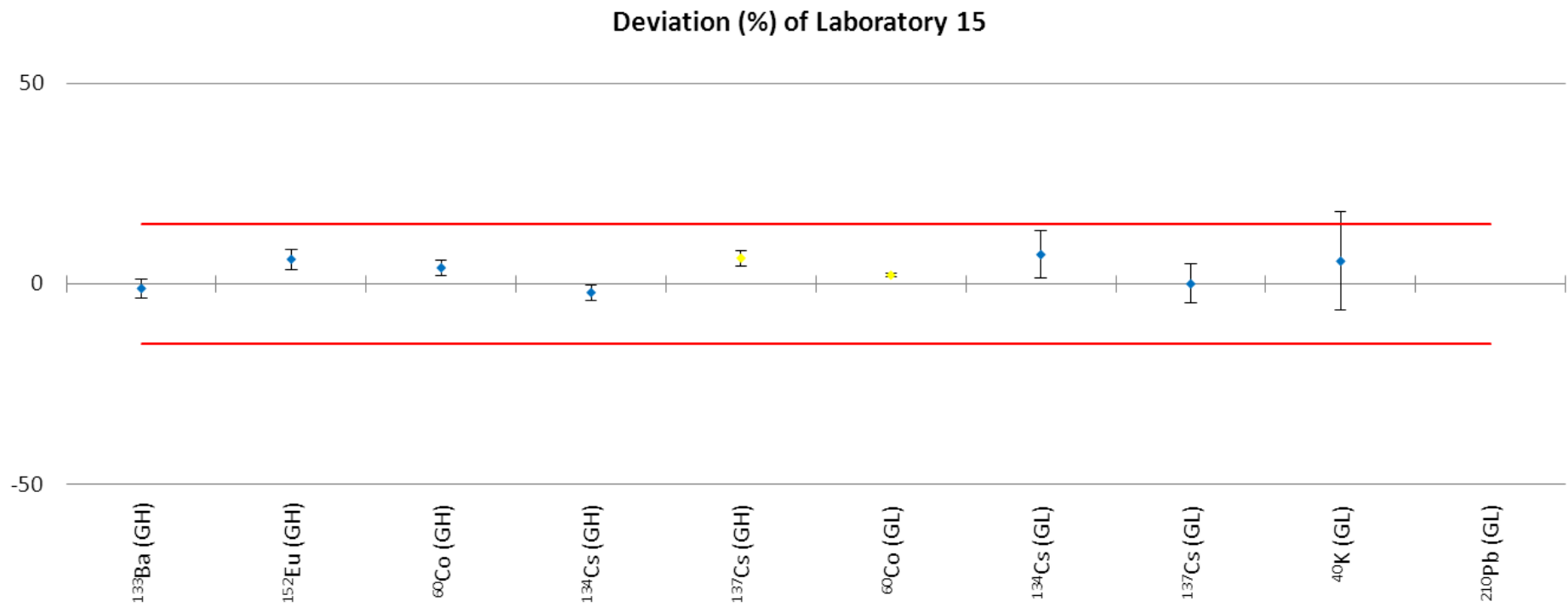
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Radionuclide	Laboratory 8.2	NPL Assigned Value	Deviation /%	Zeta	Z Score
²⁴¹ Am (AH)	4.4 ± 0.3 (± 7 %)	4.449 ± 0.010 (± 0.24 %)	-1.3	-0.19	-0.23
²⁴⁴ Cm (AH)	17.9 ± 1.1 (± 6 %)	19.51 ± 0.07 (± 0.4 %)	-8.2	-1.46	-1.41
²³⁷ Np (AH)	15.6 ± 0.6 (± 4 %)	14.65 ± 0.15 (± 1.0 %)	6.5	1.50	1.11
²³⁸ Pu (AH)	13.7 ± 0.9 (± 7 %)	14.95 ± 0.05 (± 0.3 %)	-8.4	-1.34	-1.43
²³⁹ Pu (AL)	11.9 ± 1.1 (± 10 %)	12.1 ± 0.3 (± 2.2 %)	-1.9	-0.20	-0.33
²³⁴ U (AL)	10.6 ± 0.6 (± 6 %)	15.0 ± 0.4 (± 3 %)	-29.5	-6.26	-5.06
²³⁵ U (AL)	0.59 ± 0.05 (± 9 %)	0.718 ± 0.019 (± 3 %)	-17.3	-2.25	-2.97
²³⁸ U (AL)	13.1 ± 0.7 (± 5.0 %)	15.0 ± 0.4 (± 3 %)	-12.8	-2.50	-2.20
⁹⁹ Tc (B1)	0.132 ± 0.018 (± 13 %)	0.1434 ± 0.0013 (± 0.9 %)	-8.0	-0.65	-1.37



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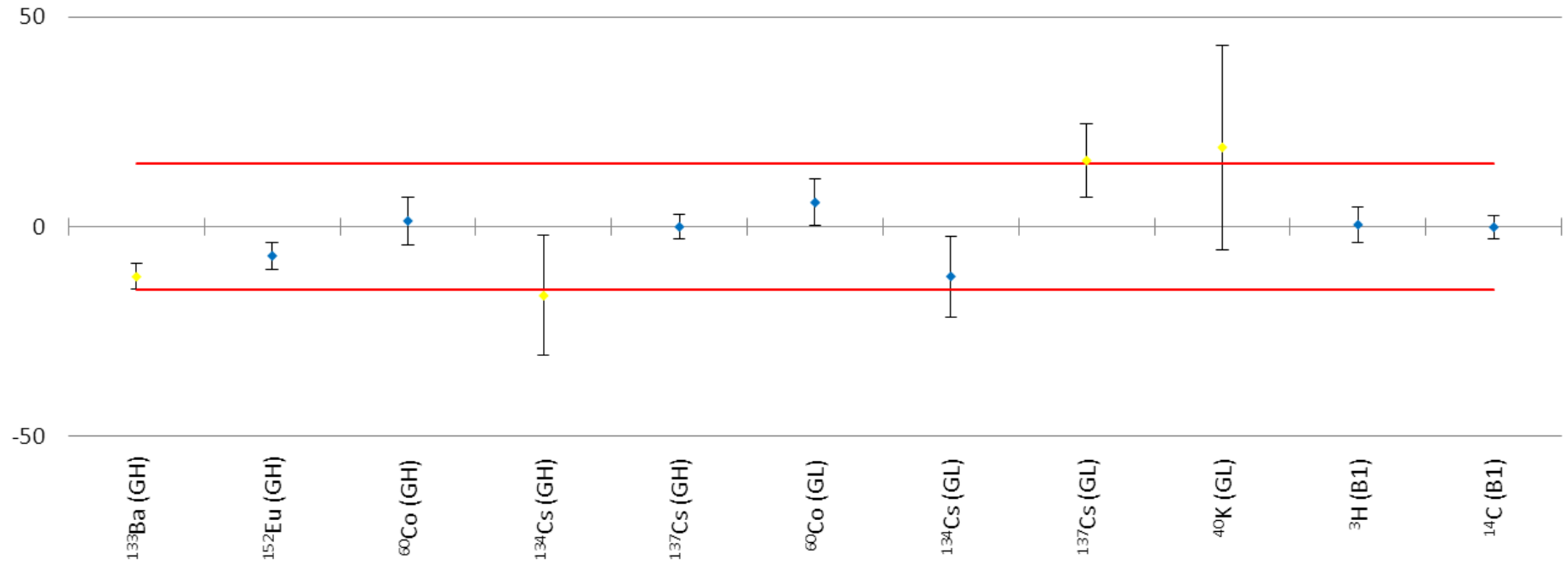
Radionuclide	Laboratory 10	NPL Assigned Value	Deviation /%	Zeta	Z Score
⁶⁰ Co (GL)	18.9 ± 1.3 (± 7 %)	17.68 ± 0.08 (± 0.50 %)	7.0	0.92	1.20
¹³⁴ Cs (GL)	2.3 ± 0.4 (± 15 %)	2.190 ± 0.017 (± 0.8 %)	4.3	0.27	0.74
¹³⁷ Cs (GL)	5.1 ± 0.8 (± 16 %)	4.12 ± 0.04 (± 0.9 %)	23.1	1.17	3.96



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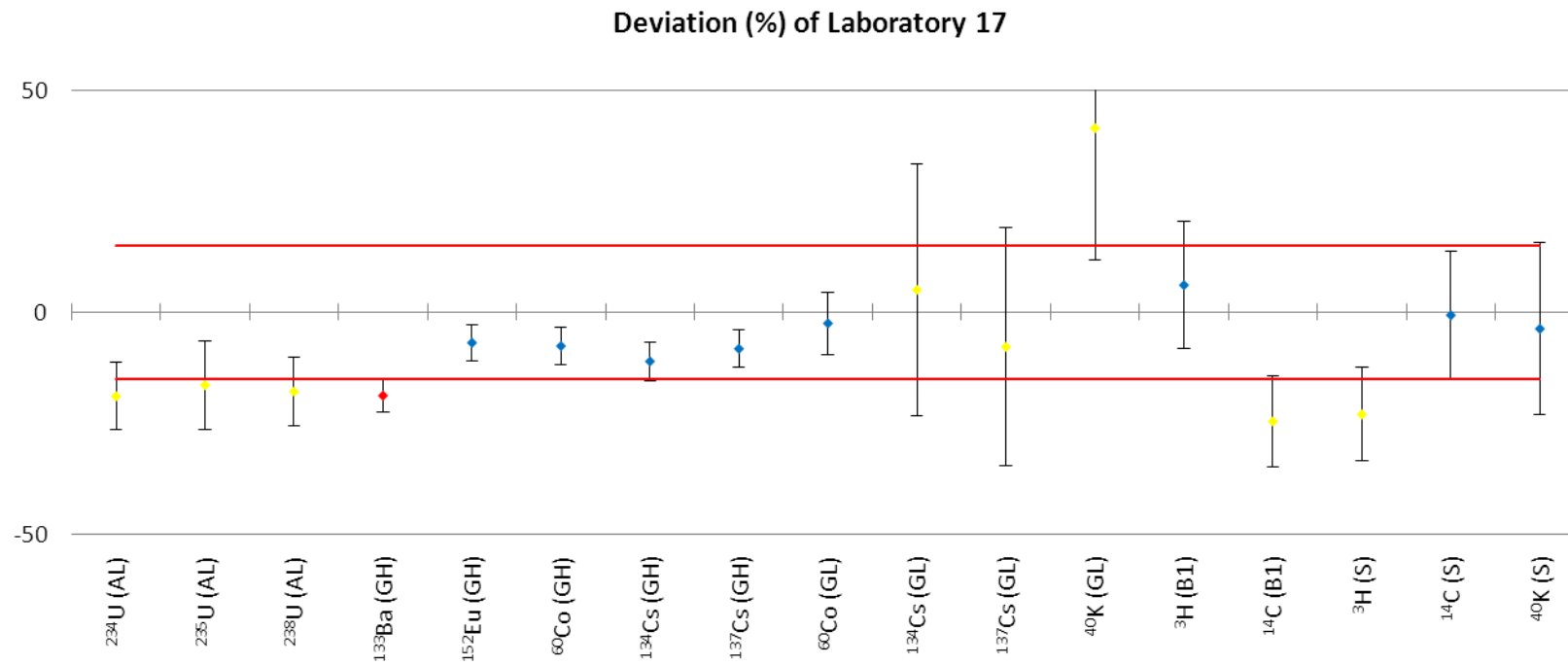
Radionuclide	Laboratory 15	NPL Assigned Value	Deviation /%	Zeta	Z Score
¹³³ Ba (GH)	7.33 ± 0.17 (± 2.3 %)	7.410 ± 0.050 (± 0.7 %)	-1.1	-0.48	-0.19
¹⁵² Eu (GH)	16.2 ± 0.4 (± 2.3 %)	15.26 ± 0.10 (± 0.7 %)	6.1	2.44	1.06
⁶⁰ Co (GH)	5.44 ± 0.10 (± 1.8 %)	5.229 ± 0.011 (± 0.22 %)	4.0	2.16	0.69
¹³⁴ Cs (GH)	2.740 ± 0.050 (± 1.8 %)	2.800 ± 0.019 (± 0.7 %)	-2.1	-1.13	-0.37
¹³⁷ Cs (GH)	16.4 ± 0.3 (± 1.8 %)	15.41 ± 0.06 (± 0.4 %)	6.4	3.34	1.10
⁶⁰ Co (GL)	18.070 ± 0.050 (± 0.25 %)	17.68 ± 0.08 (± 0.50 %)	2.2	4.36	0.38
¹³⁴ Cs (GL)	2.35 ± 0.13 (± 6 %)	2.190 ± 0.017 (± 0.8 %)	7.3	1.25	1.25
¹³⁷ Cs (GL)	4.12 ± 0.20 (± 5.0 %)	4.12 ± 0.04 (± 0.9 %)	0.0	0.00	0.00
⁴⁰ K (GL)	17.3 ± 1.8 (± 11 %)	16.4 ± 0.8 (± 5.0 %)	5.7	0.47	0.97
²¹⁰ Pb (GL)	3.38 ± 0.21 (± 7 %)	19.46 ± 0.22 (± 1.1 %)	-82.6	-52.33	-14.19

Deviation (%) of Laboratory 16



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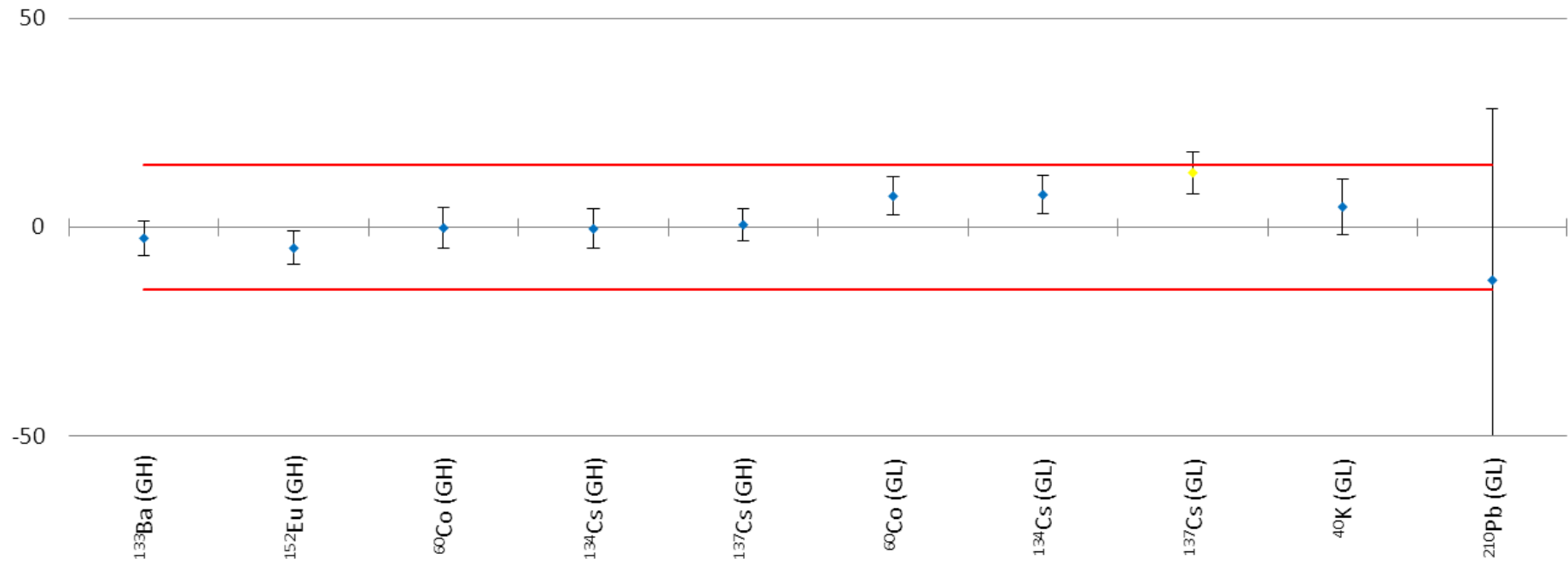
Radionuclide	Laboratory 16	NPL Assigned Value	Deviation /%	Zeta	Z Score
¹³³ Ba (GH)	6.53 ± 0.22 (± 4 %)	7.410 ± 0.050 (± 0.7 %)	-11.9	-3.91	-2.05
¹⁵² Eu (GH)	14.20 ± 0.50 (± 4 %)	15.26 ± 0.10 (± 0.7 %)	-7.0	-2.21	-1.19
⁶⁰ Co (GH)	5.3 ± 0.3 (± 6 %)	5.229 ± 0.011 (± 0.22 %)	1.4	0.24	0.23
¹³⁴ Cs (GH)	2.3 ± 0.4 (± 17 %)	2.800 ± 0.019 (± 0.7 %)	-16.4	-1.15	-2.82
¹³⁷ Cs (GH)	15.40 ± 0.50 (± 3 %)	15.41 ± 0.06 (± 0.4 %)	-0.1	-0.02	-0.01
⁶⁰ Co (GL)	18.7 ± 1.0 (± 5.0 %)	17.68 ± 0.08 (± 0.50 %)	5.7	1.03	0.99
¹³⁴ Cs (GL)	1.93 ± 0.21 (± 11 %)	2.190 ± 0.017 (± 0.8 %)	-11.9	-1.23	-2.04
¹³⁷ Cs (GL)	4.8 ± 0.4 (± 8 %)	4.12 ± 0.04 (± 0.9 %)	15.7	1.79	2.70
⁴⁰ K (GL)	20 ± 4 (± 20 %)	16.4 ± 0.8 (± 5.0 %)	18.9	0.78	3.24
³ H (B1)	1.050 ± 0.050 (± 4 %)	1.046 ± 0.008 (± 0.7 %)	0.5	0.11	0.08
¹⁴ C (B1)	0.967 ± 0.025 (± 3 %)	0.968 ± 0.008 (± 0.8 %)	-0.1	-0.05	-0.02



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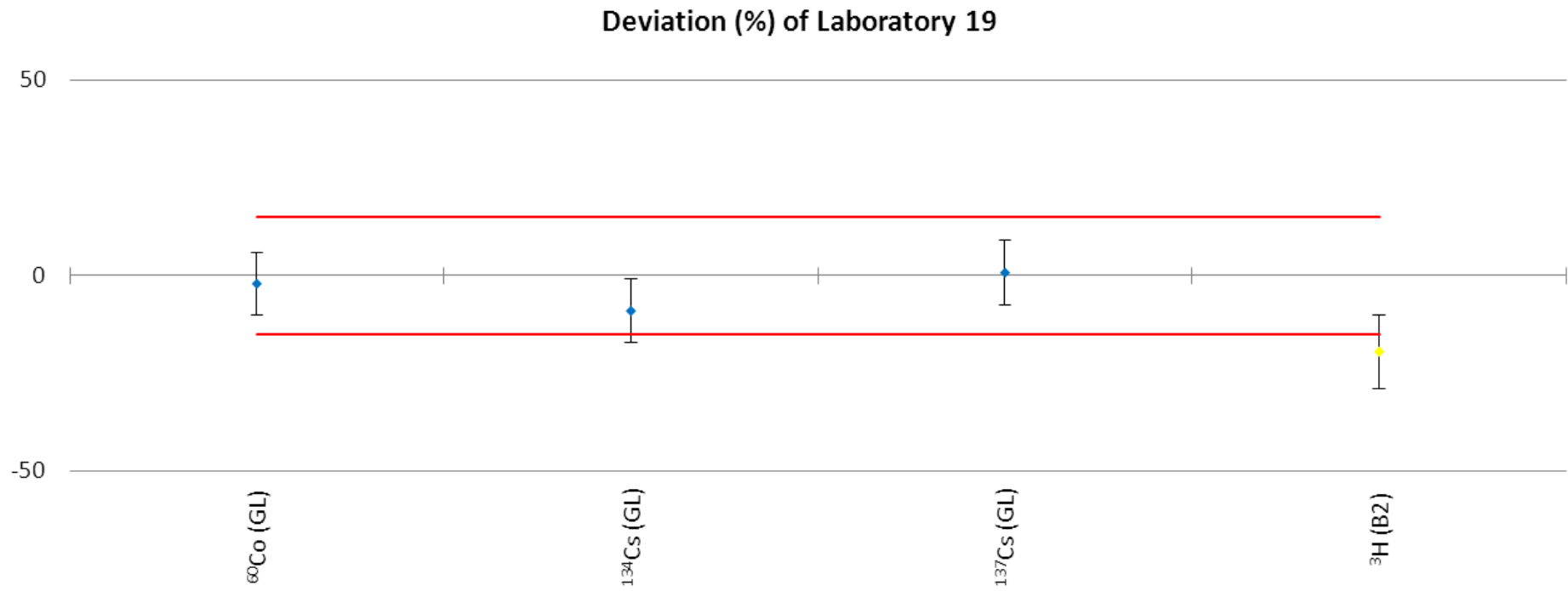
Radionuclide	Laboratory 17	NPL Assigned Value	Deviation /%	Zeta	Z Score
²³⁴ U (AL)	12.2 ± 1.1 (± 9 %)	15.0 ± 0.4 (± 3 %)	-19.0	-2.44	-3.26
²³⁵ U (AL)	0.60 ± 0.07 (± 12 %)	0.718 ± 0.019 (± 3 %)	-16.4	-1.63	-2.82
²³⁸ U (AL)	12.3 ± 1.1 (± 9 %)	15.0 ± 0.4 (± 3 %)	-17.9	-2.27	-3.07
¹³³ Ba (GH)	6.0 ± 0.3 (± 5.0 %)	7.41 ± 0.05 (± 0.7 %)	-18.8	-5.07	-3.23
¹⁵² Eu (GH)	14.2 ± 0.6 (± 5.0 %)	15.26 ± 0.10 (± 0.7 %)	-6.9	-1.65	-1.18
⁶⁰ Co (GH)	4.83 ± 0.22 (± 5.0 %)	5.229 ± 0.011 (± 0.22 %)	-7.6	-1.81	-1.31
¹³⁴ Cs (GH)	2.49 ± 0.12 (± 5.0 %)	2.800 ± 0.019 (± 0.7 %)	-11.1	-2.55	-1.90
¹³⁷ Cs (GH)	14.1 ± 0.7 (± 5.0 %)	15.41 ± 0.06 (± 0.4 %)	-8.2	-1.98	-1.41
⁶⁰ Co (GL)	17.2 ± 1.2 (± 7 %)	17.68 ± 0.08 (± 0.50 %)	-2.5	-0.36	-0.43
¹³⁴ Cs (GL)	2.3 ± 0.6 (± 30 %)	2.190 ± 0.017 (± 0.8 %)	5.0	0.18	0.87
¹³⁷ Cs (GL)	3.8 ± 1.1 (± 30 %)	4.12 ± 0.04 (± 0.9 %)	-7.8	-0.29	-1.34
⁴⁰ K (GL)	23 ± 5 (± 20 %)	16.4 ± 0.8 (± 5.0 %)	41.5	1.42	7.13
³ H (B1)	1.11 ± 0.15 (± 14 %)	1.046 ± 0.008 (± 0.7 %)	6.1	0.43	1.05
¹⁴ C (B1)	0.73 ± 0.10 (± 14 %)	0.968 ± 0.008 (± 0.8 %)	-24.6	-2.38	-4.23
³ H (S)	59 ± 8 (± 14 %)	77.1 ± 1.7 (± 2.2 %)	-23.0	-2.16	-3.96
¹⁴ C (S)	1.9 ± 0.3 (± 14 %)	1.91 ± 0.05 (± 2.5 %)	-0.7	-0.05	-0.12
⁴⁰ K (S)	170 ± 40 (± 20 %)	181 ± 6 (± 3 %)	-3.7	-0.19	-0.64

Deviation (%) of Laboratory 18



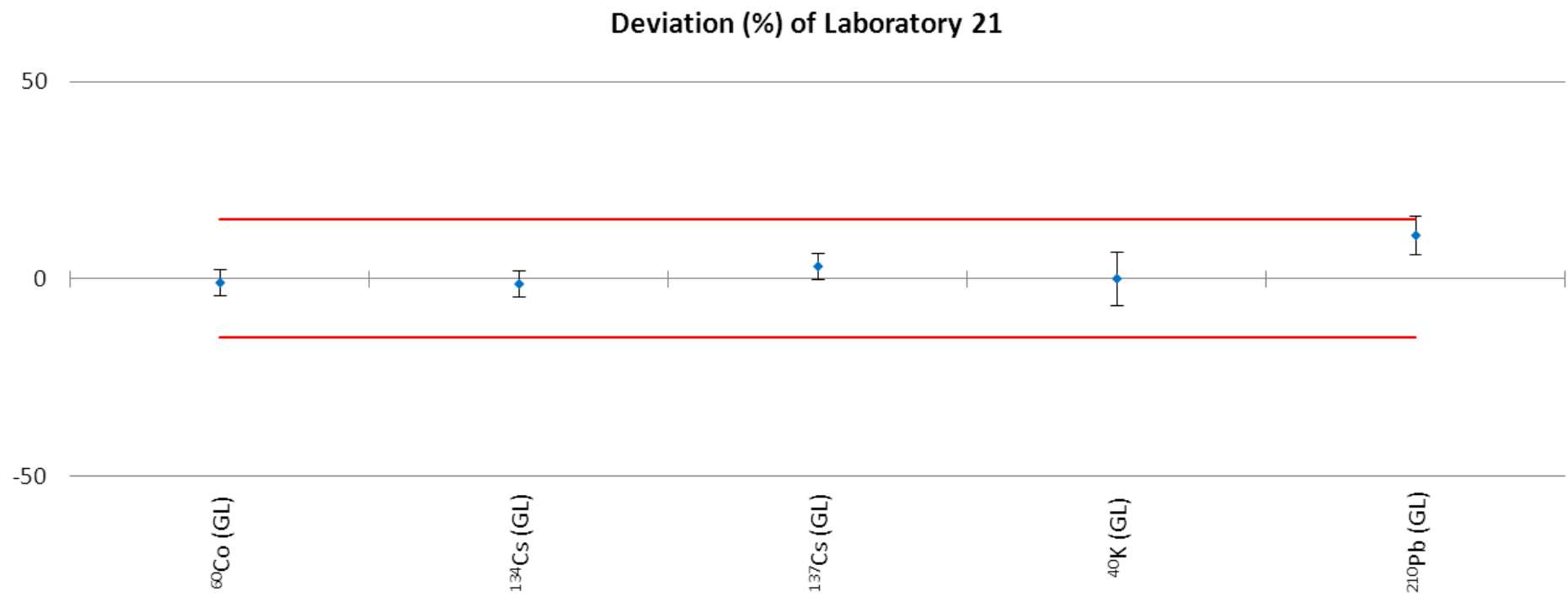
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Radionuclide	Laboratory 18	NPL Assigned Value	Deviation /%	Zeta	Z Score
¹³³ Ba (GH)	7.2 ± 0.3 (± 4 %)	7.410 ± 0.050 (± 0.7 %)	-2.6	-0.64	-0.45
¹⁵² Eu (GH)	14.5 ± 0.6 (± 4 %)	15.26 ± 0.10 (± 0.7 %)	-5.0	-1.25	-0.86
⁶⁰ Co (GH)	5.2 ± 0.3 (± 5.0 %)	5.229 ± 0.011 (± 0.22 %)	-0.2	-0.04	-0.03
¹³⁴ Cs (GH)	2.79 ± 0.13 (± 5.0 %)	2.800 ± 0.019 (± 0.7 %)	-0.4	-0.08	-0.06
¹³⁷ Cs (GH)	15.5 ± 0.6 (± 4 %)	15.41 ± 0.06 (± 0.4 %)	0.6	0.15	0.10
⁶⁰ Co (GL)	19.0 ± 0.8 (± 4 %)	17.68 ± 0.08 (± 0.50 %)	7.4	1.64	1.28
¹³⁴ Cs (GL)	2.36 ± 0.10 (± 5.0 %)	2.190 ± 0.017 (± 0.8 %)	7.8	1.68	1.34
¹³⁷ Cs (GL)	4.66 ± 0.20 (± 5.0 %)	4.12 ± 0.04 (± 0.9 %)	13.1	2.65	2.24
⁴⁰ K (GL)	17.2 ± 0.7 (± 4 %)	16.4 ± 0.8 (± 5.0 %)	4.9	0.76	0.84
²¹⁰ Pb (GL)	17 ± 8 (± 50 %)	19.46 ± 0.22 (± 1.1 %)	-12.7	-0.31	-2.17



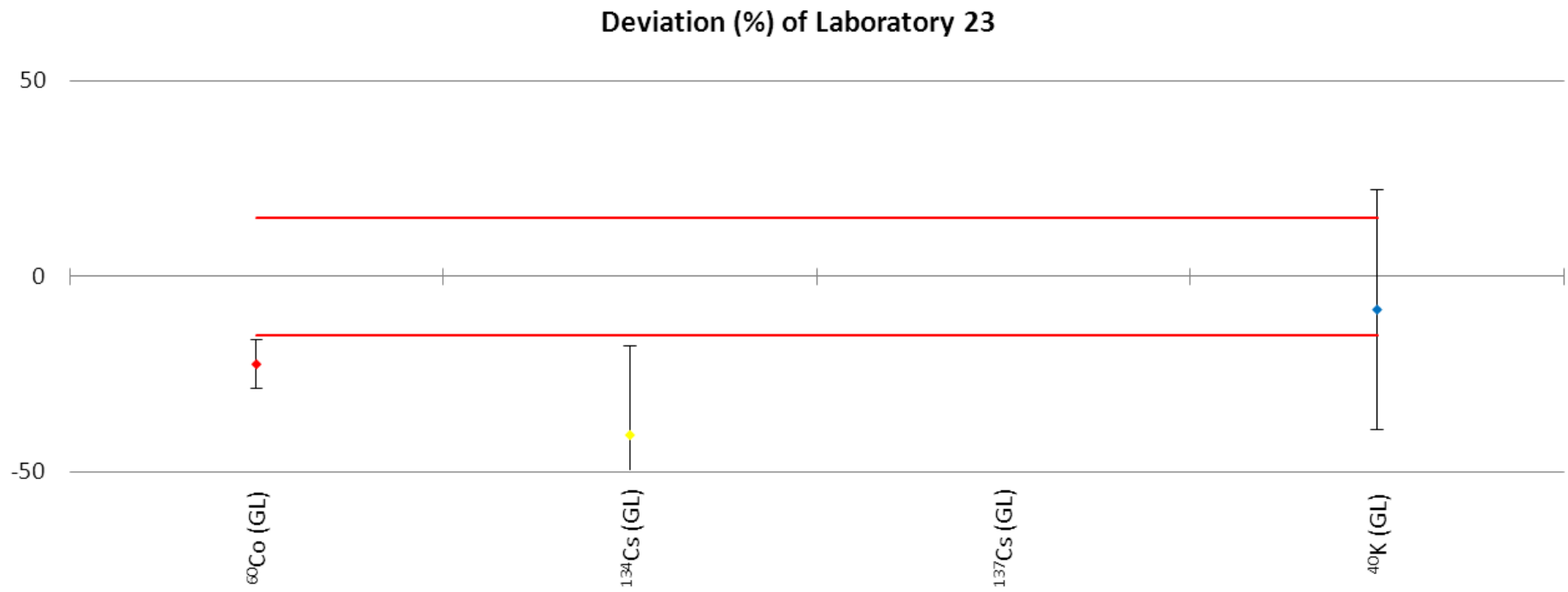
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Radionuclide	Laboratory 19	NPL Assigned Value	Deviation /%	Zeta	Z Score
⁶⁰ Co (GL)	17.3 ± 1.4 (± 8 %)	17.68 ± 0.08 (± 0.50 %)	-2.2	-0.27	-0.37
¹³⁴ Cs (GL)	1.99 ± 0.18 (± 9 %)	2.190 ± 0.017 (± 0.8 %)	-9.1	-1.10	-1.57
¹³⁷ Cs (GL)	4.2 ± 0.4 (± 8 %)	4.12 ± 0.04 (± 0.9 %)	0.7	0.08	0.12
³ H (B2)	0.87 ± 0.10 (± 12 %)	1.076 ± 0.008 (± 0.7 %)	-19.5	-2.06	-3.36



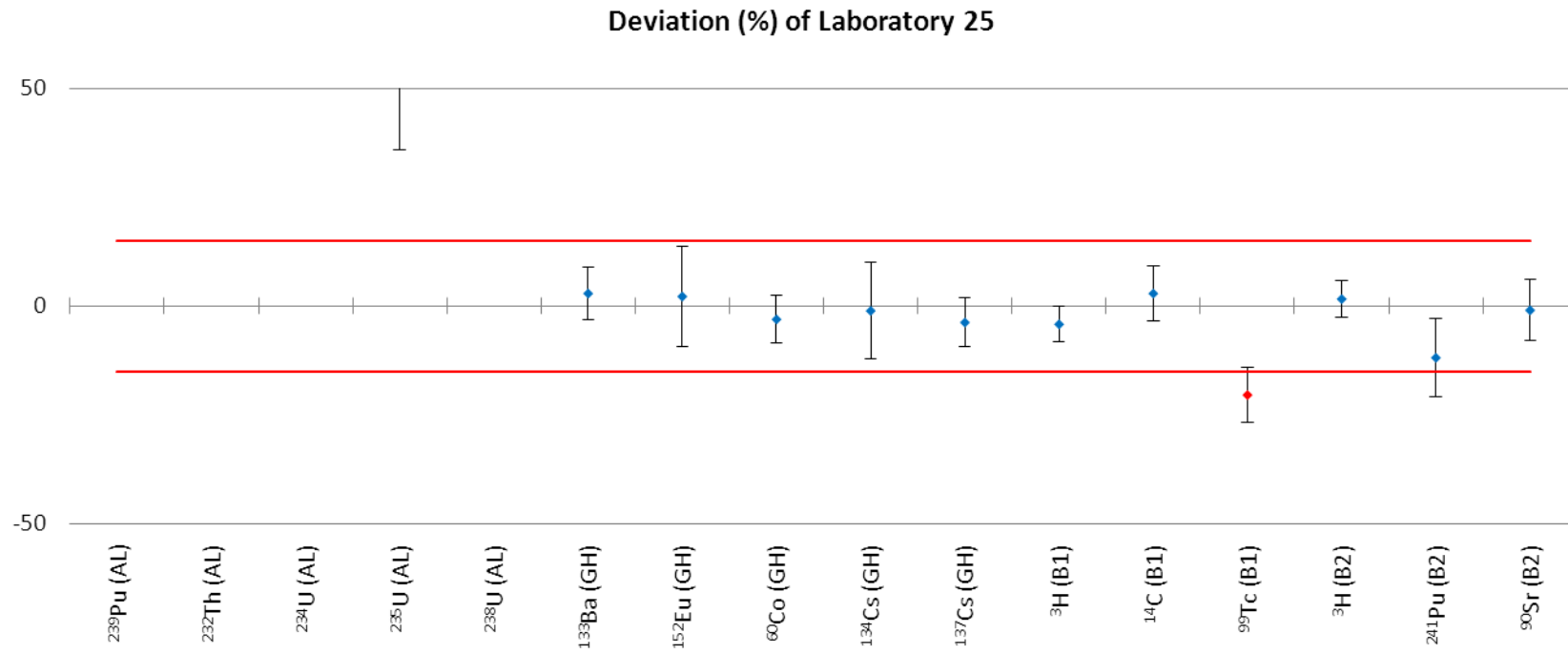
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Radionuclide	Laboratory 21	NPL Assigned Value	Deviation /%	Zeta	Z Score
⁶⁰ Co (GL)	17.5 ± 0.6 (± 4 %)	17.68 ± 0.08 (± 0.50 %)	-1.0	-0.30	-0.18
¹³⁴ Cs (GL)	2.16 ± 0.07 (± 4 %)	2.190 ± 0.017 (± 0.8 %)	-1.4	-0.41	-0.23
¹³⁷ Cs (GL)	4.25 ± 0.13 (± 3 %)	4.12 ± 0.04 (± 0.9 %)	3.1	0.95	0.53
⁴⁰ K (GL)	16.4 ± 0.8 (± 5.0 %)	16.4 ± 0.8 (± 5.0 %)	0.0	0.00	0.00
²¹⁰ Pb (GL)	21.6 ± 0.9 (± 4 %)	19.46 ± 0.22 (± 1.1 %)	11.0	2.30	1.88



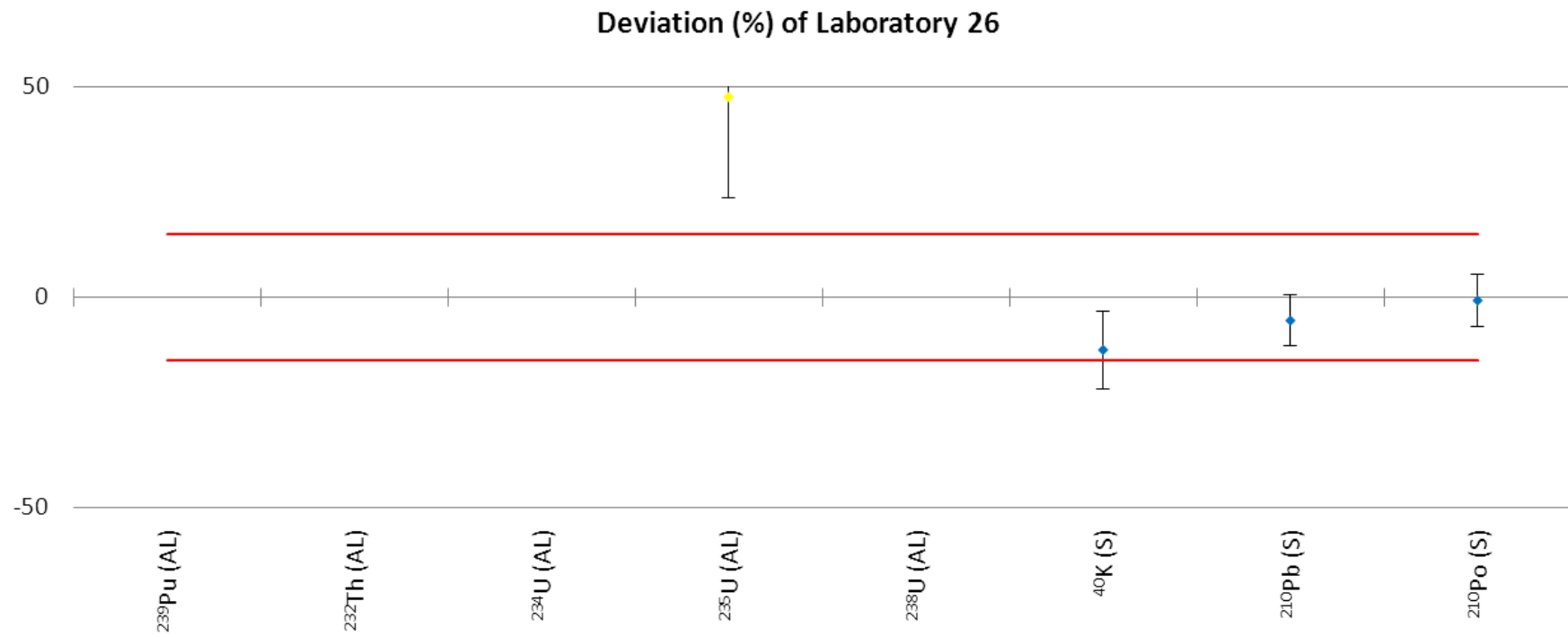
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Radionuclide	Laboratory 23	NPL Assigned Value	Deviation /%	Zeta	Z Score
⁶⁰ Co (GL)	13.7 ± 1.1 (± 8 %)	17.68 ± 0.08 (± 0.50 %)	-22.5	-3.61	-3.87
¹³⁴ Cs (GL)	1.30 ± 0.50 (± 40 %)	2.190 ± 0.017 (± 0.8 %)	-40.6	-1.78	-6.98
¹³⁷ Cs (GL)	0.6 ± 0.4 (± 70 %)	4.12 ± 0.04 (± 0.9 %)	-85.4	-8.77	-14.67
⁴⁰ K (GL)	15.0 ± 5.0 (± 40 %)	16.4 ± 0.8 (± 5.0 %)	-8.5	-0.28	-1.47



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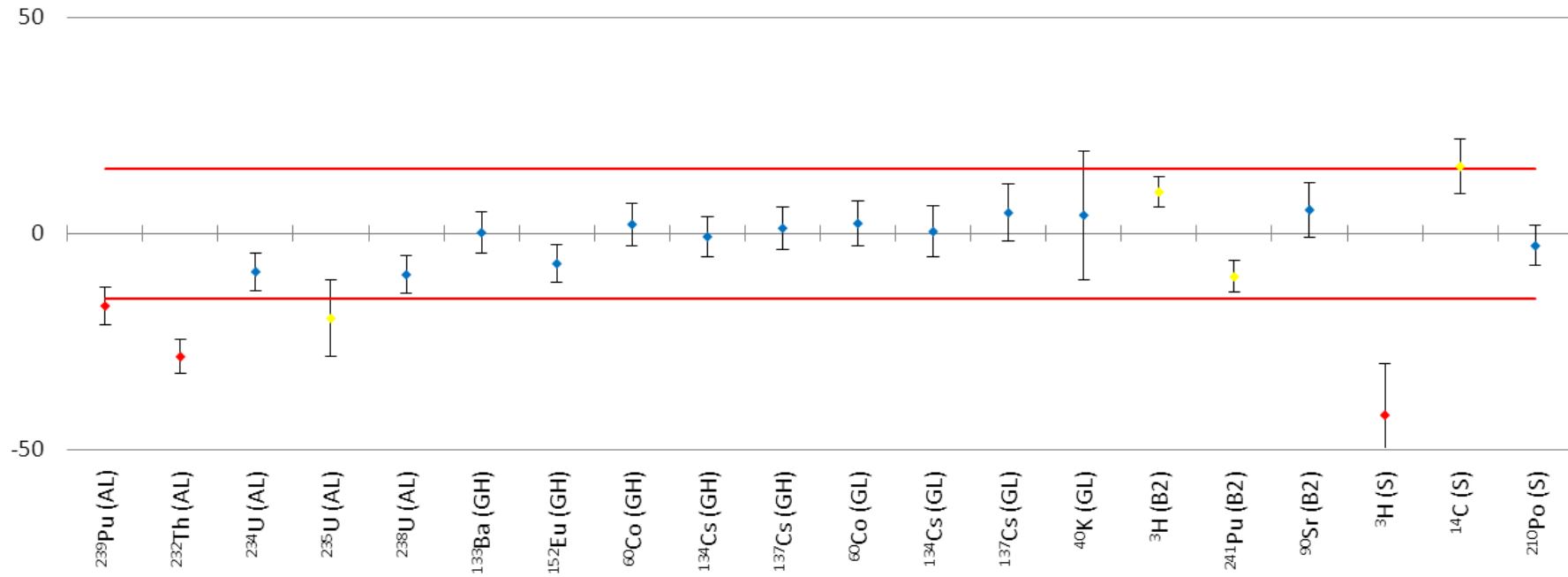
Radionuclide	Laboratory 25	NPL Assigned Value	Deviation /%	Zeta	Z Score
²³⁹ Pu (AL)	25.0 ± 2.0 (± 8 %)	12.1 ± 0.3 (± 2.2 %)	106.0	6.28	18.20
²³² Th (AL)	5.1 ± 0.4 (± 7 %)	2.52 ± 0.06 (± 2.4 %)	103.0	7.73	17.69
²³⁴ U (AL)	29.6 ± 2.2 (± 7 %)	15.0 ± 0.4 (± 3 %)	96.7	6.65	16.60
²³⁵ U (AL)	1.12 ± 0.14 (± 12 %)	0.718 ± 0.019 (± 3 %)	56.0	2.85	9.61
²³⁸ U (AL)	30.0 ± 2.2 (± 7 %)	15.0 ± 0.4 (± 3 %)	99.5	6.76	17.09
¹³³ Ba (GH)	7.60 ± 0.50 (± 6 %)	7.410 ± 0.050 (± 0.7 %)	2.9	0.48	0.50
¹⁵² Eu (GH)	15.6 ± 1.8 (± 11 %)	15.26 ± 0.10 (± 0.7 %)	2.2	0.19	0.38
⁶⁰ Co (GH)	5.1 ± 0.3 (± 6 %)	5.229 ± 0.011 (± 0.22 %)	-3.0	-0.55	-0.52
¹³⁴ Cs (GH)	2.8 ± 0.3 (± 11 %)	2.800 ± 0.019 (± 0.7 %)	-1.1	-0.10	-0.18
¹³⁷ Cs (GH)	14.8 ± 0.9 (± 6 %)	15.41 ± 0.06 (± 0.4 %)	-3.8	-0.67	-0.65
³ H (B1)	1.000 ± 0.050 (± 5.0 %)	1.046 ± 0.008 (± 0.7 %)	-4.2	-1.01	-0.72
¹⁴ C (B1)	1.00 ± 0.06 (± 6 %)	0.968 ± 0.008 (± 0.8 %)	2.9	0.46	0.50
⁹⁹ Tc (B1)	0.114 ± 0.009 (± 8 %)	0.1434 ± 0.0013 (± 0.9 %)	-20.4	-3.19	-3.51
³ H (B2)	1.090 ± 0.050 (± 5.0 %)	1.076 ± 0.008 (± 0.7 %)	1.6	0.38	0.28
²⁴¹ Pu (B2)	0.83 ± 0.08 (± 10 %)	0.942 ± 0.010 (± 1.1 %)	-11.9	-1.33	-2.04
⁹⁰ Sr (B2)	0.142 ± 0.010 (± 7 %)	0.1429 ± 0.0003 (± 0.20 %)	-1.0	-0.13	-0.16



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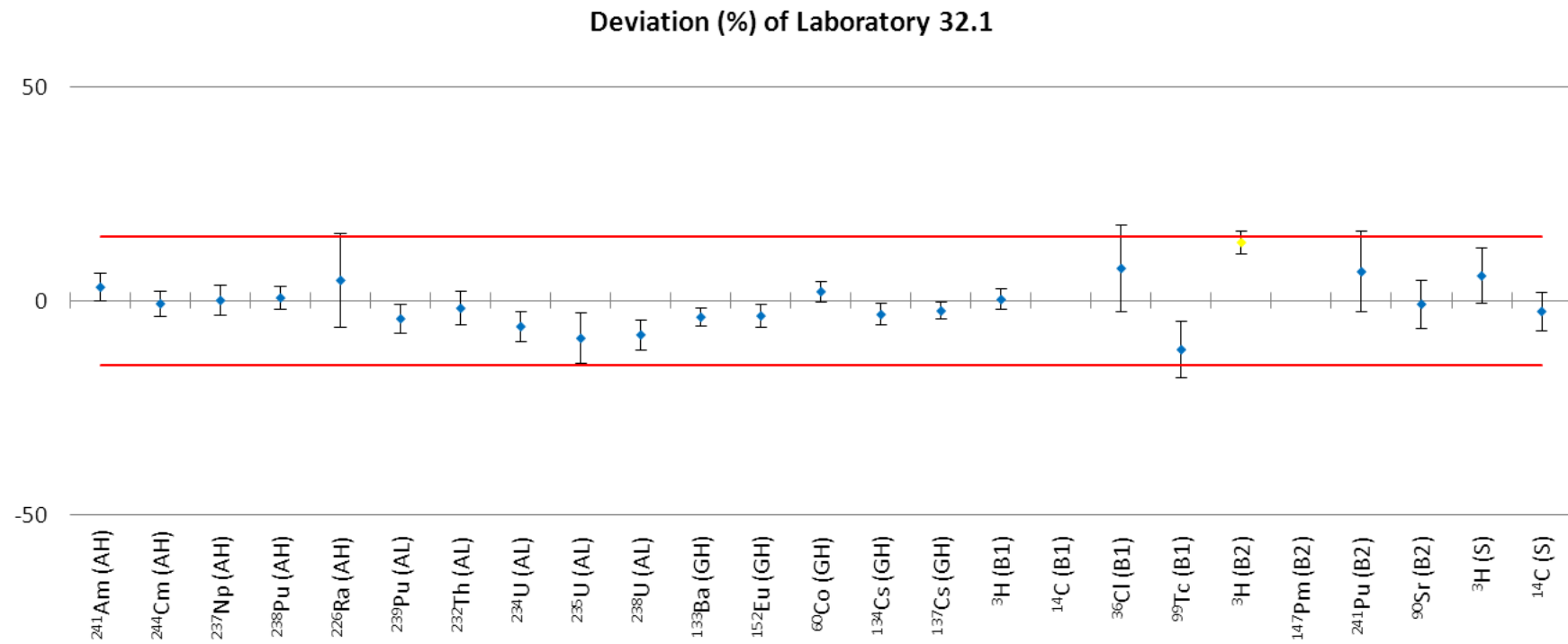
Radionuclide	Laboratory 26	NPL Assigned Value	Deviation /%	Zeta	Z Score
²³⁹ Pu (AL)	22.4 ± 0.7 (± 3 %)	12.1 ± 0.3 (± 2.2 %)	84.4	14.35	14.49
²³² Th (AL)	4.41 ± 0.24 (± 6 %)	2.52 ± 0.06 (± 2.4 %)	75.2	7.64	12.91
²³⁴ U (AL)	28 ± 3 (± 10 %)	15.0 ± 0.4 (± 3 %)	89.6	4.60	15.39
²³⁵ U (AL)	1.06 ± 0.17 (± 16 %)	0.718 ± 0.019 (± 3 %)	47.6	2.00	8.18
²³⁸ U (AL)	29 ± 3 (± 10 %)	15.0 ± 0.4 (± 3 %)	90.3	4.49	15.51
⁴⁰ K (S)	158 ± 16 (± 10 %)	181 ± 6 (± 3 %)	-12.5	-1.34	-2.15
²¹⁰ Pb (S)	43.9 ± 2.5 (± 6 %)	46.5 ± 1.4 (± 3 %)	-5.5	-0.90	-0.95
²¹⁰ Po (S)	48 ± 3 (± 6 %)	47.9 ± 0.7 (± 1.5 %)	-0.7	-0.12	-0.13

Deviation (%) of Laboratory 28



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Radionuclide	Laboratory 28	NPL Assigned Value	Deviation /%	Zeta	Z Score
²³⁹ Pu (AL)	10.10 ± 0.50 (± 5.0 %)	12.1 ± 0.3 (± 2.2 %)	-16.7	-3.69	-2.88
²³² Th (AL)	1.80 ± 0.09 (± 5.0 %)	2.52 ± 0.06 (± 2.4 %)	-28.5	-6.65	-4.89
²³⁴ U (AL)	13.7 ± 0.6 (± 4 %)	15.0 ± 0.4 (± 3 %)	-8.8	-1.95	-1.52
²³⁵ U (AL)	0.58 ± 0.06 (± 11 %)	0.718 ± 0.019 (± 3 %)	-19.6	-2.18	-3.37
²³⁸ U (AL)	13.6 ± 0.6 (± 4 %)	15.0 ± 0.4 (± 3 %)	-9.5	-2.10	-1.63
¹³³ Ba (GH)	7.4 ± 0.4 (± 5.0 %)	7.410 ± 0.050 (± 0.7 %)	0.2	0.04	0.04
¹⁵² Eu (GH)	14.2 ± 0.7 (± 5.0 %)	15.26 ± 0.10 (± 0.7 %)	-7.0	-1.61	-1.19
⁶⁰ Co (GH)	5.3 ± 0.3 (± 5.0 %)	5.229 ± 0.011 (± 0.22 %)	2.1	0.43	0.36
¹³⁴ Cs (GH)	2.78 ± 0.13 (± 5.0 %)	2.800 ± 0.019 (± 0.7 %)	-0.7	-0.15	-0.12
¹³⁷ Cs (GH)	15.6 ± 0.8 (± 5.0 %)	15.41 ± 0.06 (± 0.4 %)	1.2	0.26	0.21
⁶⁰ Co (GL)	18.1 ± 0.9 (± 5.0 %)	17.68 ± 0.08 (± 0.50 %)	2.4	0.46	0.40
¹³⁴ Cs (GL)	2.20 ± 0.13 (± 6 %)	2.190 ± 0.017 (± 0.8 %)	0.5	0.08	0.08
¹³⁷ Cs (GL)	4.3 ± 0.3 (± 6 %)	4.12 ± 0.04 (± 0.9 %)	4.8	0.73	0.83
⁴⁰ K (GL)	17.1 ± 2.3 (± 13 %)	16.4 ± 0.8 (± 5.0 %)	4.3	0.29	0.73
³ H (B2)	1.18 ± 0.04 (± 4 %)	1.076 ± 0.008 (± 0.7 %)	9.6	2.68	1.65
²⁴¹ Pu (B2)	0.85 ± 0.04 (± 4 %)	0.942 ± 0.010 (± 1.1 %)	-10.0	-2.72	-1.71
⁹⁰ Sr (B2)	0.151 ± 0.009 (± 6 %)	0.1429 ± 0.0003 (± 0.20 %)	5.5	0.87	0.94
³ H (S)	45 ± 9 (± 20 %)	77.1 ± 1.7 (± 2.2 %)	-42.0	-3.52	-7.22
¹⁴ C (S)	2.21 ± 0.11 (± 5.0 %)	1.91 ± 0.05 (± 2.5 %)	15.5	2.48	2.67
²¹⁰ Po (S)	46.5 ± 2.1 (± 5.0 %)	47.9 ± 0.7 (± 1.5 %)	-2.8	-0.61	-0.49

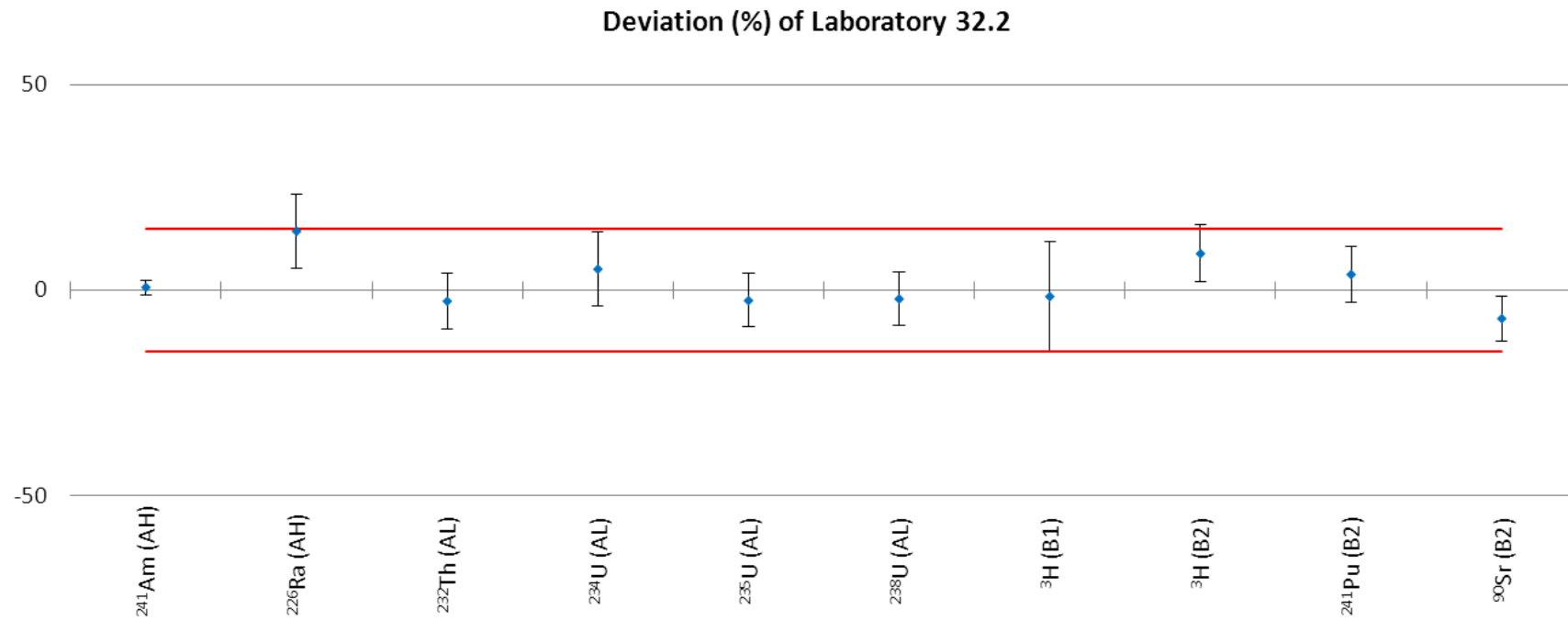


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Radionuclide	Laboratory 32.1	NPL Assigned Value	Deviation /%	Zeta	Z Score
²⁴¹ Am (AH)	4.59 ± 0.14 (± 3 %)	4.449 ± 0.010 (± 0.24 %)	3.2	1.00	0.54
²⁴⁴ Cm (AH)	19.4 ± 0.6 (± 3 %)	19.51 ± 0.07 (± 0.4 %)	-0.7	-0.24	-0.12
²³⁷ Np (AH)	14.70 ± 0.50 (± 4 %)	14.65 ± 0.15 (± 1.0 %)	0.1	0.02	0.01
²³⁸ Pu (AH)	15.0 ± 0.4 (± 2.5 %)	14.950 ± 0.050 (± 0.3 %)	0.7	0.26	0.12
²²⁶ Ra (AH)	1.53 ± 0.16 (± 10 %)	1.461 ± 0.019 (± 1.3 %)	4.8	0.43	0.82
²³⁹ Pu (AL)	11.6 ± 0.4 (± 3 %)	12.1 ± 0.3 (± 2.2 %)	-4.2	-1.20	-0.72
²³² Th (AL)	2.47 ± 0.08 (± 3 %)	2.52 ± 0.06 (± 2.4 %)	-1.8	-0.46	-0.30
²³⁴ U (AL)	14.1 ± 0.4 (± 3 %)	15.0 ± 0.4 (± 3 %)	-6.1	-1.63	-1.04
²³⁵ U (AL)	0.66 ± 0.04 (± 6 %)	0.718 ± 0.019 (± 3 %)	-8.8	-1.49	-1.51
²³⁸ U (AL)	13.8 ± 0.4 (± 3 %)	15.0 ± 0.4 (± 3 %)	-8.0	-2.18	-1.37
¹³³ Ba (GH)	7.13 ± 0.15 (± 2.1 %)	7.410 ± 0.050 (± 0.7 %)	-3.8	-1.79	-0.66
¹⁵² Eu (GH)	14.7 ± 0.4 (± 3 %)	15.26 ± 0.10 (± 0.7 %)	-3.5	-1.34	-0.61
⁶⁰ Co (GH)	5.34 ± 0.12 (± 2.2 %)	5.229 ± 0.011 (± 0.22 %)	2.1	0.92	0.36
¹³⁴ Cs (GH)	2.71 ± 0.07 (± 2.5 %)	2.800 ± 0.019 (± 0.7 %)	-3.2	-1.26	-0.55
¹³⁷ Cs (GH)	15.0 ± 0.3 (± 2.0 %)	15.41 ± 0.06 (± 0.4 %)	-2.4	-1.21	-0.41
³ H (B1)	1.049 ± 0.024 (± 2.3 %)	1.046 ± 0.008 (± 0.7 %)	0.3	0.12	0.05
¹⁴ C (B1)	0.09 ± 0.04 (± 40 %)	0.968 ± 0.008 (± 0.8 %)	-90.4	-23.16	-15.53
³⁶ Cl (B1)	0.530 ± 0.050 (± 9 %)	0.4900 ± 0.0020 (± 0.4 %)	7.6	0.75	1.30
⁹⁹ Tc (B1)	0.127 ± 0.009 (± 8 %)	0.1434 ± 0.0013 (± 0.9 %)	-11.4	-1.73	-1.96
³ H (B2)	1.22 ± 0.03 (± 2.3 %)	1.076 ± 0.008 (± 0.7 %)	13.6	5.06	2.34
¹⁴⁷ Pm (B2)	0.15 ± 0.04 (± 23 %)	0.435 ± 0.004 (± 0.9 %)	-66.4	-8.68	-11.40
²⁴¹ Pu (B2)	1.01 ± 0.09 (± 9 %)	0.942 ± 0.010 (± 1.1 %)	6.8	0.72	1.17

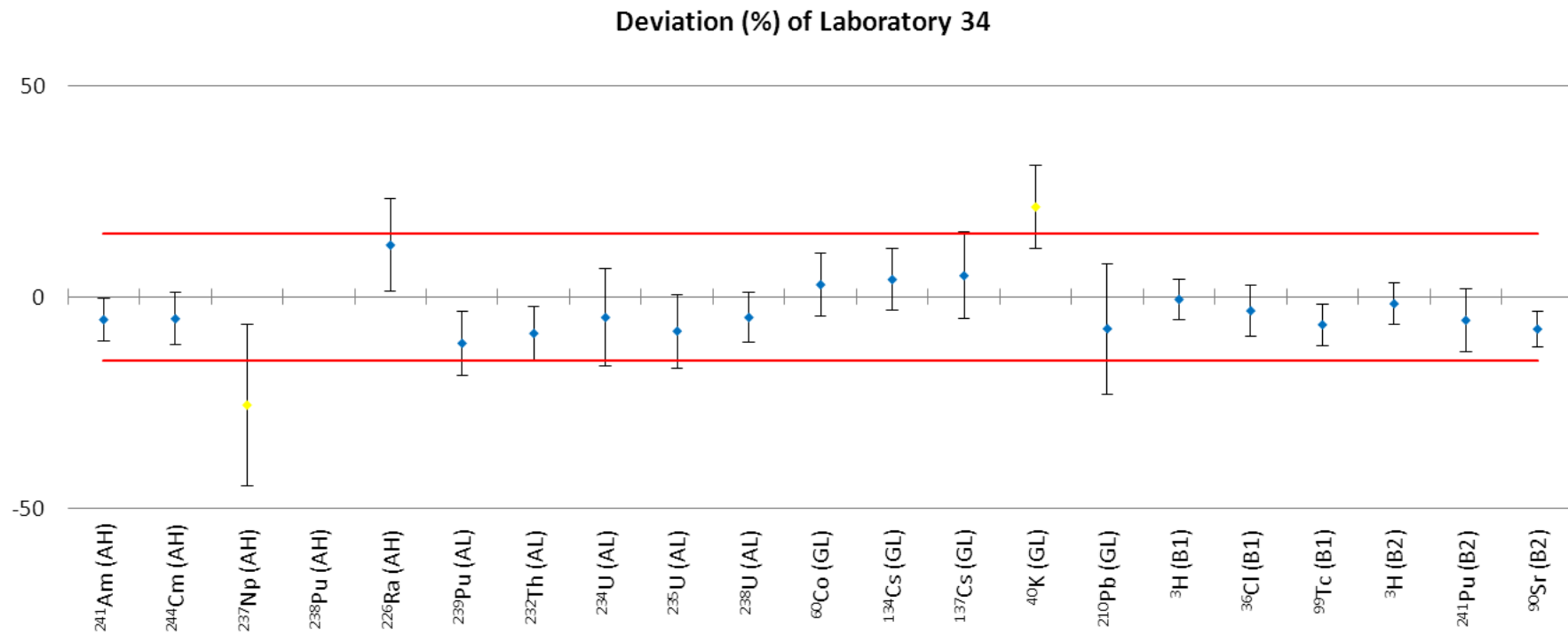
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Radionuclide	Laboratory 32.1	NPL Assigned Value	Deviation /%	Zeta	Z Score
⁹⁰ Sr (B2)	0.142 ± 0.008 (± 6 %)	0.1429 ± 0.0003 (± 0.20 %)	-0.8	-0.14	-0.14
³ H (S)	82.0 ± 5.0 (± 6 %)	77.1 ± 1.7 (± 2.2 %)	5.8	0.90	1.00
¹⁴ C (S)	1.86 ± 0.07 (± 4 %)	1.91 ± 0.05 (± 2.5 %)	-2.5	-0.56	-0.43



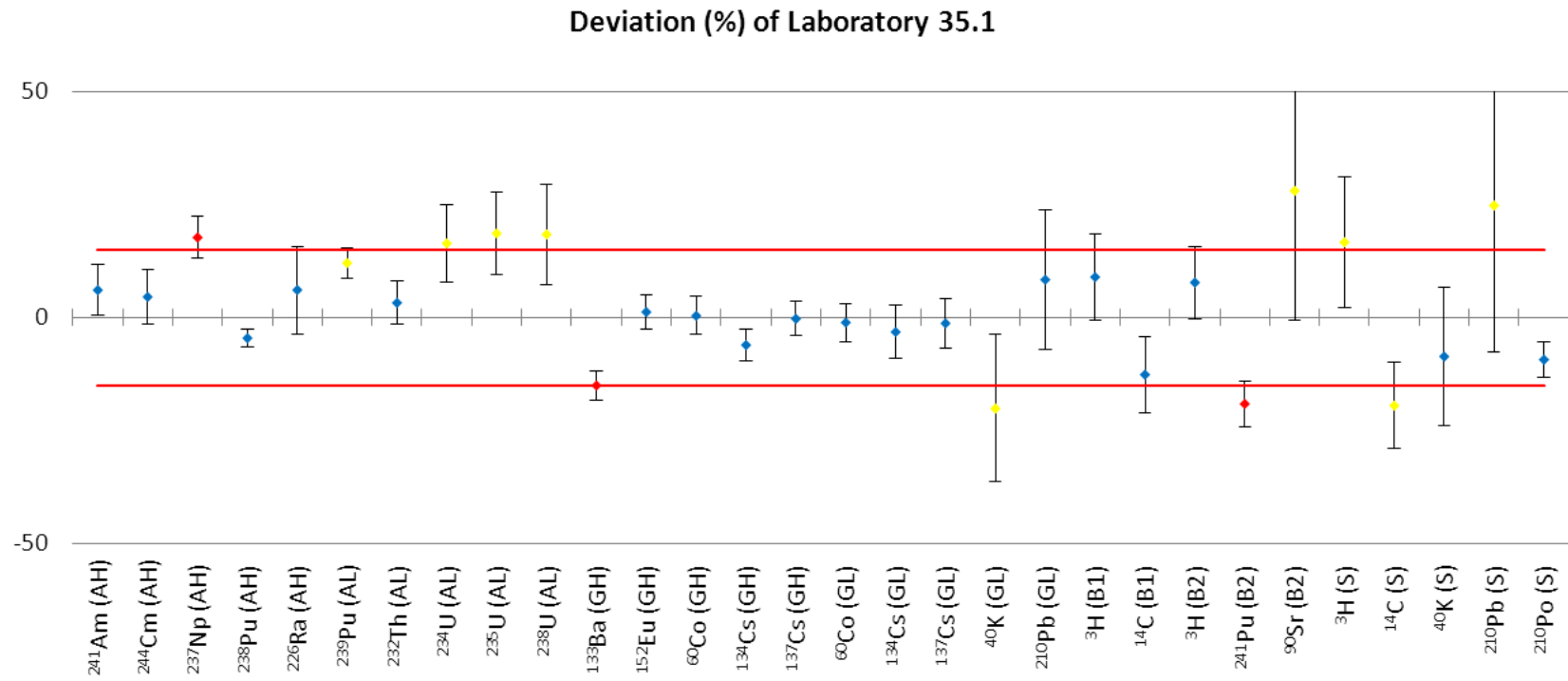
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Radionuclide	Laboratory 32.2	NPL Assigned Value	Deviation /%	Zeta	Z Score
²⁴¹ Am (AH)	4.48 ± 0.08 (± 1.7 %)	4.449 ± 0.010 (± 0.24 %)	0.7	0.39	0.12
²²⁶ Ra (AH)	1.67 ± 0.13 (± 8 %)	1.461 ± 0.019 (± 1.3 %)	14.3	1.59	2.46
²³² Th (AL)	2.45 ± 0.16 (± 7 %)	2.52 ± 0.06 (± 2.4 %)	-2.7	-0.39	-0.46
²³⁴ U (AL)	15.8 ± 1.3 (± 8 %)	15.0 ± 0.4 (± 3 %)	5.1	0.57	0.88
²³⁵ U (AL)	0.700 ± 0.050 (± 6 %)	0.718 ± 0.019 (± 3 %)	-2.5	-0.39	-0.43
²³⁸ U (AL)	14.7 ± 0.9 (± 6 %)	15.0 ± 0.4 (± 3 %)	-2.1	-0.33	-0.36
³ H (B1)	1.03 ± 0.14 (± 14 %)	1.046 ± 0.008 (± 0.7 %)	-1.5	-0.11	-0.26
³ H (B2)	1.17 ± 0.08 (± 6 %)	1.076 ± 0.008 (± 0.7 %)	8.9	1.29	1.53
²⁴¹ Pu (B2)	0.98 ± 0.06 (± 7 %)	0.942 ± 0.010 (± 1.1 %)	3.8	0.56	0.66
⁹⁰ Sr (B2)	0.133 ± 0.008 (± 6 %)	0.1429 ± 0.0003 (± 0.20 %)	-6.9	-1.28	-1.19



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Radionuclide	Laboratory 34	NPL Assigned Value	Deviation /%	Zeta	Z Score
²⁴¹ Am (AH)	4.21 ± 0.22 (± 5.0 %)	4.449 ± 0.010 (± 0.24 %)	-5.4	-1.09	-0.92
²⁴⁴ Cm (AH)	18.5 ± 1.2 (± 7 %)	19.51 ± 0.07 (± 0.4 %)	-5.2	-0.84	-0.89
²³⁷ Np (AH)	11 ± 3 (± 30 %)	14.65 ± 0.15 (± 1.0 %)	-25.6	-1.34	-4.40
²³⁸ Pu (AH)	3.7 ± 1.0 (± 25 %)	14.950 ± 0.050 (± 0.3 %)	-75.0	-11.80	-12.89
²²⁶ Ra (AH)	1.64 ± 0.16 (± 10 %)	1.461 ± 0.019 (± 1.3 %)	12.3	1.11	2.11
²³⁹ Pu (AL)	10.8 ± 0.9 (± 8 %)	12.1 ± 0.3 (± 2.2 %)	-11.0	-1.42	-1.89
²³² Th (AL)	2.30 ± 0.15 (± 7 %)	2.52 ± 0.06 (± 2.4 %)	-8.6	-1.34	-1.48
²³⁴ U (AL)	14.3 ± 1.7 (± 12 %)	15.0 ± 0.4 (± 3 %)	-4.9	-0.42	-0.83
²³⁵ U (AL)	0.66 ± 0.06 (± 9 %)	0.718 ± 0.019 (± 3 %)	-8.1	-0.92	-1.39
²³⁸ U (AL)	14.3 ± 0.8 (± 6 %)	15.0 ± 0.4 (± 3 %)	-4.9	-0.82	-0.83
⁶⁰ Co (GL)	18.2 ± 1.3 (± 7 %)	17.68 ± 0.08 (± 0.50 %)	2.9	0.40	0.50
¹³⁴ Cs (GL)	2.28 ± 0.16 (± 7 %)	2.190 ± 0.017 (± 0.8 %)	4.1	0.56	0.71
¹³⁷ Cs (GL)	4.3 ± 0.4 (± 10 %)	4.12 ± 0.04 (± 0.9 %)	5.1	0.49	0.87
⁴⁰ K (GL)	19.9 ± 1.3 (± 7 %)	16.4 ± 0.8 (± 5.0 %)	21.3	2.31	3.66
²¹⁰ Pb (GL)	18 ± 3 (± 17 %)	19.46 ± 0.22 (± 1.1 %)	-7.5	-0.49	-1.29
³ H (B1)	1.040 ± 0.050 (± 5.0 %)	1.046 ± 0.008 (± 0.7 %)	-0.6	-0.12	-0.10
³⁶ Cl (B1)	0.47 ± 0.03 (± 7 %)	0.4900 ± 0.0020 (± 0.4 %)	-3.3	-0.53	-0.56
⁹⁹ Tc (B1)	0.134 ± 0.007 (± 5.0 %)	0.1434 ± 0.0013 (± 0.9 %)	-6.6	-1.32	-1.13
³ H (B2)	1.06 ± 0.06 (± 5.0 %)	1.076 ± 0.008 (± 0.7 %)	-1.6	-0.32	-0.28
²⁴¹ Pu (B2)	0.89 ± 0.07 (± 8 %)	0.942 ± 0.010 (± 1.1 %)	-5.5	-0.74	-0.95
⁹⁰ Sr (B2)	0.132 ± 0.006 (± 5.0 %)	0.1429 ± 0.0003 (± 0.20 %)	-7.6	-1.81	-1.31

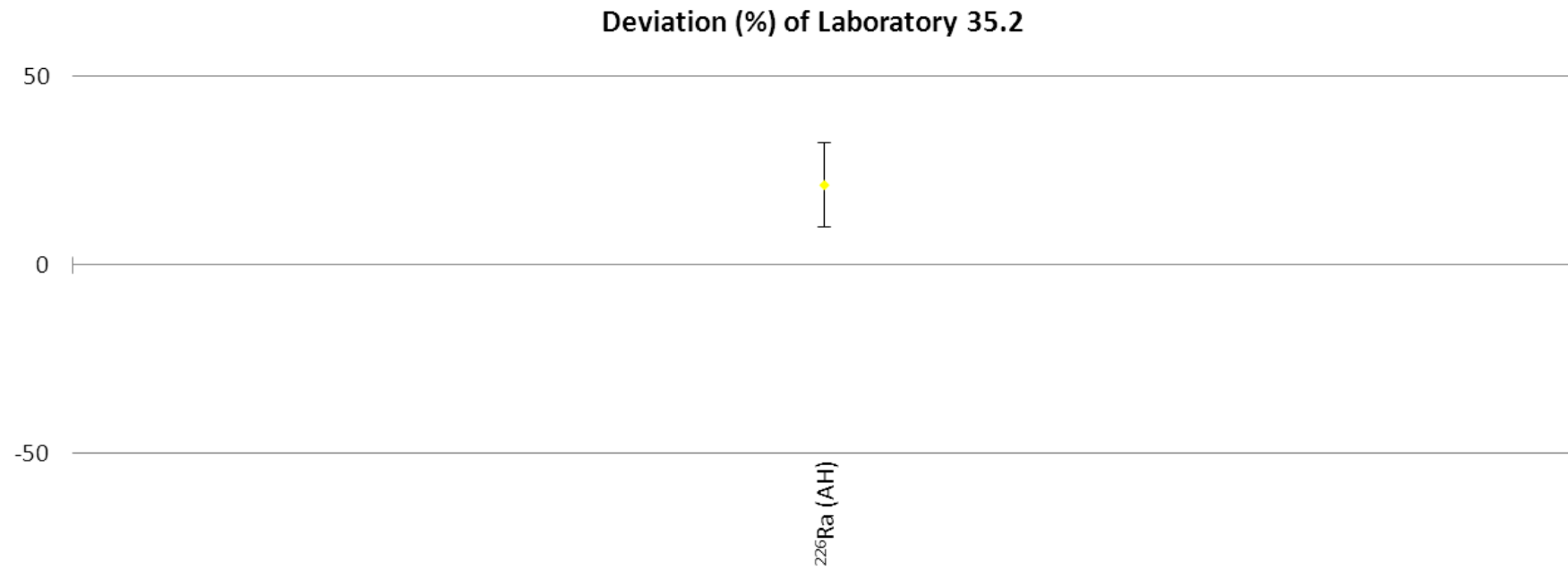


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Radionuclide	Laboratory 35.1	NPL Assigned Value	Deviation /%	Zeta	Z Score
²⁴¹ Am (AH)	4.72 ± 0.25 (± 6 %)	4.449 ± 0.010 (± 0.24 %)	6.1	1.08	1.05
²⁴⁴ Cm (AH)	20.4 ± 1.2 (± 6 %)	19.51 ± 0.07 (± 0.4 %)	4.6	0.74	0.79
²³⁷ Np (AH)	17.2 ± 0.7 (± 4 %)	14.65 ± 0.15 (± 1.0 %)	17.7	3.84	3.05
²³⁸ Pu (AH)	14.3 ± 0.3 (± 2.0 %)	14.950 ± 0.050 (± 0.3 %)	-4.5	-2.31	-0.78
²²⁶ Ra (AH)	1.55 ± 0.14 (± 9 %)	1.461 ± 0.019 (± 1.3 %)	6.1	0.63	1.05
²³⁹ Pu (AL)	13.6 ± 0.3 (± 2.0 %)	12.1 ± 0.3 (± 2.2 %)	12.1	3.84	2.08
²³² Th (AL)	2.60 ± 0.10 (± 4 %)	2.52 ± 0.06 (± 2.4 %)	3.3	0.70	0.56
²³⁴ U (AL)	17.5 ± 1.2 (± 7 %)	15.0 ± 0.4 (± 3 %)	16.4	1.96	2.82
²³⁵ U (AL)	0.85 ± 0.06 (± 7 %)	0.718 ± 0.019 (± 3 %)	18.7	2.07	3.20
²³⁸ U (AL)	17.8 ± 1.6 (± 9 %)	15.0 ± 0.4 (± 3 %)	18.4	1.68	3.17
¹³³ Ba (GH)	6.30 ± 0.24 (± 4 %)	7.410 ± 0.050 (± 0.7 %)	-15.0	-4.54	-2.58
¹⁵² Eu (GH)	15.4 ± 0.6 (± 4 %)	15.26 ± 0.10 (± 0.7 %)	1.2	0.33	0.21
⁶⁰ Co (GH)	5.25 ± 0.22 (± 4 %)	5.229 ± 0.011 (± 0.22 %)	0.4	0.09	0.07
¹³⁴ Cs (GH)	2.63 ± 0.10 (± 4 %)	2.800 ± 0.019 (± 0.7 %)	-6.1	-1.76	-1.04
¹³⁷ Cs (GH)	15.4 ± 0.6 (± 4 %)	15.41 ± 0.06 (± 0.4 %)	-0.3	-0.07	-0.04
⁶⁰ Co (GL)	17.5 ± 0.8 (± 5.0 %)	17.68 ± 0.08 (± 0.50 %)	-1.1	-0.26	-0.19
¹³⁴ Cs (GL)	2.12 ± 0.13 (± 6 %)	2.190 ± 0.017 (± 0.8 %)	-3.2	-0.53	-0.55
¹³⁷ Cs (GL)	4.07 ± 0.22 (± 6 %)	4.12 ± 0.04 (± 0.9 %)	-1.3	-0.23	-0.22
⁴⁰ K (GL)	13 ± 3 (± 20 %)	16.4 ± 0.8 (± 5.0 %)	-20.1	-1.22	-3.46
²¹⁰ Pb (GL)	21 ± 3 (± 14 %)	19.46 ± 0.22 (± 1.1 %)	8.4	0.54	1.44
³ H (B1)	1.14 ± 0.10 (± 9 %)	1.046 ± 0.008 (± 0.7 %)	9.0	0.94	1.54
¹⁴ C (B1)	0.85 ± 0.08 (± 10 %)	0.968 ± 0.008 (± 0.8 %)	-12.6	-1.50	-2.17

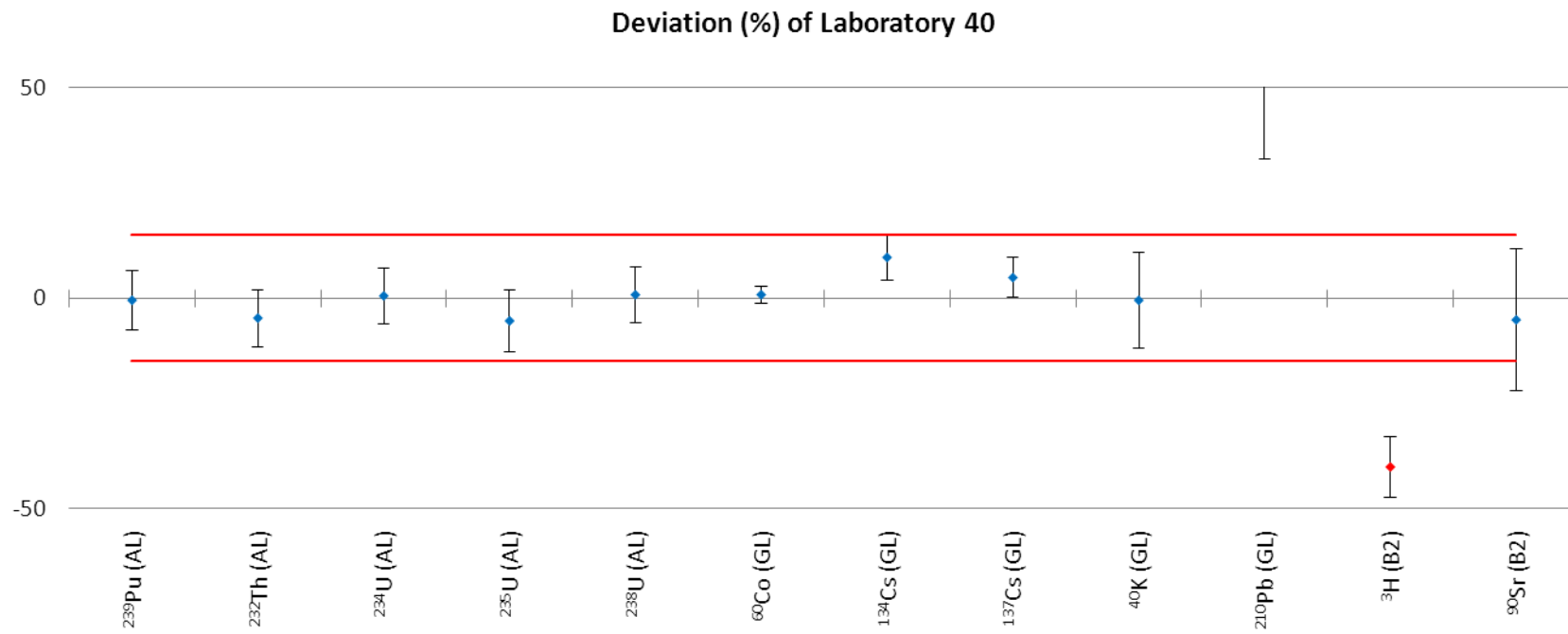
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Radionuclide	Laboratory 35.1	NPL Assigned Value	Deviation /%	Zeta	Z Score
^3H (B2)	1.16 $\pm$ 0.09 ($\pm$ 8 %)	1.076 $\pm$ 0.008 ($\pm$ 0.7 %)	7.8	0.97	1.34
^{241}Pu (B2)	0.760 $\pm$ 0.050 ($\pm$ 6 %)	0.942 $\pm$ 0.010 ($\pm$ 1.1 %)	-19.1	-3.74	-3.28
^{90}Sr (B2)	0.18 $\pm$ 0.04 ($\pm$ 22 %)	0.1429 $\pm$ 0.0003 ($\pm$ 0.20 %)	28.1	0.98	4.83
^3H (S)	90 $\pm$ 11 ($\pm$ 12 %)	77.1 $\pm$ 1.7 ($\pm$ 2.2 %)	16.7	1.16	2.87
^{14}C (S)	1.54 $\pm$ 0.18 ($\pm$ 12 %)	1.91 $\pm$ 0.05 ($\pm$ 2.5 %)	-19.5	-2.00	-3.35
^{40}K (S)	160 $\pm$ 30 ($\pm$ 16 %)	181 $\pm$ 6 ($\pm$ 3 %)	-8.6	-0.57	-1.48
^{210}Pb (S)	58 $\pm$ 15 ($\pm$ 30 %)	46.5 $\pm$ 1.4 ($\pm$ 3 %)	24.8	0.77	4.26
^{210}Po (S)	43.4 $\pm$ 1.8 ($\pm$ 4 %)	47.9 $\pm$ 0.7 ($\pm$ 1.5 %)	-9.3	-2.31	-1.60



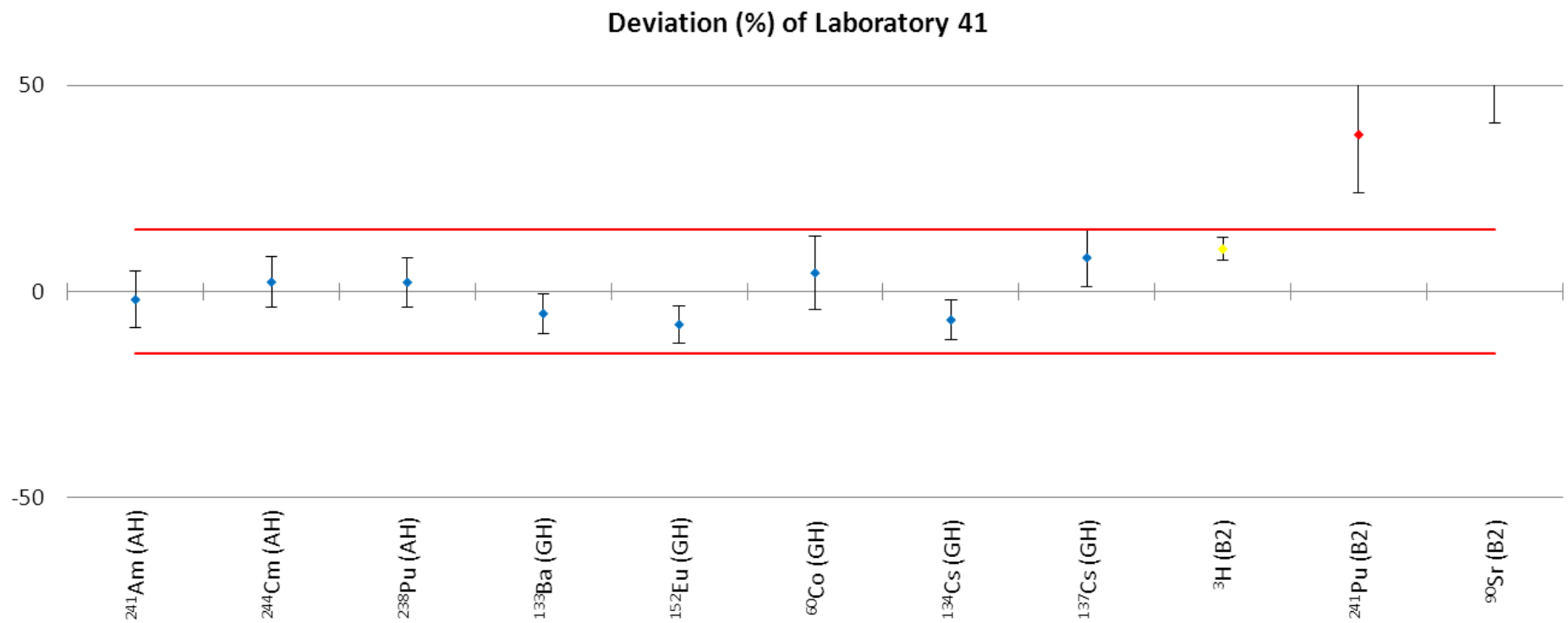
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Radionuclide	Laboratory 35.2	NPL Assigned Value	Deviation /%	Zeta	Z Score
²²⁶ Ra (AH)	1.77 ± 0.16 (± 9 %)	1.461 ± 0.019 (± 1.3 %)	21.2	1.92	3.64



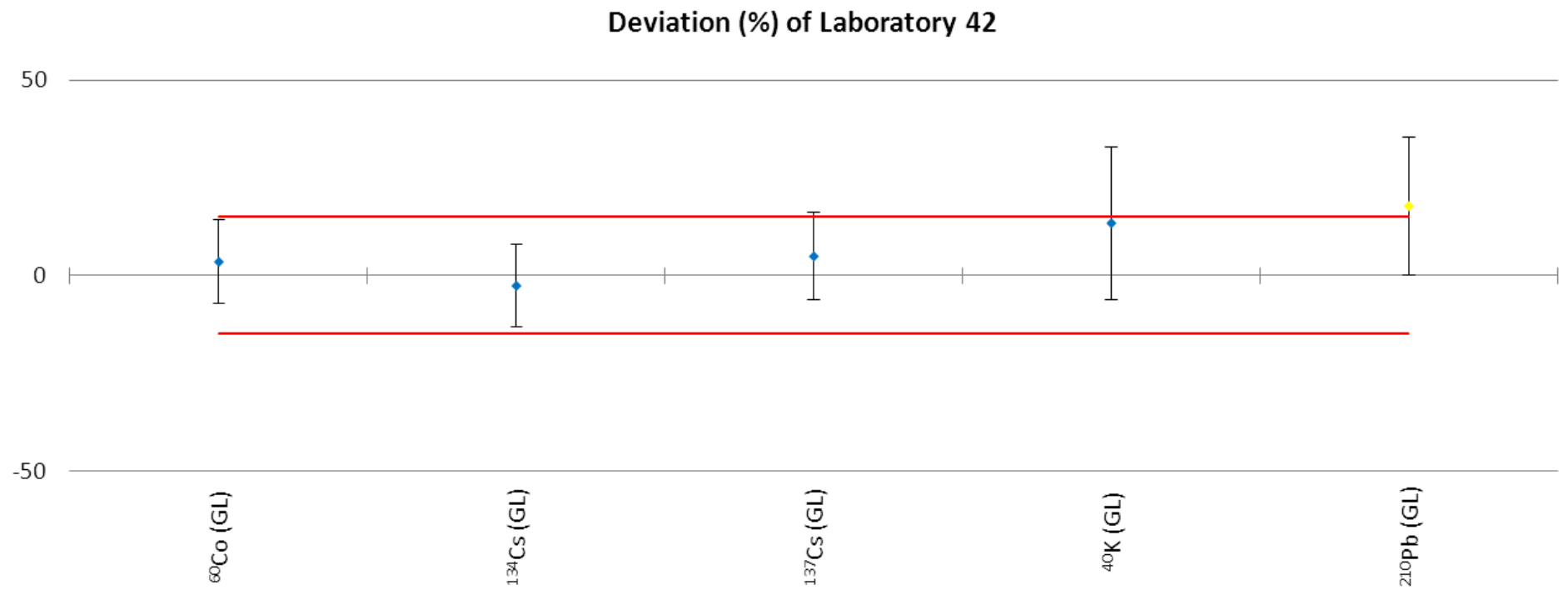
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Radionuclide	Laboratory 40	NPL Assigned Value	Deviation /%	Zeta	Z Score
²³⁹ Pu (AL)	12.1 ± 0.8 (± 7 %)	12.1 ± 0.3 (± 2.2 %)	-0.4	-0.06	-0.07
²³² Th (AL)	2.40 ± 0.16 (± 7 %)	2.52 ± 0.06 (± 2.4 %)	-4.7	-0.69	-0.80
²³⁴ U (AL)	15.1 ± 0.9 (± 6 %)	15.0 ± 0.4 (± 3 %)	0.6	0.09	0.10
²³⁵ U (AL)	0.680 ± 0.050 (± 7 %)	0.718 ± 0.019 (± 3 %)	-5.3	-0.73	-0.91
²³⁸ U (AL)	15.2 ± 0.9 (± 6 %)	15.0 ± 0.4 (± 3 %)	0.9	0.13	0.15
⁶⁰ Co (GL)	17.8 ± 0.4 (± 1.9 %)	17.68 ± 0.08 (± 0.50 %)	0.9	0.45	0.15
¹³⁴ Cs (GL)	2.40 ± 0.12 (± 5.0 %)	2.190 ± 0.017 (± 0.8 %)	9.7	1.77	1.67
¹³⁷ Cs (GL)	4.33 ± 0.19 (± 5.0 %)	4.12 ± 0.04 (± 0.9 %)	4.9	1.03	0.85
⁴⁰ K (GL)	16.3 ± 1.7 (± 10 %)	16.4 ± 0.8 (± 5.0 %)	-0.4	-0.04	-0.08
²¹⁰ Pb (GL)	36 ± 10 (± 30 %)	19.46 ± 0.22 (± 1.1 %)	82.4	1.68	14.15
³ H (B2)	0.65 ± 0.08 (± 12 %)	1.076 ± 0.008 (± 0.7 %)	-40.0	-5.55	-6.87
⁹⁰ Sr (B2)	0.136 ± 0.024 (± 18 %)	0.1429 ± 0.0003 (± 0.20 %)	-5.1	-0.30	-0.87



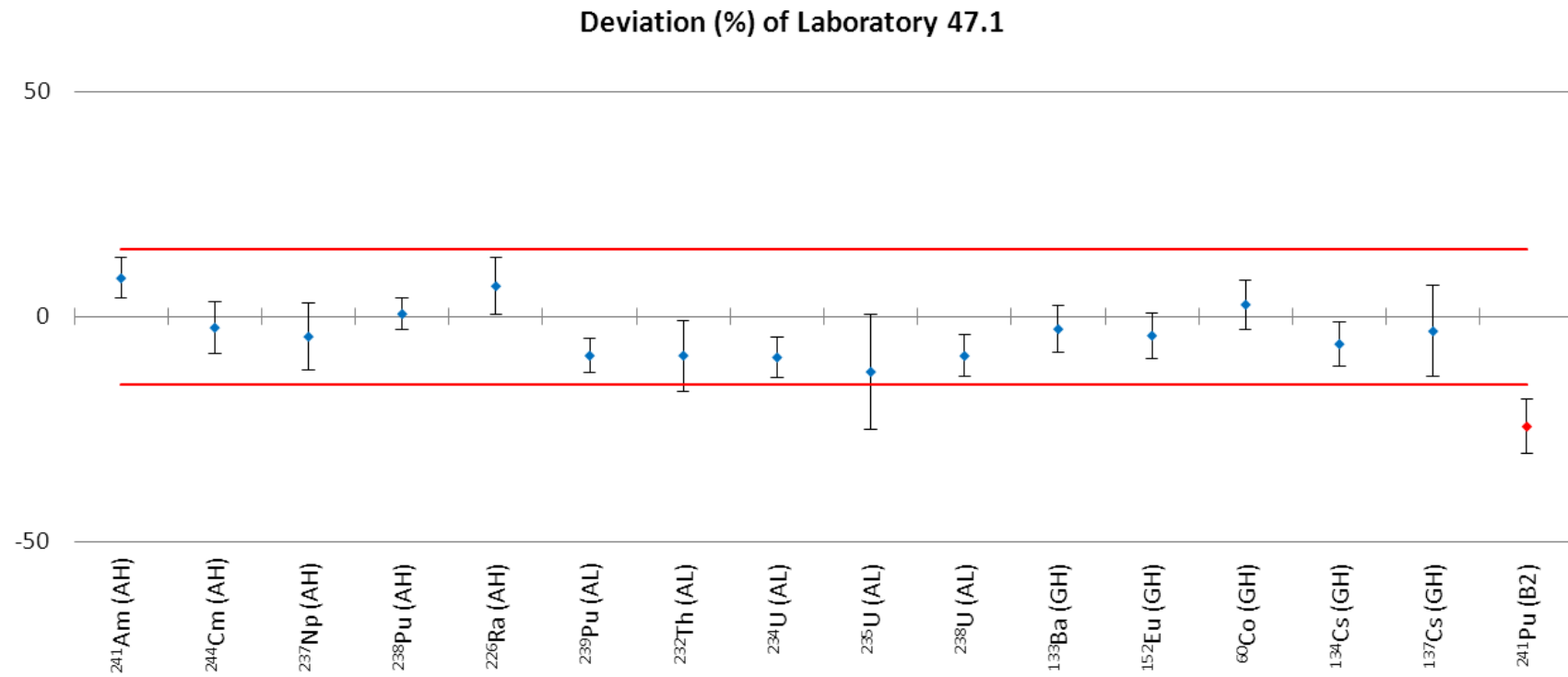
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Radionuclide	Laboratory 41	NPL Assigned Value	Deviation /%	Zeta	Z Score
²⁴¹ Am (AH)	4.4 ± 0.3 (± 7 %)	4.449 ± 0.010 (± 0.24 %)	-2.0	-0.29	-0.34
²⁴⁴ Cm (AH)	20.0 ± 1.2 (± 6 %)	19.51 ± 0.07 (± 0.4 %)	2.3	0.38	0.39
²³⁸ Pu (AH)	15.3 ± 0.9 (± 6 %)	14.950 ± 0.050 (± 0.3 %)	2.2	0.37	0.38
¹³³ Ba (GH)	7.0 ± 0.4 (± 5.0 %)	7.410 ± 0.050 (± 0.7 %)	-5.4	-1.11	-0.92
¹⁵² Eu (GH)	14.0 ± 0.7 (± 5.0 %)	15.26 ± 0.10 (± 0.7 %)	-8.0	-1.79	-1.37
⁶⁰ Co (GH)	5.50 ± 0.50 (± 9 %)	5.229 ± 0.011 (± 0.22 %)	4.5	0.50	0.77
¹³⁴ Cs (GH)	2.61 ± 0.14 (± 5.0 %)	2.800 ± 0.019 (± 0.7 %)	-6.9	-1.41	-1.18
¹³⁷ Cs (GH)	16.7 ± 1.1 (± 7 %)	15.41 ± 0.06 (± 0.4 %)	8.2	1.19	1.40
³ H (B2)	1.19 ± 0.03 (± 2.4 %)	1.076 ± 0.008 (± 0.7 %)	10.3	3.82	1.77
²⁴¹ Pu (B2)	1.30 ± 0.13 (± 10 %)	0.942 ± 0.010 (± 1.1 %)	38.0	2.70	6.53
⁹⁰ Sr (B2)	0.216 ± 0.015 (± 7 %)	0.1429 ± 0.0003 (± 0.20 %)	51.2	4.88	8.79



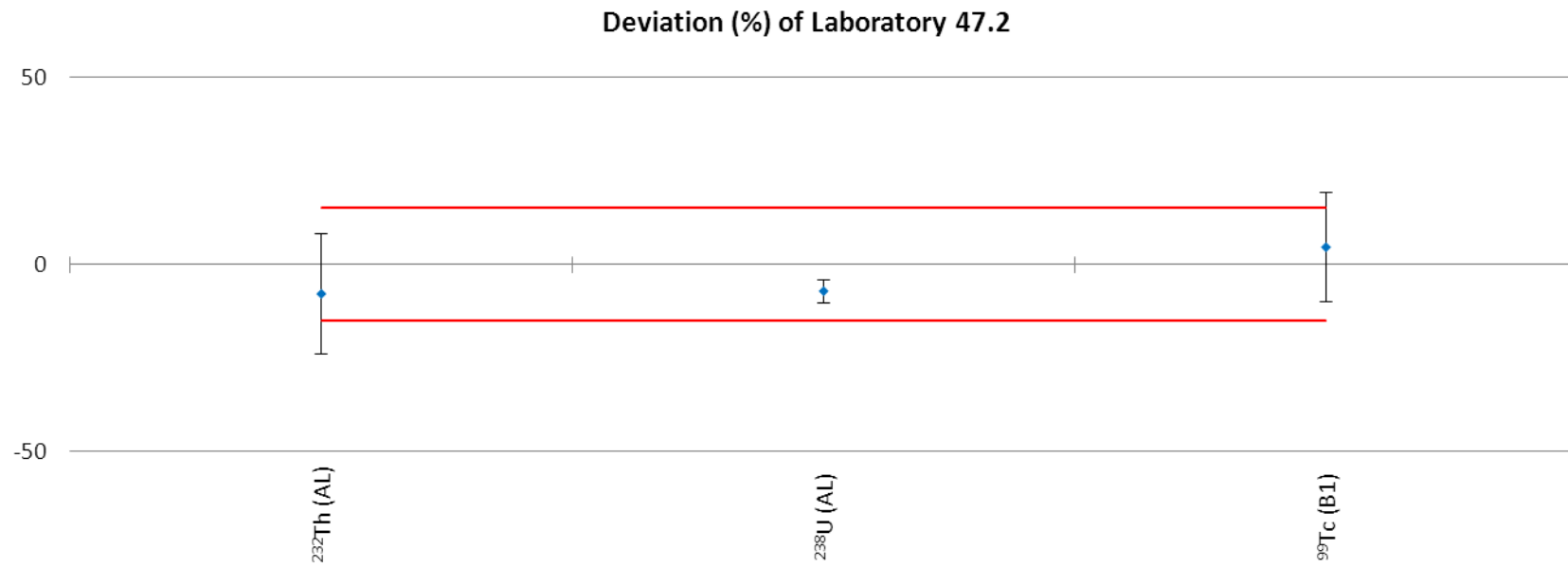
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Radionuclide	Laboratory 42	NPL Assigned Value	Deviation /%	Zeta	Z Score
⁶⁰ Co (GL)	18.3 ± 1.9 (± 10 %)	17.68 ± 0.08 (± 0.50 %)	3.4	0.32	0.59
¹³⁴ Cs (GL)	2.13 ± 0.23 (± 11 %)	2.190 ± 0.017 (± 0.8 %)	-2.7	-0.26	-0.46
¹³⁷ Cs (GL)	4.30 ± 0.50 (± 11 %)	4.12 ± 0.04 (± 0.9 %)	4.8	0.43	0.83
⁴⁰ K (GL)	19 ± 3 (± 17 %)	16.4 ± 0.8 (± 5.0 %)	13.4	0.69	2.29
²¹⁰ Pb (GL)	23 ± 4 (± 15 %)	19.46 ± 0.22 (± 1.1 %)	17.7	1.00	3.04



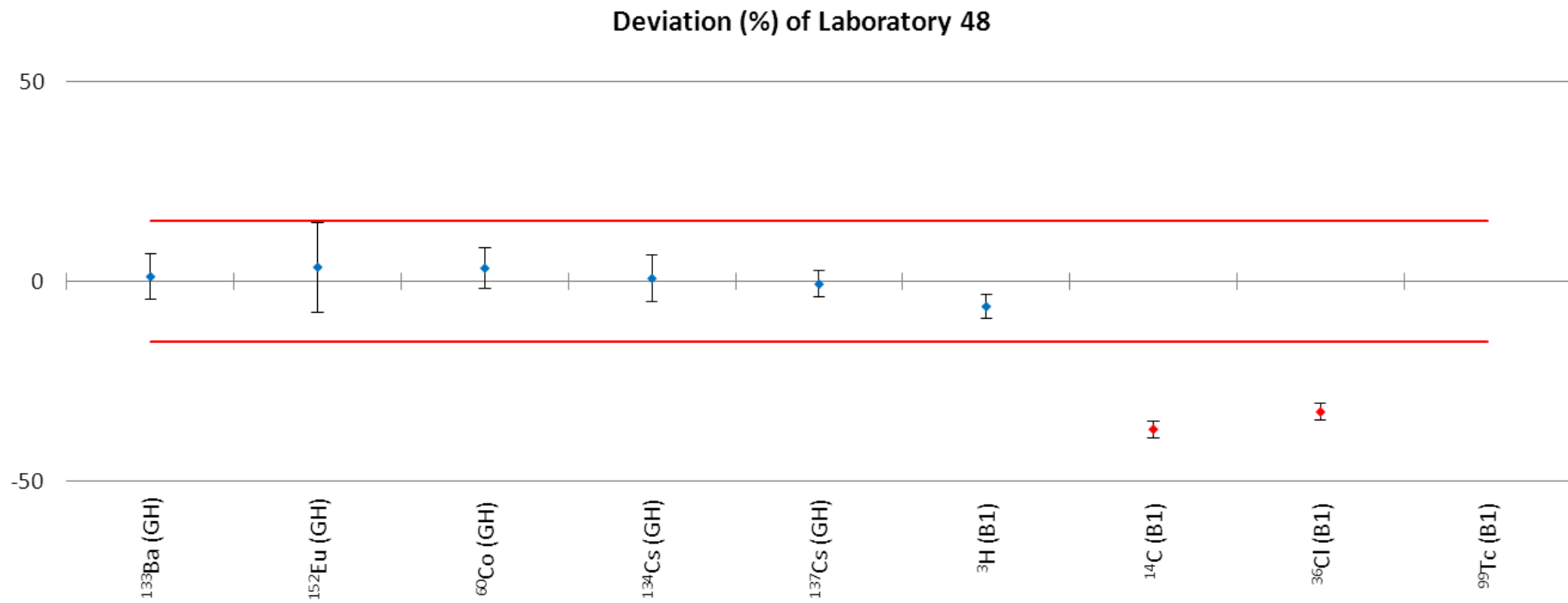
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Radionuclide	Laboratory 47.1	NPL Assigned Value	Deviation /%	Zeta	Z Score
²⁴¹ Am (AH)	4.83 ± 0.20 (± 4 %)	4.449 ± 0.010 (± 0.24 %)	8.6	1.90	1.47
²⁴⁴ Cm (AH)	19.0 ± 1.1 (± 6 %)	19.51 ± 0.07 (± 0.4 %)	-2.4	-0.43	-0.42
²³⁷ Np (AH)	14.0 ± 1.1 (± 8 %)	14.65 ± 0.15 (± 1.0 %)	-4.4	-0.60	-0.76
²³⁸ Pu (AH)	15.0 ± 0.6 (± 4 %)	14.950 ± 0.050 (± 0.3 %)	0.6	0.17	0.10
²²⁶ Ra (AH)	1.56 ± 0.09 (± 6 %)	1.461 ± 0.019 (± 1.3 %)	6.8	1.08	1.17
²³⁹ Pu (AL)	11.1 ± 0.4 (± 4 %)	12.1 ± 0.3 (± 2.2 %)	-8.7	-2.18	-1.49
²³² Th (AL)	2.30 ± 0.19 (± 8 %)	2.52 ± 0.06 (± 2.4 %)	-8.6	-1.09	-1.48
²³⁴ U (AL)	13.7 ± 0.6 (± 5.0 %)	15.0 ± 0.4 (± 3 %)	-9.0	-1.93	-1.55
²³⁵ U (AL)	0.63 ± 0.09 (± 14 %)	0.718 ± 0.019 (± 3 %)	-12.3	-0.96	-2.11
²³⁸ U (AL)	13.7 ± 0.6 (± 5.0 %)	15.0 ± 0.4 (± 3 %)	-8.7	-1.83	-1.50
¹³³ Ba (GH)	7.2 ± 0.4 (± 6 %)	7.410 ± 0.050 (± 0.7 %)	-2.8	-0.53	-0.47
¹⁵² Eu (GH)	14.6 ± 0.8 (± 5.0 %)	15.26 ± 0.10 (± 0.7 %)	-4.2	-0.84	-0.72
⁶⁰ Co (GH)	5.4 ± 0.3 (± 6 %)	5.229 ± 0.011 (± 0.22 %)	2.7	0.49	0.46
¹³⁴ Cs (GH)	2.63 ± 0.14 (± 6 %)	2.800 ± 0.019 (± 0.7 %)	-6.1	-1.20	-1.04
¹³⁷ Cs (GH)	14.9 ± 1.6 (± 10 %)	15.41 ± 0.06 (± 0.4 %)	-3.2	-0.32	-0.56
²⁴¹ Pu (B2)	0.71 ± 0.06 (± 8 %)	0.942 ± 0.010 (± 1.1 %)	-24.4	-4.04	-4.19



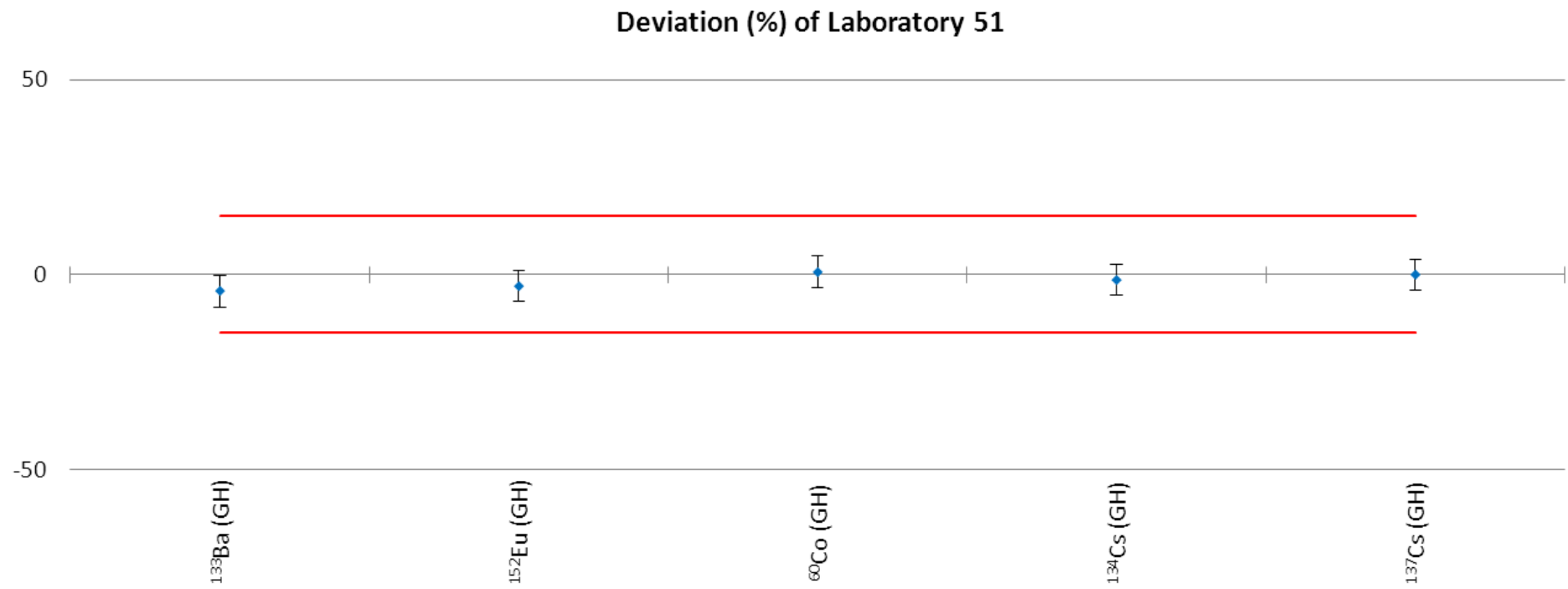
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Radionuclide	Laboratory 47.2	NPL Assigned Value	Deviation /%	Zeta	Z Score
²³² Th (AL)	2.3 ± 0.4 (± 17 %)	2.52 ± 0.06 (± 2.4 %)	-7.8	-0.49	-1.35
²³⁸ U (AL)	14.0 ± 0.3 (± 2.0 %)	15.0 ± 0.4 (± 3 %)	-7.1	-2.24	-1.22
⁹⁹ Tc (B1)	0.150 ± 0.021 (± 14 %)	0.1434 ± 0.0013 (± 0.9 %)	4.6	0.31	0.79



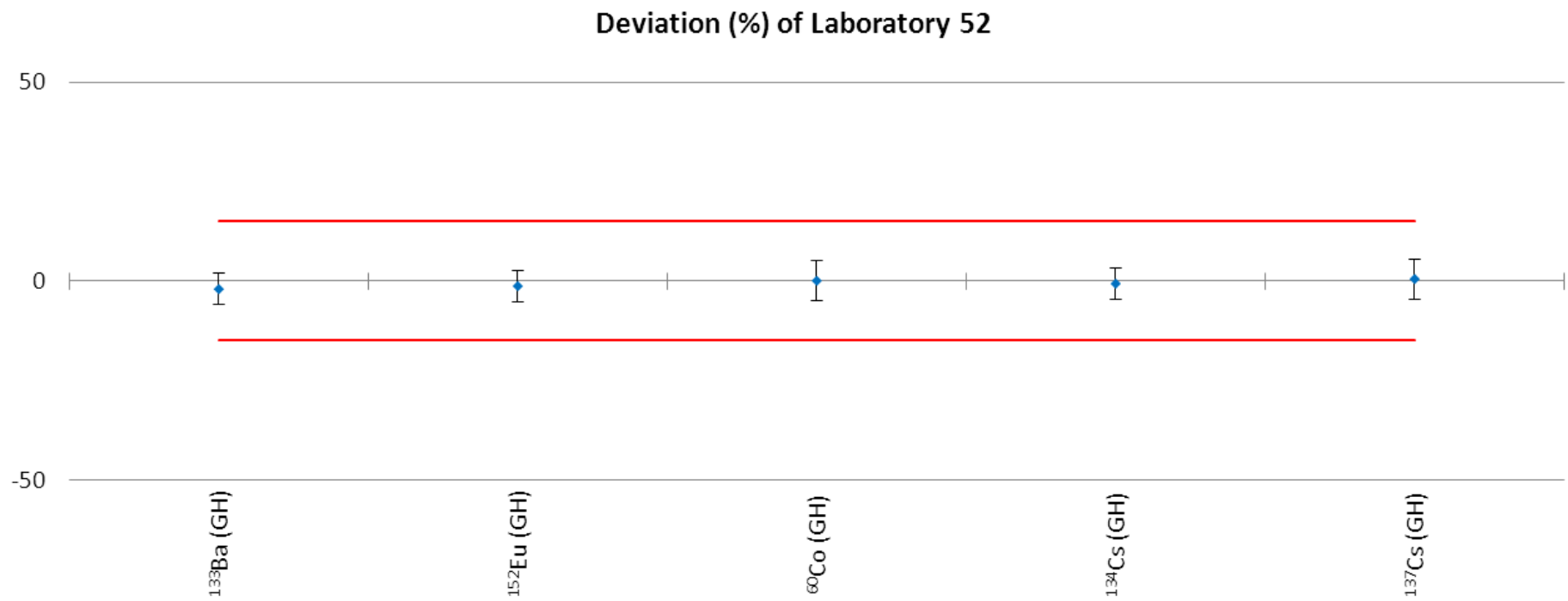
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Radionuclide	Laboratory 48	NPL Assigned Value	Deviation /%	Zeta	Z Score
¹³³ Ba (GH)	7.5 ± 0.4 (± 6 %)	7.410 ± 0.050 (± 0.7 %)	1.2	0.21	0.20
¹⁵² Eu (GH)	15.8 ± 1.7 (± 11 %)	15.26 ± 0.10 (± 0.7 %)	3.5	0.32	0.61
⁶⁰ Co (GH)	5.4 ± 0.3 (± 5.0 %)	5.229 ± 0.011 (± 0.22 %)	3.3	0.63	0.56
¹³⁴ Cs (GH)	2.82 ± 0.16 (± 6 %)	2.800 ± 0.019 (± 0.7 %)	0.7	0.12	0.12
¹³⁷ Cs (GH)	15.30 ± 0.50 (± 4 %)	15.41 ± 0.06 (± 0.4 %)	-0.7	-0.22	-0.12
³ H (B1)	0.98 ± 0.03 (± 3 %)	1.046 ± 0.008 (± 0.7 %)	-6.3	-2.14	-1.08
¹⁴ C (B1)	0.610 ± 0.020 (± 4 %)	0.968 ± 0.008 (± 0.8 %)	-37.0	-16.70	-6.35
³⁶ Cl (B1)	0.330 ± 0.010 (± 3 %)	0.4900 ± 0.0020 (± 0.4 %)	-32.7	-15.70	-5.61
⁹⁹ Tc (B1)	0.230 ± 0.010 (± 5.0 %)	0.1434 ± 0.0013 (± 0.9 %)	60.4	8.59	10.37



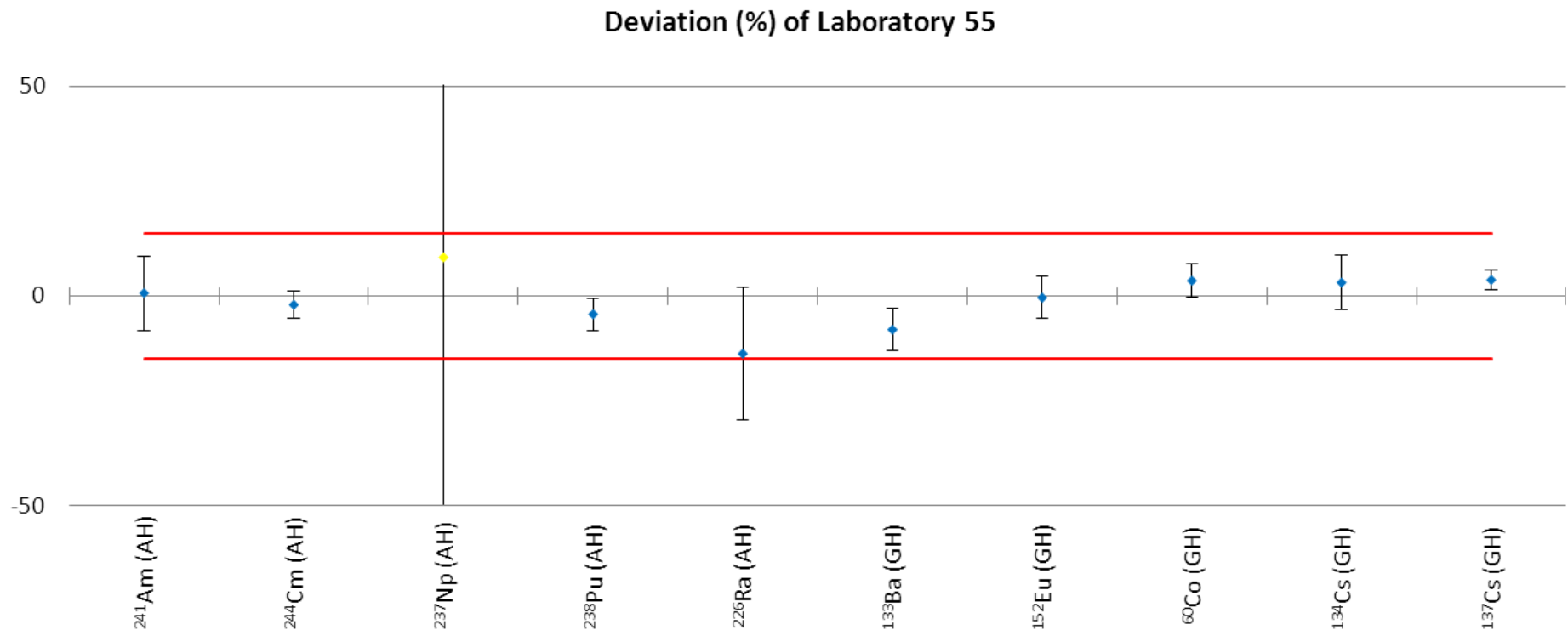
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Radionuclide	Laboratory 51	NPL Assigned Value	Deviation /%	Zeta	Z Score
¹³³ Ba (GH)	7.1 ± 0.3 (± 5.0 %)	7.410 ± 0.050 (± 0.7 %)	-4.2	-1.03	-0.73
¹⁵² Eu (GH)	14.8 ± 0.6 (± 4 %)	15.26 ± 0.10 (± 0.7 %)	-3.0	-0.76	-0.52
⁶⁰ Co (GH)	5.26 ± 0.21 (± 4 %)	5.229 ± 0.011 (± 0.22 %)	0.6	0.15	0.10
¹³⁴ Cs (GH)	2.76 ± 0.11 (± 4 %)	2.800 ± 0.019 (± 0.7 %)	-1.4	-0.36	-0.25
¹³⁷ Cs (GH)	15.4 ± 0.6 (± 4 %)	15.41 ± 0.06 (± 0.4 %)	-0.1	-0.02	-0.01



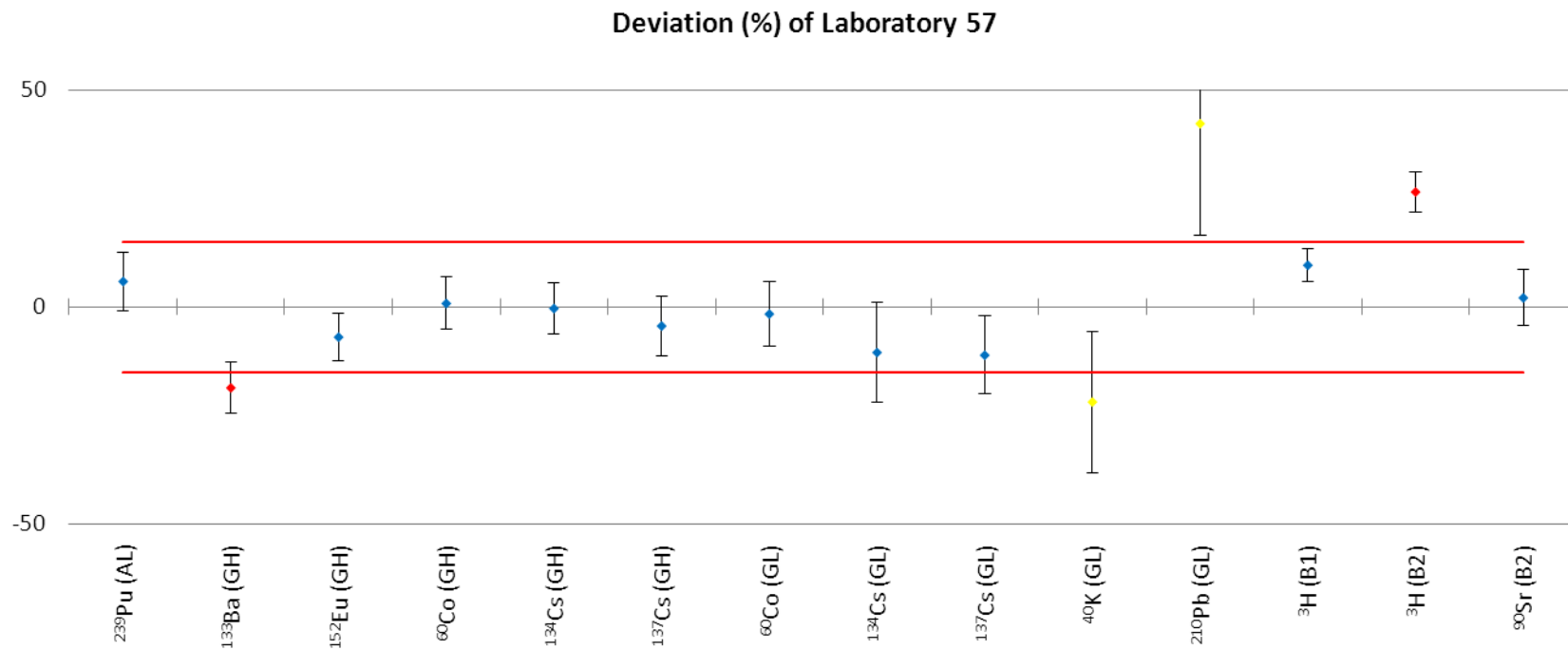
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Radionuclide	Laboratory 52	NPL Assigned Value	Deviation /%	Zeta	Z Score
¹³³ Ba (GH)	7.3 ± 0.3 (± 4 %)	7.410 ± 0.050 (± 0.7 %)	-2.1	-0.52	-0.36
¹⁵² Eu (GH)	15.1 ± 0.6 (± 4 %)	15.26 ± 0.10 (± 0.7 %)	-1.3	-0.33	-0.23
⁶⁰ Co (GH)	5.2 ± 0.3 (± 5.0 %)	5.229 ± 0.011 (± 0.22 %)	0.0	0.00	0.00
¹³⁴ Cs (GH)	2.78 ± 0.11 (± 4 %)	2.800 ± 0.019 (± 0.7 %)	-0.7	-0.18	-0.12
¹³⁷ Cs (GH)	15.5 ± 0.8 (± 5.0 %)	15.41 ± 0.06 (± 0.4 %)	0.5	0.09	0.08



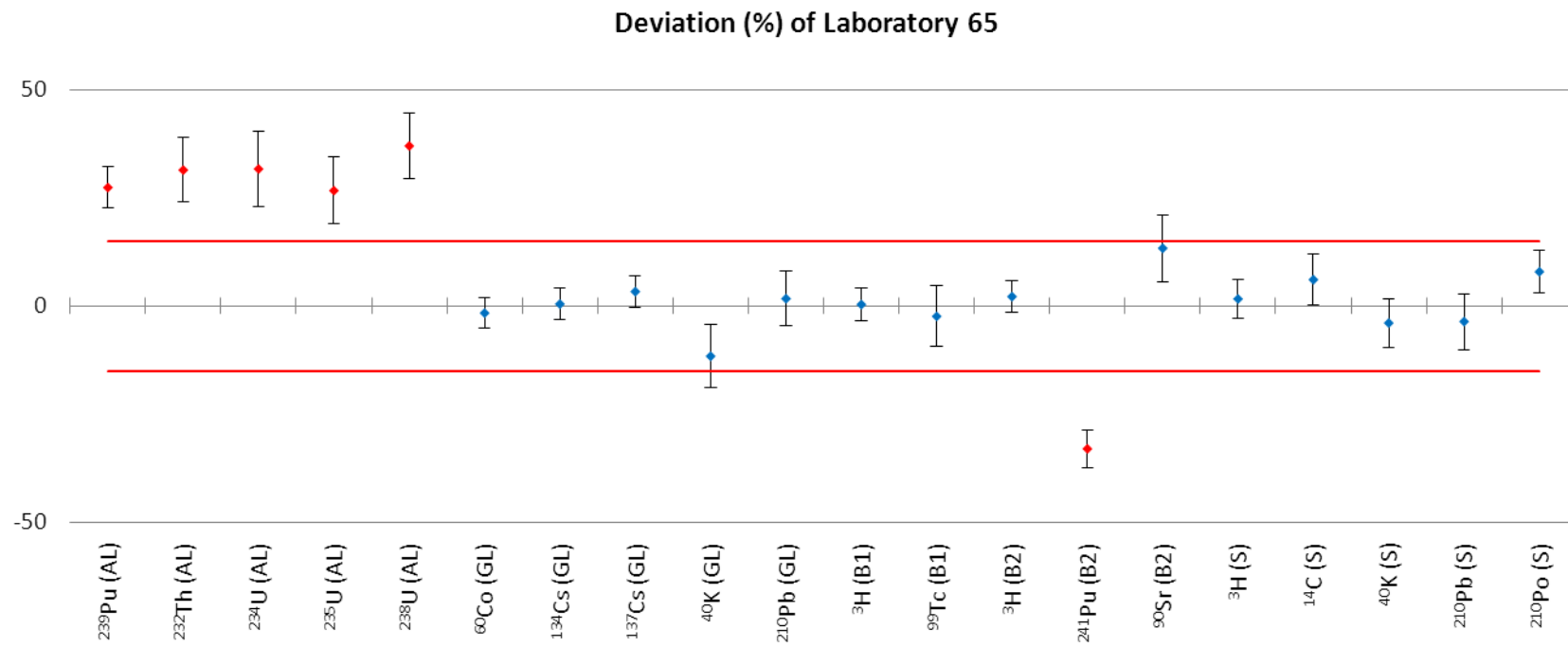
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Radionuclide	Laboratory 55	NPL Assigned Value	Deviation /%	Zeta	Z Score
²⁴¹ Am (AH)	4.5 ± 0.4 (± 9 %)	4.449 ± 0.010 (± 0.24 %)	0.7	0.08	0.12
²⁴⁴ Cm (AH)	19.1 ± 0.7 (± 4 %)	19.51 ± 0.07 (± 0.4 %)	-2.1	-0.62	-0.36
²³⁷ Np (AH)	16 ± 14 (± 90 %)	14.65 ± 0.15 (± 1.0 %)	9.2	0.09	1.58
²³⁸ Pu (AH)	14.3 ± 0.6 (± 4 %)	14.950 ± 0.050 (± 0.3 %)	-4.3	-1.14	-0.75
²²⁶ Ra (AH)	1.26 ± 0.23 (± 18 %)	1.461 ± 0.019 (± 1.3 %)	-13.7	-0.87	-2.36
¹³³ Ba (GH)	6.8 ± 0.4 (± 6 %)	7.410 ± 0.050 (± 0.7 %)	-8.0	-1.62	-1.38
¹⁵² Eu (GH)	15.2 ± 0.8 (± 5.0 %)	15.26 ± 0.10 (± 0.7 %)	-0.4	-0.08	-0.07
⁶⁰ Co (GH)	5.42 ± 0.21 (± 4 %)	5.229 ± 0.011 (± 0.22 %)	3.6	0.90	0.63
¹³⁴ Cs (GH)	2.89 ± 0.18 (± 6 %)	2.800 ± 0.019 (± 0.7 %)	3.2	0.50	0.55
¹³⁷ Cs (GH)	16.0 ± 0.4 (± 2.1 %)	15.41 ± 0.06 (± 0.4 %)	3.8	1.71	0.66



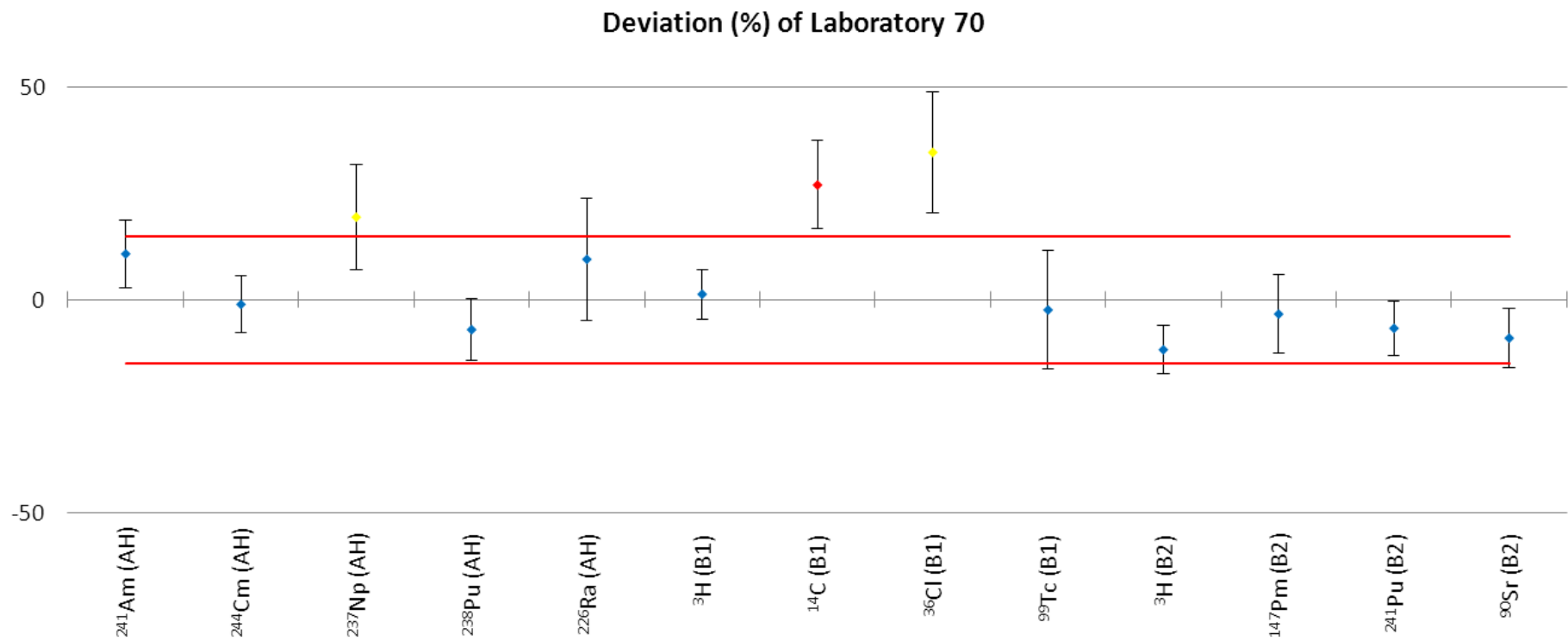
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Radionuclide	Laboratory 57	NPL Assigned Value	Deviation /%	Zeta	Z Score
²³⁹ Pu (AL)	12.8 ± 0.8 (± 6 %)	12.1 ± 0.3 (± 2.2 %)	5.9	0.88	1.01
¹³³ Ba (GH)	6.00 ± 0.50 (± 7 %)	7.410 ± 0.050 (± 0.7 %)	-18.6	-3.18	-3.20
¹⁵² Eu (GH)	14.2 ± 0.9 (± 6 %)	15.26 ± 0.10 (± 0.7 %)	-6.9	-1.25	-1.19
⁶⁰ Co (GH)	5.3 ± 0.3 (± 6 %)	5.229 ± 0.011 (± 0.22 %)	0.8	0.14	0.14
¹³⁴ Cs (GH)	2.79 ± 0.17 (± 6 %)	2.800 ± 0.019 (± 0.7 %)	-0.3	-0.06	-0.06
¹³⁷ Cs (GH)	14.7 ± 1.1 (± 7 %)	15.41 ± 0.06 (± 0.4 %)	-4.4	-0.63	-0.75
⁶⁰ Co (GL)	17.4 ± 1.3 (± 8 %)	17.68 ± 0.08 (± 0.50 %)	-1.6	-0.22	-0.28
¹³⁴ Cs (GL)	1.96 ± 0.25 (± 13 %)	2.190 ± 0.017 (± 0.8 %)	-10.5	-0.92	-1.80
¹³⁷ Cs (GL)	3.7 ± 0.4 (± 10 %)	4.12 ± 0.04 (± 0.9 %)	-11.1	-1.23	-1.91
⁴⁰ K (GL)	13 ± 3 (± 20 %)	16.4 ± 0.8 (± 5.0 %)	-21.9	-1.32	-3.76
²¹⁰ Pb (GL)	28.0 ± 5.0 (± 18 %)	19.46 ± 0.22 (± 1.1 %)	42.3	1.65	7.27
³ H (B1)	1.15 ± 0.04 (± 4 %)	1.046 ± 0.008 (± 0.7 %)	9.6	2.48	1.66
³ H (B2)	1.360 ± 0.050 (± 4 %)	1.076 ± 0.008 (± 0.7 %)	26.5	5.82	4.56
⁹⁰ Sr (B2)	0.146 ± 0.009 (± 7 %)	0.1429 ± 0.0003 (± 0.20 %)	2.1	0.33	0.37



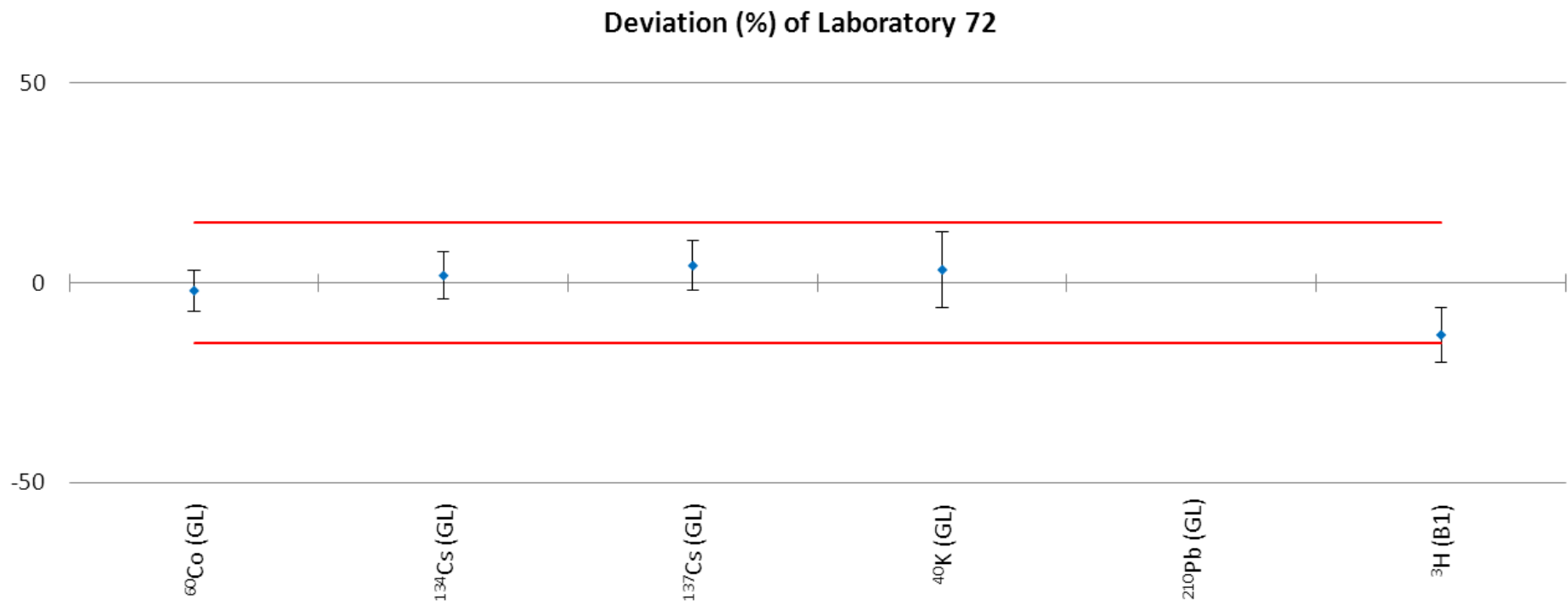
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Radionuclide	Laboratory 65	NPL Assigned Value	Deviation /%	Zeta	Z Score
²³⁹ Pu (AL)	15.50 ± 0.50 (± 3 %)	12.1 ± 0.3 (± 2.2 %)	27.4	6.23	4.71
²³² Th (AL)	3.31 ± 0.17 (± 5.0 %)	2.52 ± 0.06 (± 2.4 %)	31.5	4.39	5.41
²³⁴ U (AL)	19.8 ± 1.2 (± 6 %)	15.0 ± 0.4 (± 3 %)	31.7	3.78	5.45
²³⁵ U (AL)	0.910 ± 0.050 (± 6 %)	0.718 ± 0.019 (± 3 %)	26.7	3.60	4.59
²³⁸ U (AL)	20.6 ± 1.0 (± 5.0 %)	15.0 ± 0.4 (± 3 %)	37.1	5.19	6.37
⁶⁰ Co (GL)	17.4 ± 0.6 (± 4 %)	17.68 ± 0.08 (± 0.50 %)	-1.6	-0.47	-0.28
¹³⁴ Cs (GL)	2.20 ± 0.08 (± 4 %)	2.190 ± 0.017 (± 0.8 %)	0.5	0.13	0.08
¹³⁷ Cs (GL)	4.26 ± 0.15 (± 4 %)	4.12 ± 0.04 (± 0.9 %)	3.4	0.89	0.58
⁴⁰ K (GL)	14.5 ± 1.0 (± 7 %)	16.4 ± 0.8 (± 5.0 %)	-11.6	-1.50	-1.99
²¹⁰ Pb (GL)	19.8 ± 1.2 (± 6 %)	19.46 ± 0.22 (± 1.1 %)	1.7	0.27	0.30
³ H (B1)	1.05 ± 0.04 (± 4 %)	1.046 ± 0.008 (± 0.7 %)	0.4	0.10	0.06
⁹⁹ Tc (B1)	0.140 ± 0.010 (± 7 %)	0.1434 ± 0.0013 (± 0.9 %)	-2.4	-0.34	-0.41
³ H (B2)	1.10 ± 0.04 (± 4 %)	1.076 ± 0.008 (± 0.7 %)	2.2	0.58	0.38
²⁴¹ Pu (B2)	0.63 ± 0.04 (± 7 %)	0.942 ± 0.010 (± 1.1 %)	-33.0	-7.35	-5.67
⁹⁰ Sr (B2)	0.162 ± 0.011 (± 7 %)	0.1429 ± 0.0003 (± 0.20 %)	13.4	1.74	2.30
³ H (S)	78 ± 3 (± 4 %)	77.1 ± 1.7 (± 2.2 %)	1.7	0.36	0.28
¹⁴ C (S)	2.03 ± 0.10 (± 5.0 %)	1.91 ± 0.05 (± 2.5 %)	6.1	1.06	1.05
²¹⁰ Pb (S)	45 ± 3 (± 6 %)	46.5 ± 1.4 (± 3 %)	-3.6	-0.55	-0.61
²¹⁰ Po (S)	51.7 ± 2.2 (± 5.0 %)	47.9 ± 0.7 (± 1.5 %)	8.0	1.65	1.37



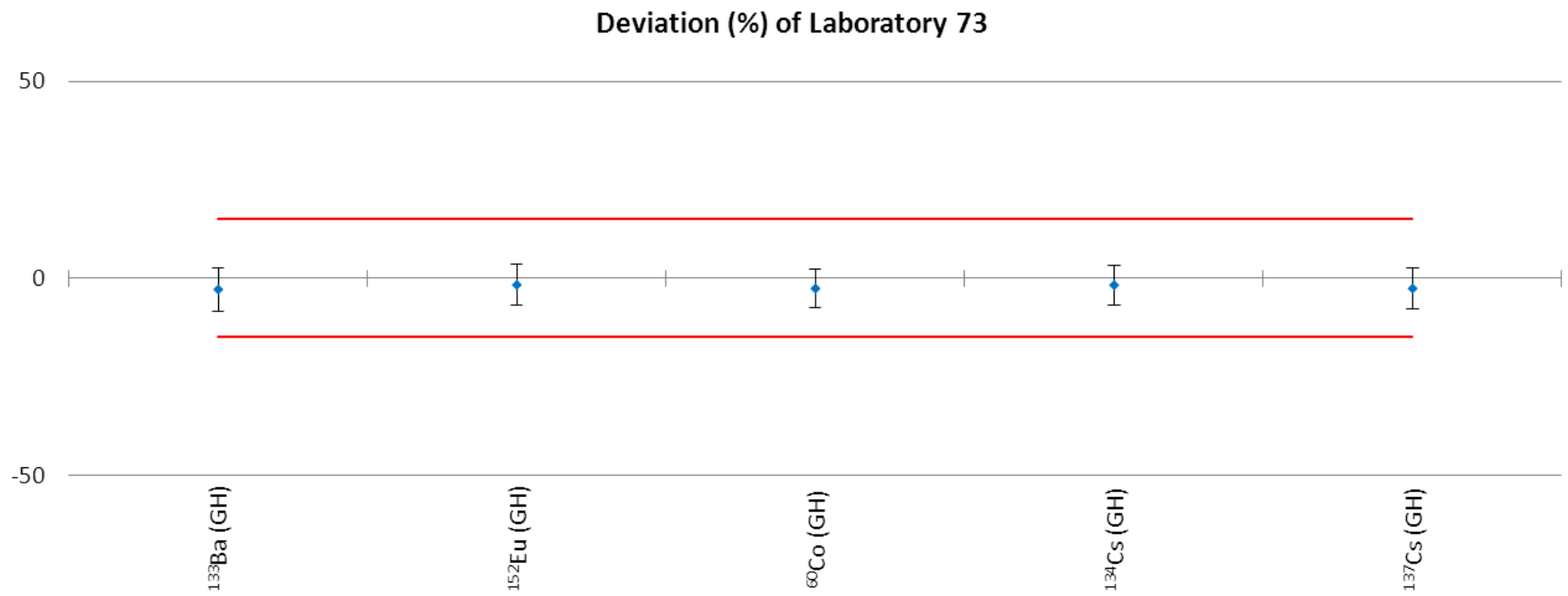
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Radionuclide	Laboratory 70	NPL Assigned Value	Deviation /%	Zeta	Z Score
²⁴¹ Am (AH)	4.9 ± 0.4 (± 7 %)	4.449 ± 0.010 (± 0.24 %)	10.8	1.37	1.86
²⁴⁴ Cm (AH)	19.3 ± 1.3 (± 7 %)	19.51 ± 0.07 (± 0.4 %)	-1.1	-0.16	-0.18
²³⁷ Np (AH)	17.5 ± 1.8 (± 10 %)	14.65 ± 0.15 (± 1.0 %)	19.5	1.58	3.34
²³⁸ Pu (AH)	13.9 ± 1.1 (± 8 %)	14.950 ± 0.050 (± 0.3 %)	-7.0	-0.95	-1.21
²²⁶ Ra (AH)	1.60 ± 0.21 (± 13 %)	1.461 ± 0.019 (± 1.3 %)	9.5	0.66	1.64
³ H (B1)	1.06 ± 0.06 (± 6 %)	1.046 ± 0.008 (± 0.7 %)	1.3	0.23	0.23
¹⁴ C (B1)	1.23 ± 0.10 (± 8 %)	0.968 ± 0.008 (± 0.8 %)	27.0	2.61	4.64
³⁶ Cl (B1)	0.66 ± 0.07 (± 11 %)	0.4900 ± 0.0020 (± 0.4 %)	34.7	2.43	5.96
⁹⁹ Tc (B1)	0.140 ± 0.020 (± 14 %)	0.1434 ± 0.0013 (± 0.9 %)	-2.4	-0.17	-0.41
³ H (B2)	0.95 ± 0.06 (± 6 %)	1.076 ± 0.008 (± 0.7 %)	-11.7	-2.09	-2.02
¹⁴⁷ Pm (B2)	0.42 ± 0.04 (± 10 %)	0.435 ± 0.004 (± 0.9 %)	-3.3	-0.36	-0.57
²⁴¹ Pu (B2)	0.88 ± 0.06 (± 7 %)	0.942 ± 0.010 (± 1.1 %)	-6.7	-1.04	-1.15
⁹⁰ Sr (B2)	0.130 ± 0.010 (± 8 %)	0.1429 ± 0.0003 (± 0.20 %)	-9.0	-1.29	-1.55



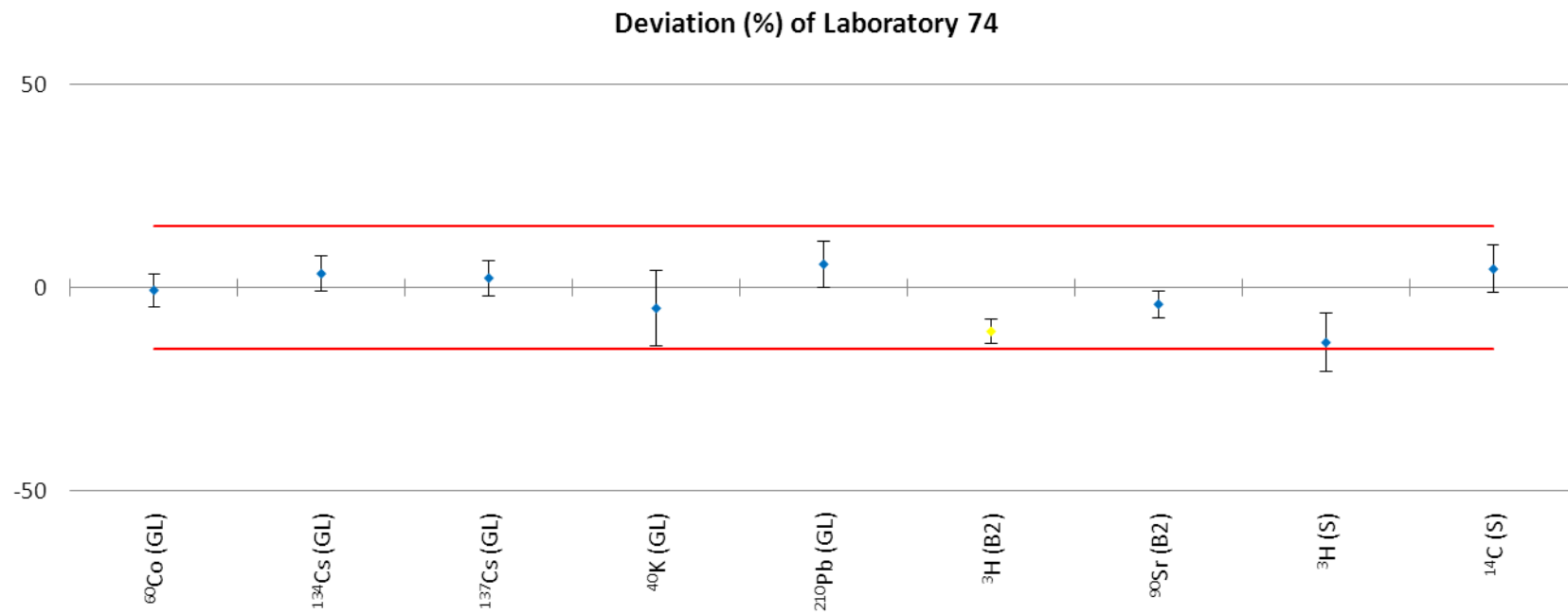
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Radionuclide	Laboratory 72	NPL Assigned Value	Deviation /%	Zeta	Z Score
⁶⁰ Co (GL)	17.3 ± 0.9 (± 5.0 %)	17.68 ± 0.08 (± 0.50 %)	-1.9	-0.38	-0.33
¹³⁴ Cs (GL)	2.23 ± 0.13 (± 6 %)	2.190 ± 0.017 (± 0.8 %)	1.8	0.31	0.32
¹³⁷ Cs (GL)	4.30 ± 0.25 (± 6 %)	4.12 ± 0.04 (± 0.9 %)	4.3	0.70	0.74
⁴⁰ K (GL)	16.9 ± 1.3 (± 8 %)	16.4 ± 0.8 (± 5.0 %)	3.3	0.35	0.56
²¹⁰ Pb (GL)	4.0 ± 0.7 (± 17 %)	19.46 ± 0.22 (± 1.1 %)	-79.2	-21.85	-13.60
³ H (B1)	0.91 ± 0.07 (± 8 %)	1.046 ± 0.008 (± 0.7 %)	-13.0	-1.93	-2.23



NPL Report IR 28

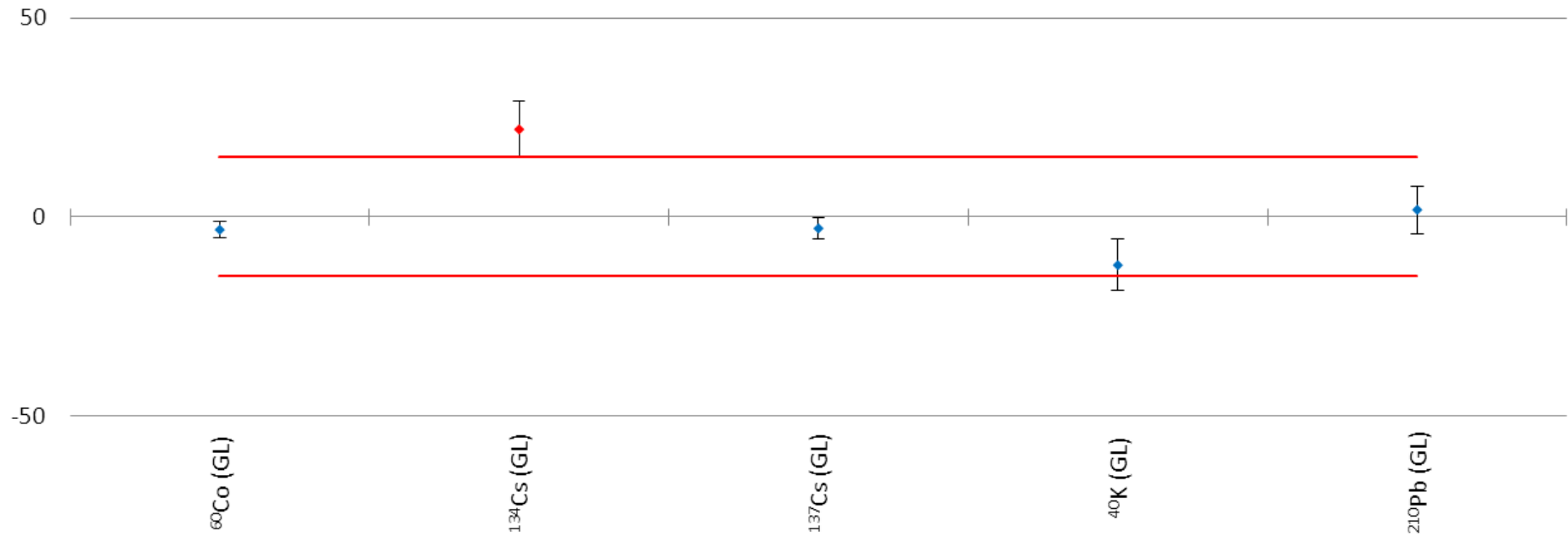
Radionuclide	Laboratory 73	NPL Assigned Value	Deviation /%	Zeta	Z Score
¹³³ Ba (GH)	7.2 ± 0.4 (± 6 %)	7.410 ± 0.050 (± 0.7 %)	-2.9	-0.53	-0.50
¹⁵² Eu (GH)	15.0 ± 0.8 (± 6 %)	15.26 ± 0.10 (± 0.7 %)	-1.7	-0.32	-0.29
⁶⁰ Co (GH)	5.09 ± 0.25 (± 5.0 %)	5.229 ± 0.011 (± 0.22 %)	-2.7	-0.56	-0.46
¹³⁴ Cs (GH)	2.75 ± 0.14 (± 5.0 %)	2.800 ± 0.019 (± 0.7 %)	-1.8	-0.35	-0.31
¹³⁷ Cs (GH)	15.0 ± 0.8 (± 6 %)	15.41 ± 0.06 (± 0.4 %)	-2.7	-0.51	-0.46



NPL Report IR 28

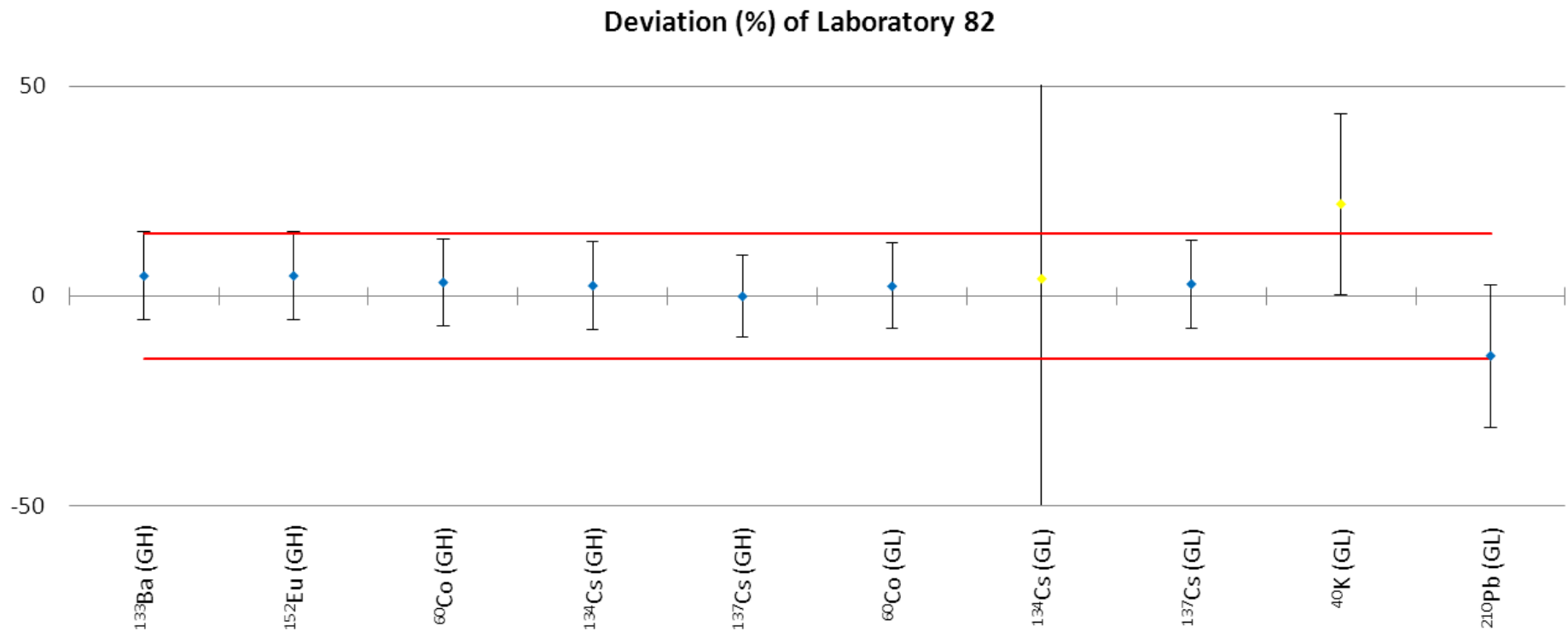
Radionuclide	Laboratory 74	NPL Assigned Value	Deviation /%	Zeta	Z Score
⁶⁰ Co (GL)	17.6 ± 0.7 (± 4 %)	17.68 ± 0.08 (± 0.50 %)	-0.7	-0.17	-0.12
¹³⁴ Cs (GL)	2.26 ± 0.09 (± 4 %)	2.190 ± 0.017 (± 0.8 %)	3.4	0.78	0.59
¹³⁷ Cs (GL)	4.22 ± 0.17 (± 4 %)	4.12 ± 0.04 (± 0.9 %)	2.3	0.54	0.40
⁴⁰ K (GL)	15.6 ± 1.3 (± 9 %)	16.4 ± 0.8 (± 5.0 %)	-5.1	-0.55	-0.88
²¹⁰ Pb (GL)	20.6 ± 1.1 (± 6 %)	19.46 ± 0.22 (± 1.1 %)	5.7	1.01	0.98
³ H (B2)	0.96 ± 0.03 (± 4 %)	1.076 ± 0.008 (± 0.7 %)	-10.8	-3.64	-1.85
⁹⁰ Sr (B2)	0.1370 ± 0.0050 (± 4 %)	0.1429 ± 0.0003 (± 0.20 %)	-4.1	-1.24	-0.70
³ H (S)	67 ± 6 (± 8 %)	77.1 ± 1.7 (± 2.2 %)	-13.5	-1.84	-2.32
¹⁴ C (S)	2.00 ± 0.10 (± 5.0 %)	1.91 ± 0.05 (± 2.5 %)	4.5	0.79	0.78

Deviation (%) of Laboratory 76



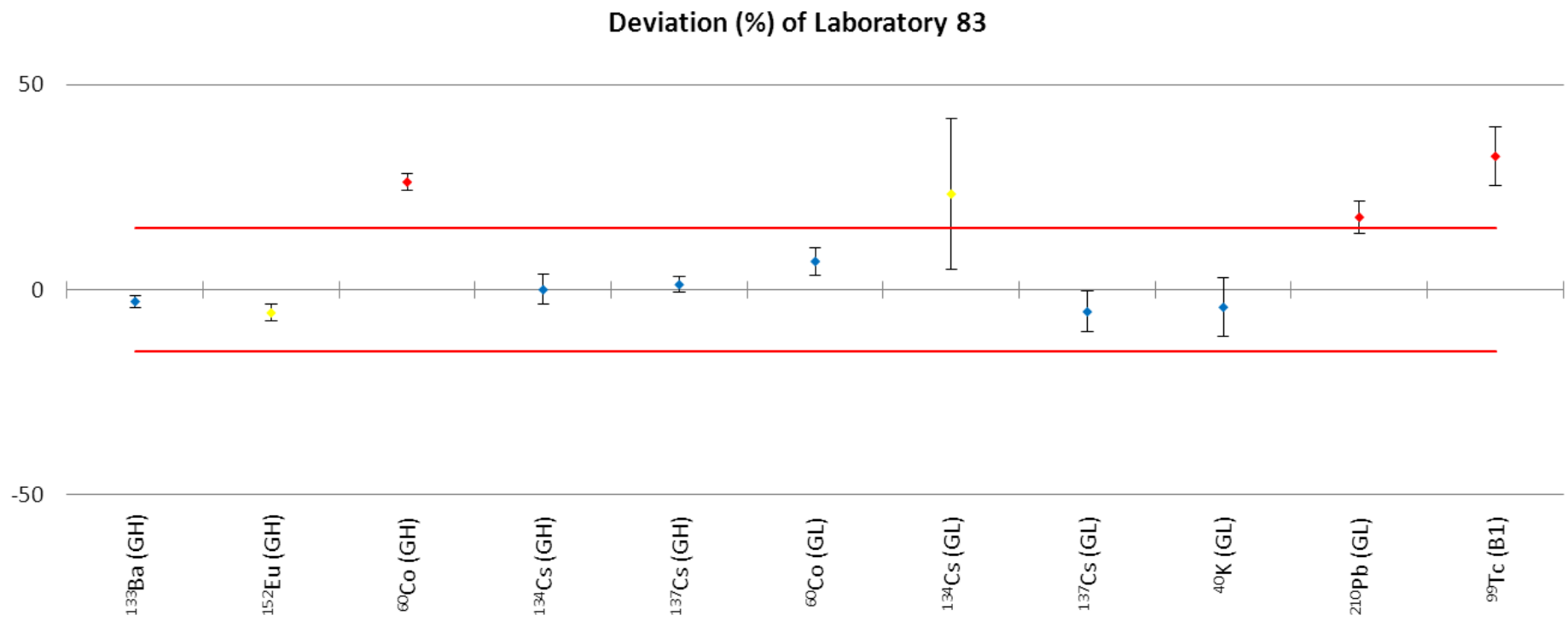
NPL Report IR 28

Radionuclide	Laboratory 76	NPL Assigned Value	Deviation /%	Zeta	Z Score
⁶⁰ Co (GL)	17.1 ± 0.4 (± 2.0 %)	17.68 ± 0.08 (± 0.50 %)	-3.3	-1.69	-0.57
¹³⁴ Cs (GL)	2.67 ± 0.15 (± 6 %)	2.190 ± 0.017 (± 0.8 %)	21.9	3.16	3.77
¹³⁷ Cs (GL)	4.00 ± 0.11 (± 3 %)	4.12 ± 0.04 (± 0.9 %)	-3.0	-1.04	-0.51
⁴⁰ K (GL)	14.4 ± 0.8 (± 6 %)	16.4 ± 0.8 (± 5.0 %)	-12.2	-1.77	-2.10
²¹⁰ Pb (GL)	19.8 ± 1.2 (± 6 %)	19.46 ± 0.22 (± 1.1 %)	1.7	0.29	0.30



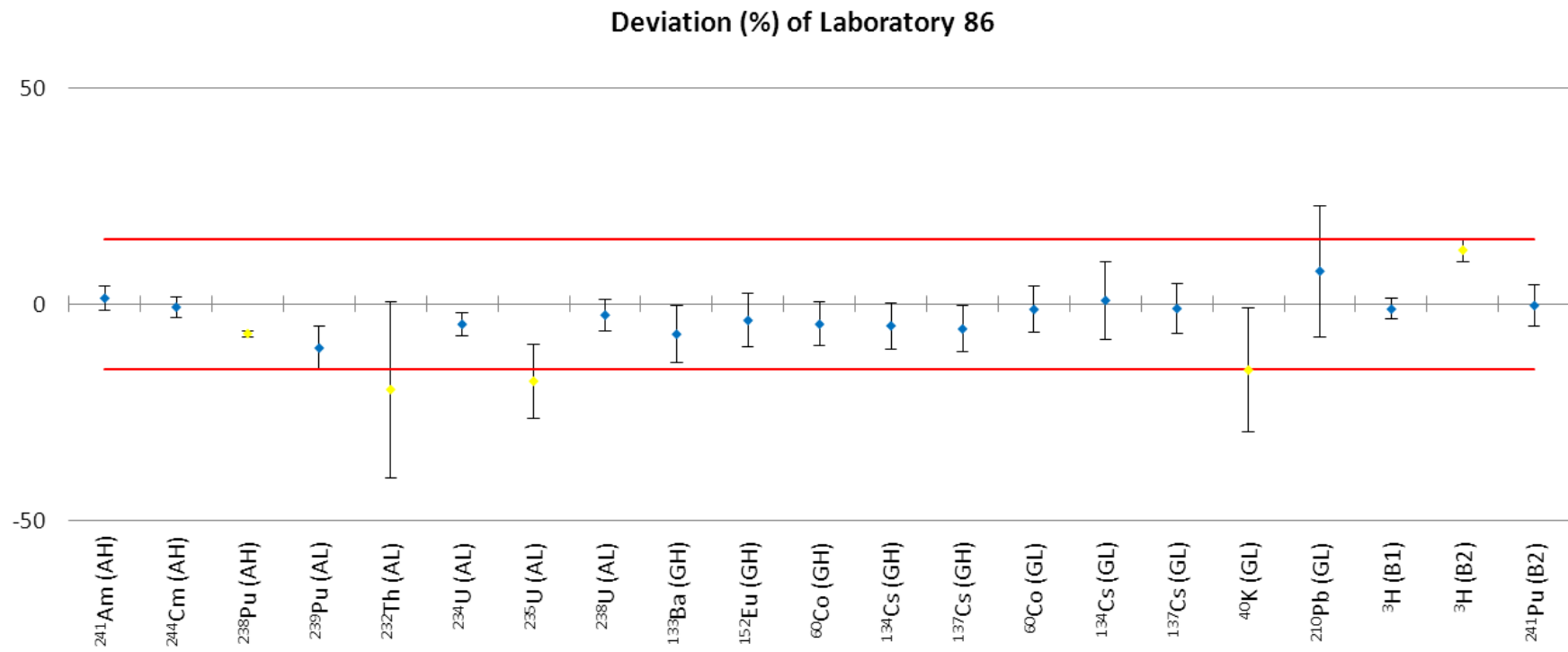
NPL Report IR 28

Radionuclide	Laboratory 82	NPL Assigned Value	Deviation /%	Zeta	Z Score
¹³³ Ba (GH)	7.8 ± 0.8 (± 10 %)	7.410 ± 0.050 (± 0.7 %)	4.8	0.46	0.82
¹⁵² Eu (GH)	16.0 ± 1.6 (± 10 %)	15.26 ± 0.10 (± 0.7 %)	4.8	0.46	0.83
⁶⁰ Co (GH)	5.4 ± 0.6 (± 10 %)	5.229 ± 0.011 (± 0.22 %)	3.3	0.32	0.56
¹³⁴ Cs (GH)	2.9 ± 0.3 (± 10 %)	2.800 ± 0.019 (± 0.7 %)	2.5	0.24	0.43
¹³⁷ Cs (GH)	15.4 ± 1.5 (± 10 %)	15.41 ± 0.06 (± 0.4 %)	-0.1	-0.01	-0.01
⁶⁰ Co (GL)	18.1 ± 1.8 (± 10 %)	17.68 ± 0.08 (± 0.50 %)	2.4	0.23	0.40
¹³⁴ Cs (GL)	2.3 ± 2.3 (± 100 %)	2.190 ± 0.017 (± 0.8 %)	4.1	0.04	0.71
¹³⁷ Cs (GL)	4.20 ± 0.50 (± 10 %)	4.12 ± 0.04 (± 0.9 %)	2.9	0.27	0.49
⁴⁰ K (GL)	20 ± 4 (± 17 %)	16.4 ± 0.8 (± 5.0 %)	21.9	1.03	3.77
²¹⁰ Pb (GL)	17 ± 4 (± 20 %)	19.46 ± 0.22 (± 1.1 %)	-14.2	-0.84	-2.44



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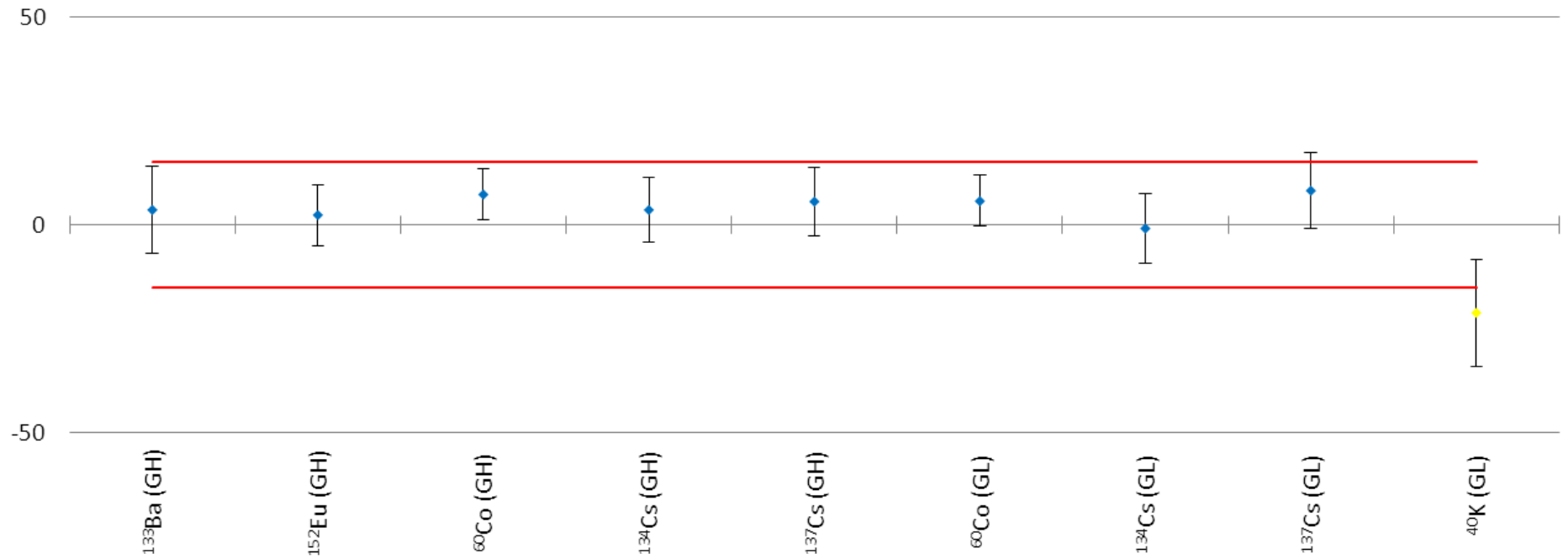
Radionuclide	Laboratory 83	NPL Assigned Value	Deviation /%	Zeta	Z Score
¹³³ Ba (GH)	7.20 ± 0.10 (± 1.4 %)	7.410 ± 0.050 (± 0.7 %)	-2.9	-1.90	-0.50
¹⁵² Eu (GH)	14.4 ± 0.3 (± 2.1 %)	15.26 ± 0.10 (± 0.7 %)	-5.6	-2.71	-0.97
⁶⁰ Co (GH)	6.60 ± 0.10 (± 1.5 %)	5.229 ± 0.011 (± 0.22 %)	26.2	13.62	4.50
¹³⁴ Cs (GH)	2.80 ± 0.10 (± 4 %)	2.800 ± 0.019 (± 0.7 %)	0.0	0.00	0.00
¹³⁷ Cs (GH)	15.6 ± 0.3 (± 1.9 %)	15.41 ± 0.06 (± 0.4 %)	1.2	0.63	0.21
⁶⁰ Co (GL)	18.9 ± 0.6 (± 4 %)	17.68 ± 0.08 (± 0.50 %)	6.9	2.01	1.18
¹³⁴ Cs (GL)	2.7 ± 0.4 (± 15 %)	2.190 ± 0.017 (± 0.8 %)	23.3	1.27	4.00
¹³⁷ Cs (GL)	3.90 ± 0.20 (± 5.0 %)	4.12 ± 0.04 (± 0.9 %)	-5.4	-1.09	-0.92
⁴⁰ K (GL)	15.7 ± 0.9 (± 6 %)	16.4 ± 0.8 (± 5.0 %)	-4.3	-0.59	-0.73
²¹⁰ Pb (GL)	22.9 ± 0.7 (± 3 %)	19.46 ± 0.22 (± 1.1 %)	17.6	4.68	3.03
⁹⁹ Tc (B1)	0.190 ± 0.010 (± 5.0 %)	0.1434 ± 0.0013 (± 0.9 %)	32.5	4.62	5.58



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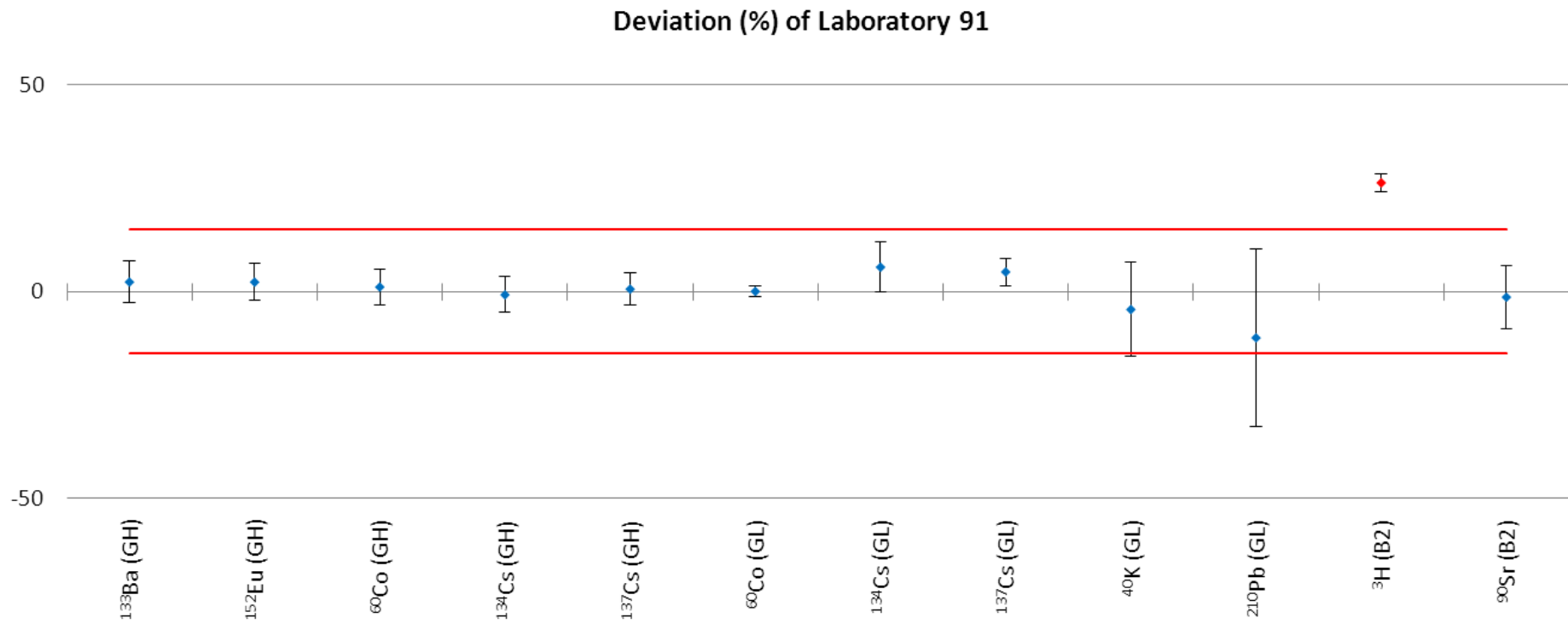
Radionuclide	Laboratory 86	NPL Assigned Value	Deviation /%	Zeta	Z Score
²⁴¹ Am (AH)	4.51 ± 0.12 (± 3 %)	4.449 ± 0.010 (± 0.24 %)	1.4	0.51	0.24
²⁴⁴ Cm (AH)	19.4 ± 0.5 (± 2.3 %)	19.51 ± 0.07 (± 0.4 %)	-0.7	-0.30	-0.12
²³⁸ Pu (AH)	13.93 ± 0.10 (± 0.7 %)	14.95 ± 0.05 (± 0.3 %)	-6.8	-9.41	-1.17
²³⁹ Pu (AL)	10.9 ± 0.6 (± 5.0 %)	12.1 ± 0.3 (± 2.2 %)	-10.2	-1.95	-1.74
²³² Th (AL)	2.0 ± 0.5 (± 25 %)	2.52 ± 0.06 (± 2.4 %)	-19.8	-0.97	-3.39
²³⁴ U (AL)	14.33 ± 0.16 (± 1.1 %)	15.0 ± 0.4 (± 3 %)	-4.7	-1.67	-0.80
²³⁵ U (AL)	0.59 ± 0.06 (± 10 %)	0.718 ± 0.019 (± 3 %)	-17.8	-2.04	-3.06
²³⁸ U (AL)	14.6 ± 0.4 (± 3 %)	15.0 ± 0.4 (± 3 %)	-2.5	-0.67	-0.43
¹³³ Ba (GH)	6.9 ± 0.5 (± 7 %)	7.41 ± 0.05 (± 0.7 %)	-7.0	-1.06	-1.19
¹⁵² Eu (GH)	14.7 ± 1.0 (± 7 %)	15.26 ± 0.10 (± 0.7 %)	-3.8	-0.60	-0.65
⁶⁰ Co (GH)	5.0 ± 0.3 (± 6 %)	5.229 ± 0.011 (± 0.22 %)	-4.6	-0.92	-0.80
¹³⁴ Cs (GH)	2.66 ± 0.15 (± 6 %)	2.800 ± 0.019 (± 0.7 %)	-5.0	-0.94	-0.86
¹³⁷ Cs (GH)	14.5 ± 0.8 (± 6 %)	15.41 ± 0.06 (± 0.4 %)	-5.7	-1.08	-0.99
⁶⁰ Co (GL)	17.5 ± 1.0 (± 6 %)	17.68 ± 0.08 (± 0.50 %)	-1.2	-0.23	-0.21
¹³⁴ Cs (GL)	2.21 ± 0.20 (± 9 %)	2.190 ± 0.017 (± 0.8 %)	0.9	0.10	0.15
¹³⁷ Cs (GL)	4.08 ± 0.23 (± 6 %)	4.12 ± 0.04 (± 0.9 %)	-1.0	-0.18	-0.17
⁴⁰ K (GL)	13.9 ± 2.3 (± 16 %)	16.4 ± 0.8 (± 5.0 %)	-15.3	-1.04	-2.62
²¹⁰ Pb (GL)	21 ± 3 (± 14 %)	19.46 ± 0.22 (± 1.1 %)	7.6	0.50	1.31
³ H (B1)	1.034 ± 0.024 (± 2.3 %)	1.046 ± 0.008 (± 0.7 %)	-1.2	-0.48	-0.20
³ H (B2)	1.21 ± 0.03 (± 2.3 %)	1.076 ± 0.008 (± 0.7 %)	12.5	4.64	2.15
²⁴¹ Pu (B2)	0.94 ± 0.05 (± 5.0 %)	0.942 ± 0.010 (± 1.1 %)	-0.3	-0.07	-0.06

Deviation (%) of Laboratory 89



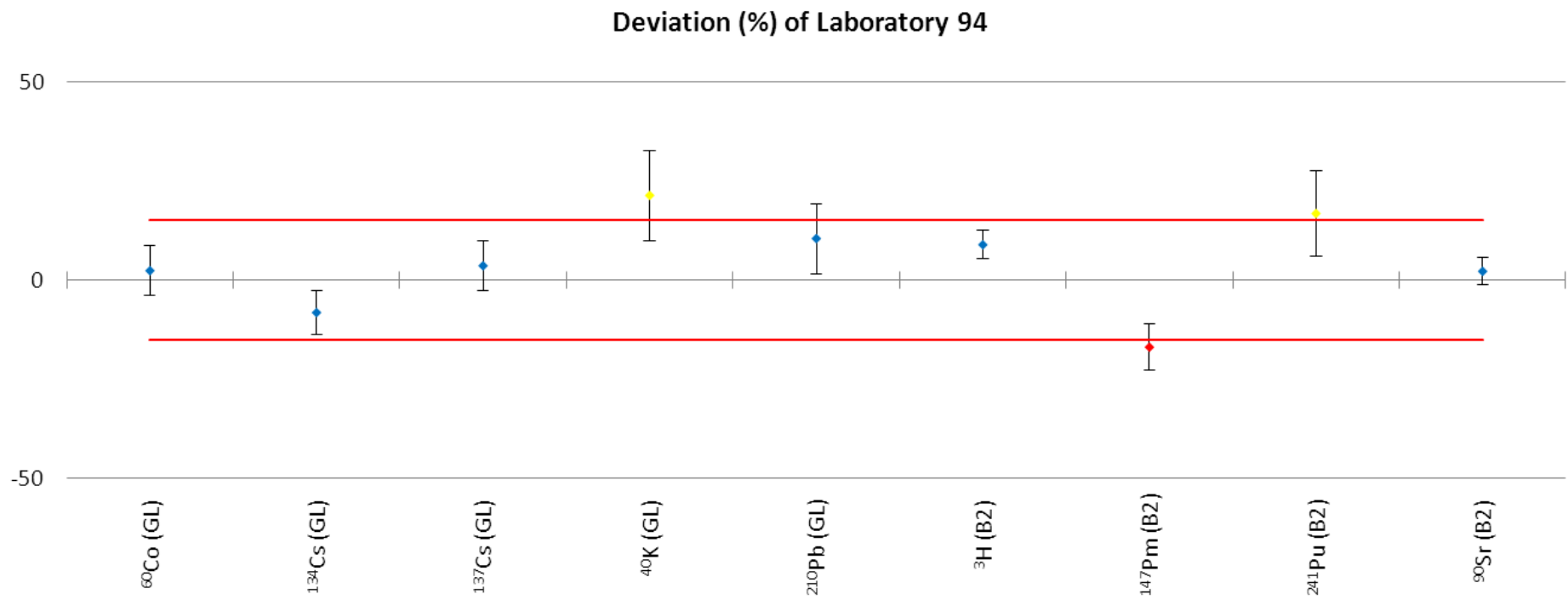
NPL Report IR 28

Radionuclide	Laboratory 89	NPL Assigned Value	Deviation /%	Zeta	Z Score
¹³³ Ba (GH)	7.7 ± 0.8 (± 10 %)	7.410 ± 0.050 (± 0.7 %)	3.6	0.34	0.62
¹⁵² Eu (GH)	15.6 ± 1.1 (± 7 %)	15.26 ± 0.10 (± 0.7 %)	2.3	0.32	0.40
⁶⁰ Co (GH)	5.6 ± 0.4 (± 6 %)	5.229 ± 0.011 (± 0.22 %)	7.3	1.19	1.25
¹³⁴ Cs (GH)	2.90 ± 0.22 (± 8 %)	2.800 ± 0.019 (± 0.7 %)	3.6	0.45	0.61
¹³⁷ Cs (GH)	16.3 ± 1.3 (± 8 %)	15.41 ± 0.06 (± 0.4 %)	5.6	0.68	0.96
⁶⁰ Co (GL)	18.7 ± 1.1 (± 6 %)	17.68 ± 0.08 (± 0.50 %)	5.7	0.93	0.98
¹³⁴ Cs (GL)	2.17 ± 0.18 (± 8 %)	2.190 ± 0.017 (± 0.8 %)	-0.9	-0.11	-0.15
¹³⁷ Cs (GL)	4.5 ± 0.4 (± 8 %)	4.12 ± 0.04 (± 0.9 %)	8.2	0.91	1.41
⁴⁰ K (GL)	12.9 ± 2.0 (± 16 %)	16.4 ± 0.8 (± 5.0 %)	-21.2	-1.60	-3.64



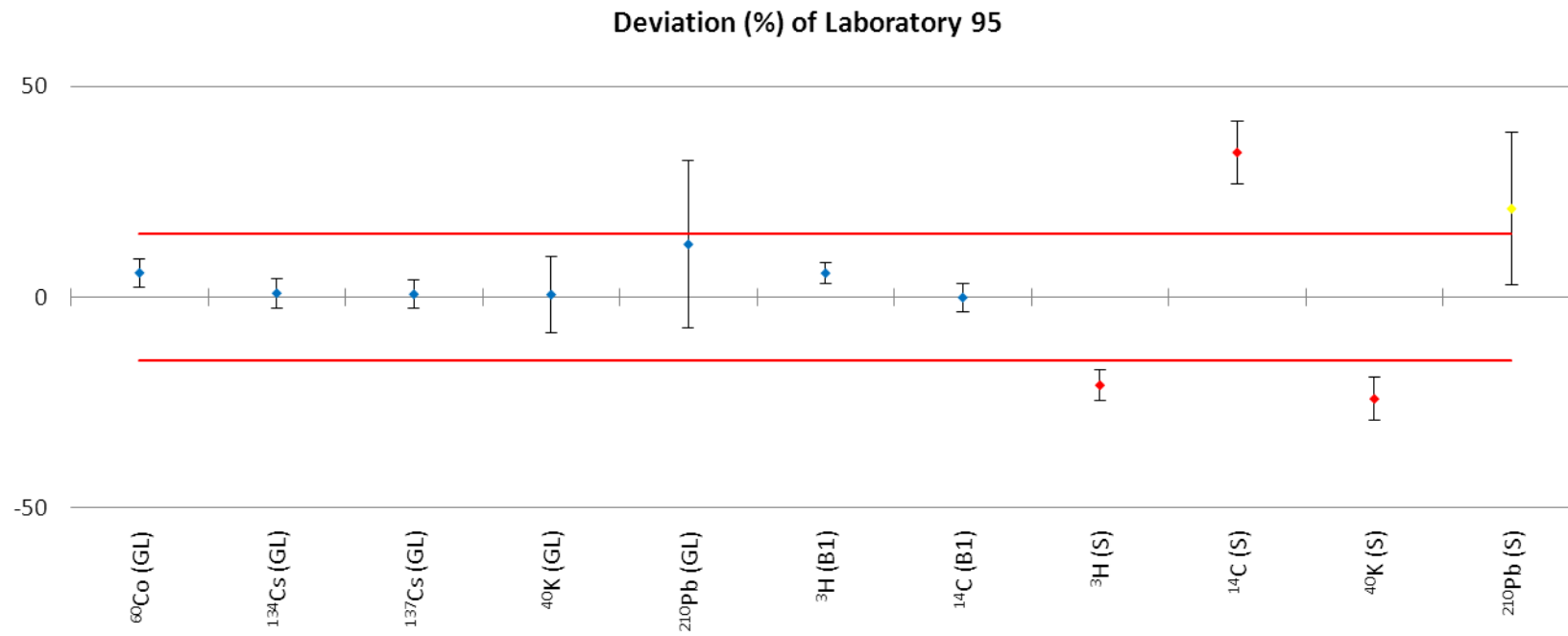
NPL Report IR 28

Radionuclide	Laboratory 91	NPL Assigned Value	Deviation /%	Zeta	Z Score
¹³³ Ba (GH)	7.6 ± 0.4 (± 5.0 %)	7.410 ± 0.050 (± 0.7 %)	2.4	0.47	0.41
¹⁵² Eu (GH)	15.6 ± 0.7 (± 5.0 %)	15.26 ± 0.10 (± 0.7 %)	2.3	0.52	0.40
⁶⁰ Co (GH)	5.29 ± 0.23 (± 5.0 %)	5.229 ± 0.011 (± 0.22 %)	1.2	0.26	0.20
¹³⁴ Cs (GH)	2.78 ± 0.12 (± 5.0 %)	2.800 ± 0.019 (± 0.7 %)	-0.7	-0.17	-0.12
¹³⁷ Cs (GH)	15.5 ± 0.6 (± 4 %)	15.41 ± 0.06 (± 0.4 %)	0.7	0.16	0.11
⁶⁰ Co (GL)	17.70 ± 0.20 (± 1.1 %)	17.68 ± 0.08 (± 0.50 %)	0.1	0.08	0.02
¹³⁴ Cs (GL)	2.32 ± 0.13 (± 6 %)	2.190 ± 0.017 (± 0.8 %)	6.0	0.99	1.02
¹³⁷ Cs (GL)	4.32 ± 0.13 (± 3 %)	4.12 ± 0.04 (± 0.9 %)	4.8	1.47	0.83
⁴⁰ K (GL)	15.7 ± 1.7 (± 11 %)	16.4 ± 0.8 (± 5.0 %)	-4.3	-0.38	-0.73
²¹⁰ Pb (GL)	17 ± 4 (± 24 %)	19.46 ± 0.22 (± 1.1 %)	-11.1	-0.51	-1.91
³ H (B2)	1.360 ± 0.020 (± 1.5 %)	1.076 ± 0.008 (± 0.7 %)	26.4	13.26	4.53
⁹⁰ Sr (B2)	0.141 ± 0.011 (± 8 %)	0.1429 ± 0.0003 (± 0.20 %)	-1.3	-0.17	-0.22



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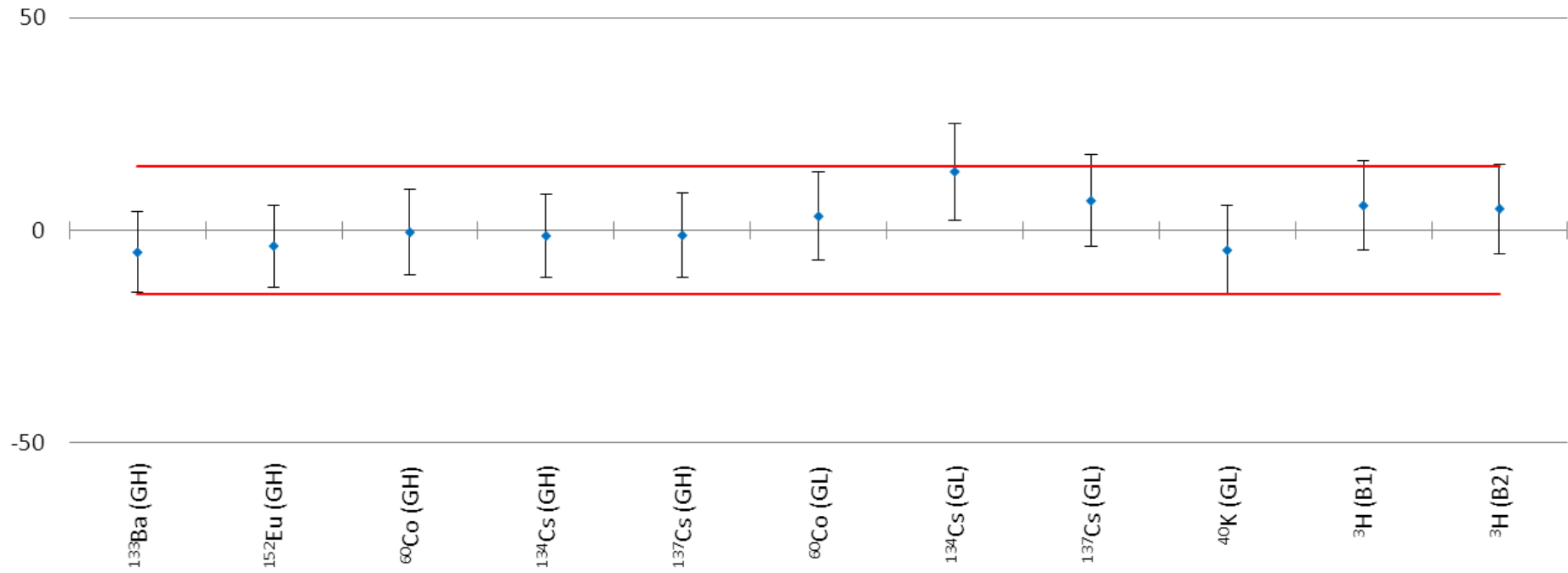
Radionuclide	Laboratory 94	NPL Assigned Value	Deviation /%	Zeta	Z Score
⁶⁰ Co (GL)	18.1 ± 1.1 (± 6 %)	17.68 ± 0.08 (± 0.50 %)	2.4	0.38	0.40
¹³⁴ Cs (GL)	2.01 ± 0.12 (± 6 %)	2.190 ± 0.017 (± 0.8 %)	-8.2	-1.48	-1.41
¹³⁷ Cs (GL)	4.3 ± 0.3 (± 6 %)	4.12 ± 0.04 (± 0.9 %)	3.6	0.56	0.62
⁴⁰ K (GL)	19.9 ± 1.6 (± 8 %)	16.4 ± 0.8 (± 5.0 %)	21.3	1.96	3.66
²¹⁰ Pb (GL)	21.5 ± 1.7 (± 8 %)	19.46 ± 0.22 (± 1.1 %)	10.5	1.19	1.80
³ H (B2)	1.17 ± 0.04 (± 3 %)	1.076 ± 0.008 (± 0.7 %)	8.9	2.53	1.53
¹⁴⁷ Pm (B2)	0.361 ± 0.025 (± 7 %)	0.435 ± 0.004 (± 0.9 %)	-16.9	-2.91	-2.91
²⁴¹ Pu (B2)	1.10 ± 0.10 (± 9 %)	0.942 ± 0.010 (± 1.1 %)	16.8	1.57	2.88
⁹⁰ Sr (B2)	0.1460 ± 0.0050 (± 4 %)	0.1429 ± 0.0003 (± 0.20 %)	2.2	0.63	0.38



NPL Report IR 28

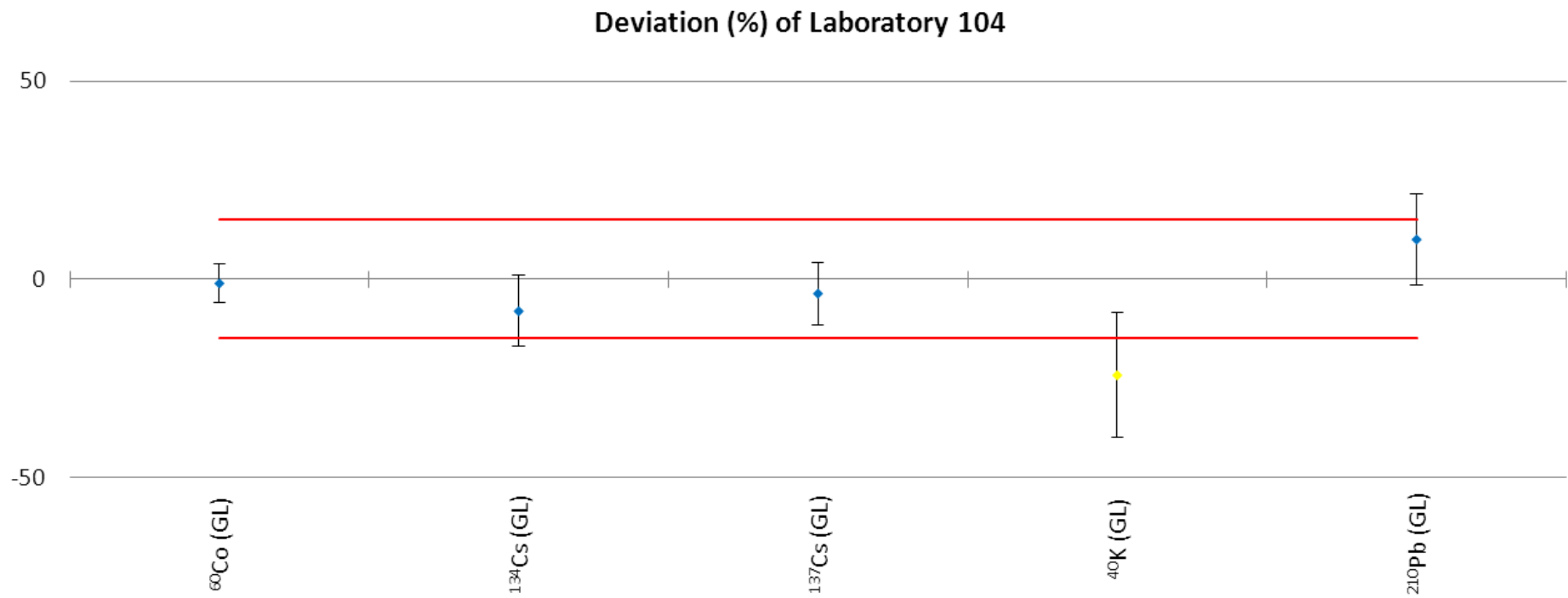
Radionuclide	Laboratory 95	NPL Assigned Value	Deviation /%	Zeta	Z Score
⁶⁰ Co (GL)	18.7 ± 0.6 (± 3 %)	17.68 ± 0.08 (± 0.50 %)	5.7	1.74	0.99
¹³⁴ Cs (GL)	2.21 ± 0.08 (± 4 %)	2.190 ± 0.017 (± 0.8 %)	0.9	0.26	0.16
¹³⁷ Cs (GL)	4.15 ± 0.13 (± 4 %)	4.12 ± 0.04 (± 0.9 %)	0.7	0.20	0.12
⁴⁰ K (GL)	16.5 ± 1.3 (± 8 %)	16.4 ± 0.8 (± 5.0 %)	0.6	0.07	0.10
²¹⁰ Pb (GL)	22 ± 4 (± 18 %)	19.46 ± 0.22 (± 1.1 %)	12.5	0.63	2.15
³ H (B1)	1.105 ± 0.025 (± 2.2 %)	1.046 ± 0.008 (± 0.7 %)	5.7	2.30	0.97
¹⁴ C (B1)	0.97 ± 0.04 (± 4 %)	0.968 ± 0.008 (± 0.8 %)	-0.1	-0.03	-0.02
³ H (S)	61 ± 3 (± 5.0 %)	77.1 ± 1.7 (± 2.2 %)	-20.9	-5.20	-3.59
¹⁴ C (S)	2.57 ± 0.13 (± 5.0 %)	1.91 ± 0.05 (± 2.5 %)	34.3	4.80	5.89
⁴⁰ K (S)	137 ± 8 (± 6 %)	181 ± 6 (± 3 %)	-24.1	-4.46	-4.14
²¹⁰ Pb (S)	56 ± 8 (± 15 %)	46.5 ± 1.4 (± 3 %)	21.0	1.17	3.60

Deviation (%) of Laboratory 99



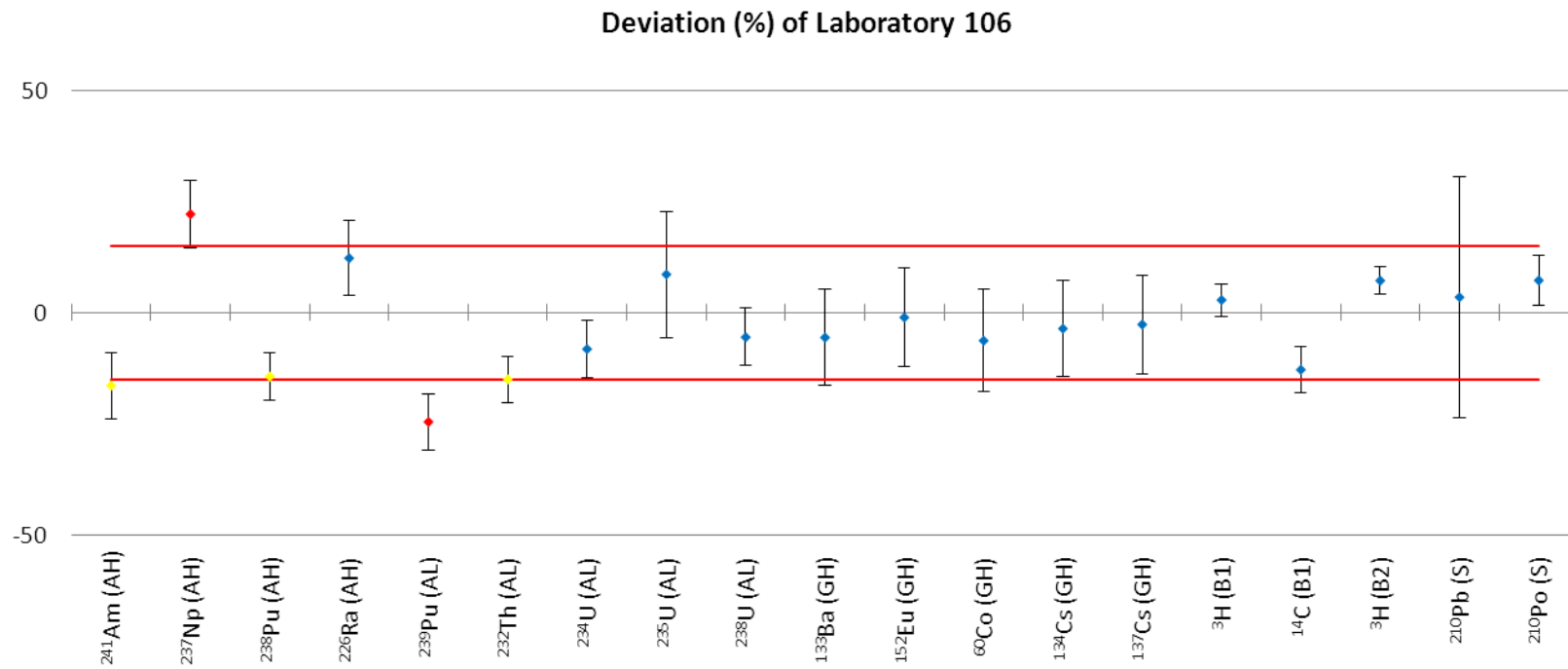
NPL Report IR 28

Radionuclide	Laboratory 99	NPL Assigned Value	Deviation /%	Zeta	Z Score
¹³³ Ba (GH)	7.0 ± 0.7 (± 10 %)	7.410 ± 0.050 (± 0.7 %)	-5.2	-0.55	-0.89
¹⁵² Eu (GH)	14.7 ± 1.5 (± 10 %)	15.26 ± 0.10 (± 0.7 %)	-3.7	-0.39	-0.64
⁶⁰ Co (GH)	5.20 ± 0.50 (± 10 %)	5.229 ± 0.011 (± 0.22 %)	-0.5	-0.05	-0.08
¹³⁴ Cs (GH)	2.8 ± 0.3 (± 10 %)	2.800 ± 0.019 (± 0.7 %)	-1.3	-0.13	-0.23
¹³⁷ Cs (GH)	15.2 ± 1.5 (± 10 %)	15.41 ± 0.06 (± 0.4 %)	-1.2	-0.12	-0.21
⁶⁰ Co (GL)	18.3 ± 1.8 (± 10 %)	17.68 ± 0.08 (± 0.50 %)	3.3	0.32	0.56
¹³⁴ Cs (GL)	2.49 ± 0.25 (± 10 %)	2.190 ± 0.017 (± 0.8 %)	13.8	1.21	2.36
¹³⁷ Cs (GL)	4.40 ± 0.50 (± 10 %)	4.12 ± 0.04 (± 0.9 %)	6.9	0.64	1.19
⁴⁰ K (GL)	15.6 ± 1.6 (± 10 %)	16.4 ± 0.8 (± 5.0 %)	-4.7	-0.44	-0.81
³ H (B1)	1.11 ± 0.11 (± 10 %)	1.046 ± 0.008 (± 0.7 %)	5.8	0.55	1.00
³ H (B2)	1.13 ± 0.11 (± 10 %)	1.076 ± 0.008 (± 0.7 %)	5.0	0.48	0.87



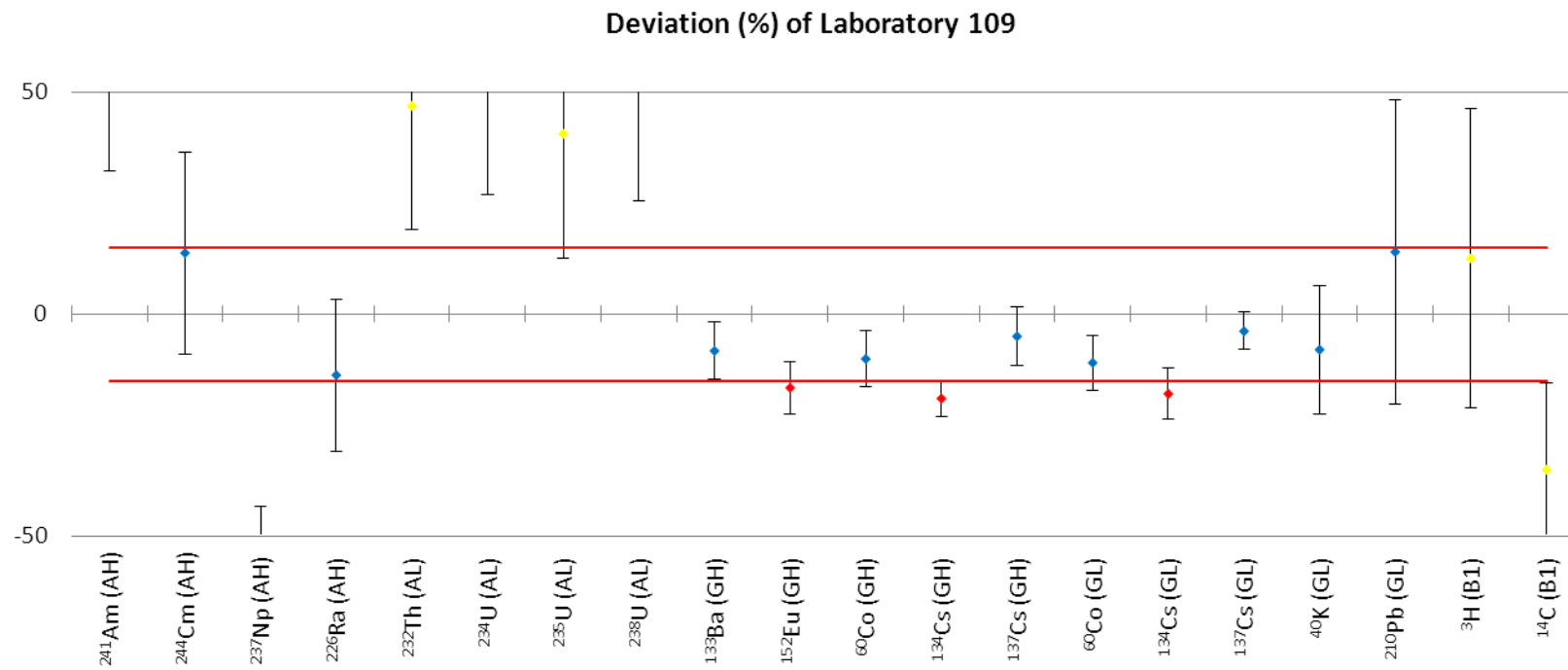
NPL Report IR 28

Radionuclide	Laboratory 104	NPL Assigned Value	Deviation /%	Zeta	Z Score
⁶⁰ Co (GL)	17.5 ± 0.9 (± 5.0 %)	17.68 ± 0.08 (± 0.50 %)	-1.1	-0.23	-0.19
¹³⁴ Cs (GL)	2.01 ± 0.20 (± 10 %)	2.190 ± 0.017 (± 0.8 %)	-8.1	-0.91	-1.40
¹³⁷ Cs (GL)	4.0 ± 0.4 (± 8 %)	4.12 ± 0.04 (± 0.9 %)	-3.7	-0.47	-0.63
⁴⁰ K (GL)	12.4 ± 2.5 (± 20 %)	16.4 ± 0.8 (± 5.0 %)	-24.3	-1.52	-4.18
²¹⁰ Pb (GL)	21.4 ± 2.2 (± 10 %)	19.46 ± 0.22 (± 1.1 %)	10.0	0.87	1.71



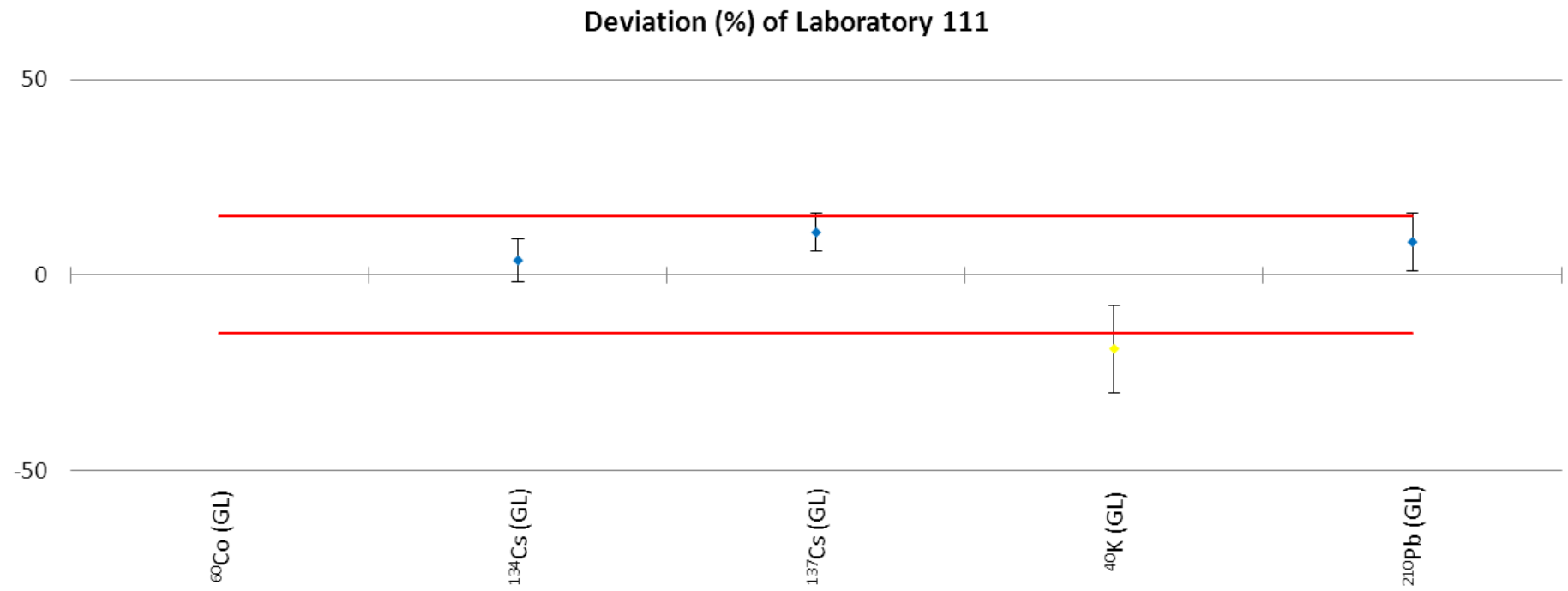
NPL Report IR 28

Radionuclide	Laboratory 106	NPL Assigned Value	Deviation /%	Zeta	Z Score
²⁴¹ Am (AH)	3.7 ± 0.4 (± 9 %)	4.449 ± 0.010 (± 0.24 %)	-16.4	-2.21	-2.81
²³⁷ Np (AH)	17.9 ± 1.1 (± 6 %)	14.65 ± 0.15 (± 1.0 %)	22.2	2.93	3.81
²³⁸ Pu (AH)	12.8 ± 0.8 (± 6 %)	14.950 ± 0.050 (± 0.3 %)	-14.4	-2.68	-2.47
²²⁶ Ra (AH)	1.64 ± 0.12 (± 7 %)	1.461 ± 0.019 (± 1.3 %)	12.3	1.48	2.11
²³⁹ Pu (AL)	9.2 ± 0.7 (± 8 %)	12.1 ± 0.3 (± 2.2 %)	-24.6	-3.83	-4.22
²³² Th (AL)	2.14 ± 0.12 (± 6 %)	2.52 ± 0.06 (± 2.4 %)	-15.0	-2.80	-2.57
²³⁴ U (AL)	13.8 ± 0.9 (± 7 %)	15.0 ± 0.4 (± 3 %)	-8.2	-1.25	-1.40
²³⁵ U (AL)	0.78 ± 0.10 (± 13 %)	0.718 ± 0.019 (± 3 %)	8.6	0.61	1.48
²³⁸ U (AL)	14.2 ± 0.9 (± 7 %)	15.0 ± 0.4 (± 3 %)	-5.5	-0.85	-0.95
¹³³ Ba (GH)	7.0 ± 0.8 (± 11 %)	7.410 ± 0.050 (± 0.7 %)	-5.6	-0.52	-0.96
¹⁵² Eu (GH)	15.1 ± 1.7 (± 11 %)	15.26 ± 0.10 (± 0.7 %)	-1.1	-0.09	-0.18
⁶⁰ Co (GH)	4.9 ± 0.6 (± 12 %)	5.229 ± 0.011 (± 0.22 %)	-6.3	-0.55	-1.08
¹³⁴ Cs (GH)	2.7 ± 0.3 (± 11 %)	2.800 ± 0.019 (± 0.7 %)	-3.6	-0.33	-0.61
¹³⁷ Cs (GH)	15.0 ± 1.7 (± 11 %)	15.41 ± 0.06 (± 0.4 %)	-2.7	-0.24	-0.46
³ H (B1)	1.08 ± 0.04 (± 4 %)	1.046 ± 0.008 (± 0.7 %)	2.9	0.79	0.49
¹⁴ C (B1)	0.840 ± 0.050 (± 6 %)	0.968 ± 0.008 (± 0.8 %)	-12.8	-2.46	-2.20
³ H (B2)	1.15 ± 0.04 (± 3 %)	1.076 ± 0.008 (± 0.7 %)	7.2	2.30	1.24
²¹⁰ Pb (S)	48 ± 13 (± 30 %)	46.5 ± 1.4 (± 3 %)	3.5	0.13	0.60
²¹⁰ Po (S)	51.3 ± 2.5 (± 5.0 %)	47.9 ± 0.7 (± 1.5 %)	7.3	1.33	1.25



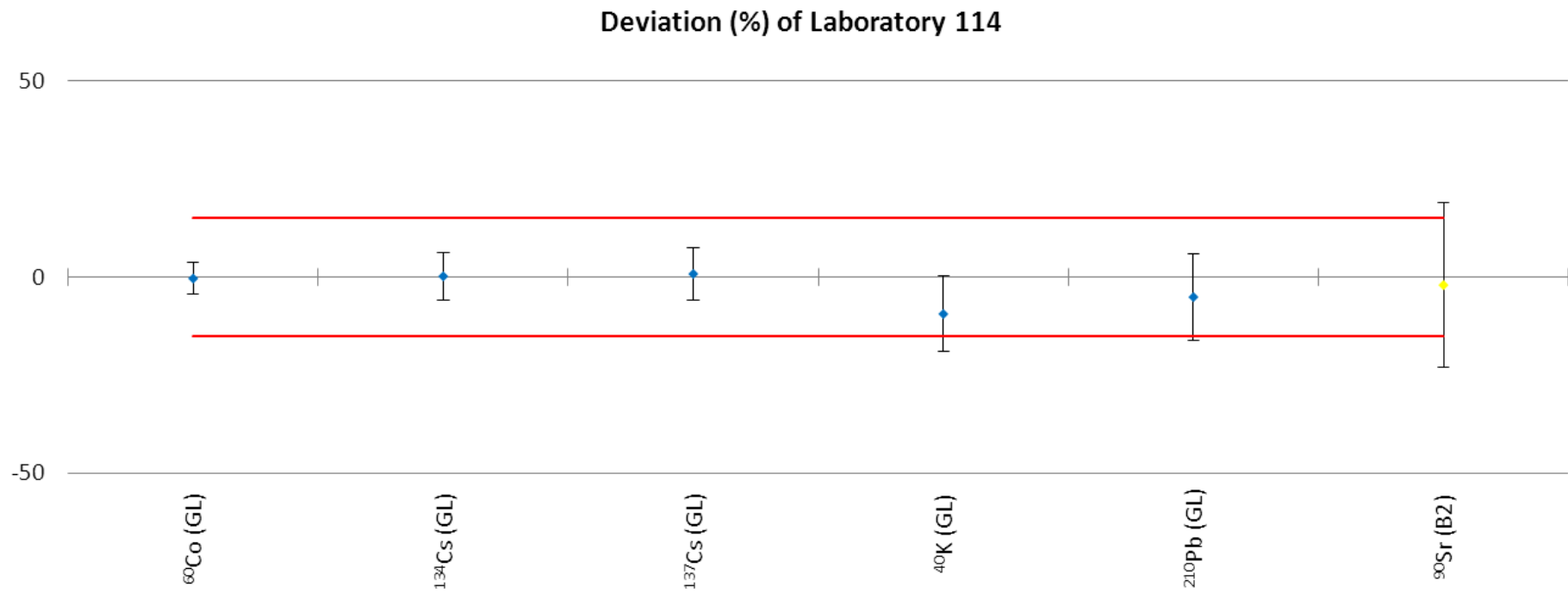
NPL Report IR 28

Radionuclide	Laboratory 109	NPL Assigned Value	Deviation /%	Zeta	Z Score
²⁴¹ Am (AH)	7.4 ± 1.5 (± 20 %)	4.449 ± 0.010 (± 0.24 %)	65.4	1.98	11.24
²⁴⁴ Cm (AH)	22.0 ± 5.0 (± 20 %)	19.51 ± 0.07 (± 0.4 %)	13.8	0.61	2.37
²³⁷ Np (AH)	6.9 ± 1.4 (± 20 %)	14.65 ± 0.15 (± 1.0 %)	-52.8	-5.58	-9.07
²²⁶ Ra (AH)	1.26 ± 0.25 (± 20 %)	1.461 ± 0.019 (± 1.3 %)	-13.7	-0.80	-2.36
²³² Th (AL)	3.7 ± 0.7 (± 19 %)	2.52 ± 0.06 (± 2.4 %)	47.0	1.68	8.07
²³⁴ U (AL)	24.0 ± 5.0 (± 20 %)	15.0 ± 0.4 (± 3 %)	59.0	1.84	10.14
²³⁵ U (AL)	1.01 ± 0.20 (± 20 %)	0.718 ± 0.019 (± 3 %)	40.7	1.45	6.98
²³⁸ U (AL)	24.0 ± 5.0 (± 20 %)	15.0 ± 0.4 (± 3 %)	57.0	1.82	9.79
¹³³ Ba (GH)	6.80 ± 0.50 (± 7 %)	7.410 ± 0.050 (± 0.7 %)	-8.3	-1.28	-1.42
¹⁵² Eu (GH)	12.7 ± 0.9 (± 7 %)	15.26 ± 0.10 (± 0.7 %)	-16.6	-2.82	-2.85
⁶⁰ Co (GH)	4.7 ± 0.4 (± 7 %)	5.229 ± 0.011 (± 0.22 %)	-10.1	-1.60	-1.73
¹³⁴ Cs (GH)	2.27 ± 0.11 (± 5.0 %)	2.800 ± 0.019 (± 0.7 %)	-19.0	-4.64	-3.26
¹³⁷ Cs (GH)	14.6 ± 1.0 (± 7 %)	15.41 ± 0.06 (± 0.4 %)	-5.0	-0.75	-0.86
⁶⁰ Co (GL)	15.7 ± 1.1 (± 7 %)	17.68 ± 0.08 (± 0.50 %)	-10.9	-1.75	-1.88
¹³⁴ Cs (GL)	1.80 ± 0.13 (± 7 %)	2.190 ± 0.017 (± 0.8 %)	-17.9	-3.09	-3.08
¹³⁷ Cs (GL)	3.96 ± 0.17 (± 5.0 %)	4.12 ± 0.04 (± 0.9 %)	-3.8	-0.91	-0.66
⁴⁰ K (GL)	15.1 ± 2.3 (± 15 %)	16.4 ± 0.8 (± 5.0 %)	-8.0	-0.55	-1.37
²¹⁰ Pb (GL)	22 ± 7 (± 30 %)	19.46 ± 0.22 (± 1.1 %)	14.1	0.41	2.41
³ H (B1)	1.2 ± 0.4 (± 30 %)	1.046 ± 0.008 (± 0.7 %)	12.6	0.37	2.17
¹⁴ C (B1)	0.63 ± 0.19 (± 30 %)	0.968 ± 0.008 (± 0.8 %)	-35.0	-1.80	-6.02



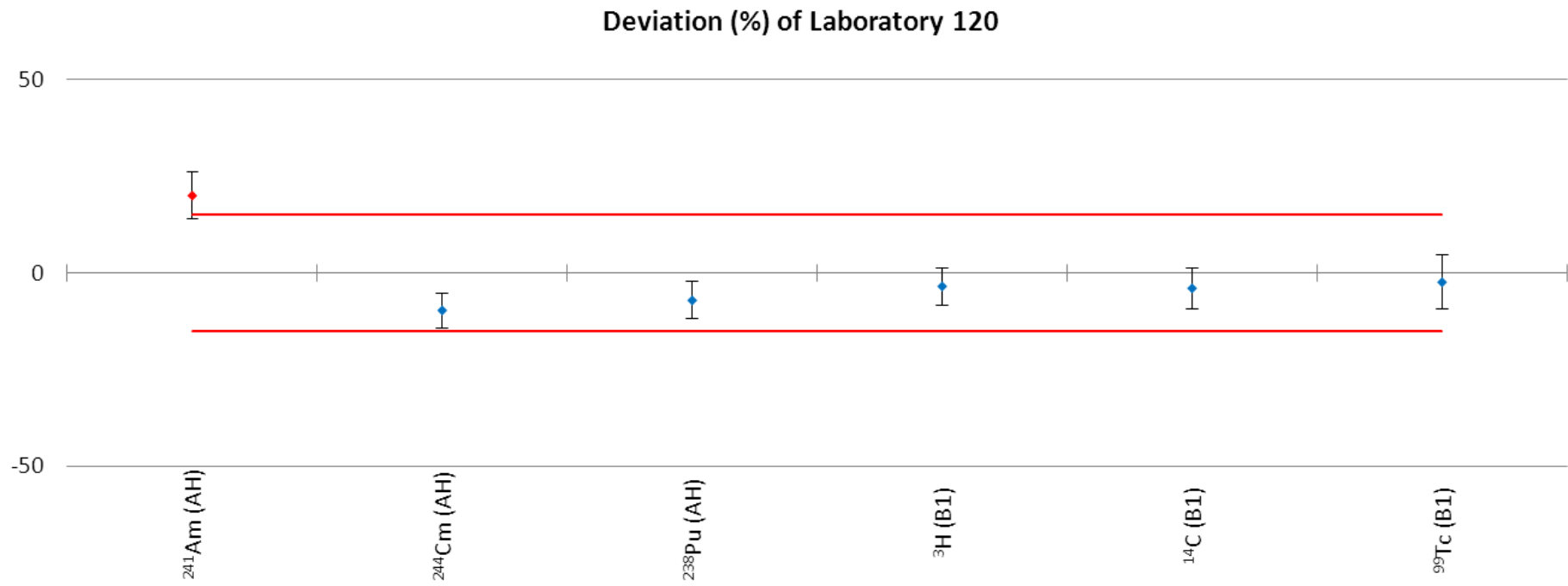
NPL Report IR 28

Radionuclide	Laboratory 111	NPL Assigned Value	Deviation /%	Zeta	Z Score
⁶⁰ Co (GL)	1.780 ± 0.050 (± 3 %)	17.68 ± 0.08 (± 0.50 %)	-89.9	-173.80	-15.44
¹³⁴ Cs (GL)	2.27 ± 0.12 (± 6 %)	2.190 ± 0.017 (± 0.8 %)	3.7	0.66	0.63
¹³⁷ Cs (GL)	4.57 ± 0.20 (± 5.0 %)	4.12 ± 0.04 (± 0.9 %)	10.9	2.20	1.87
⁴⁰ K (GL)	13.3 ± 1.7 (± 13 %)	16.4 ± 0.8 (± 5.0 %)	-18.9	-1.64	-3.25
²¹⁰ Pb (GL)	21.1 ± 1.4 (± 7 %)	19.46 ± 0.22 (± 1.1 %)	8.4	1.13	1.44



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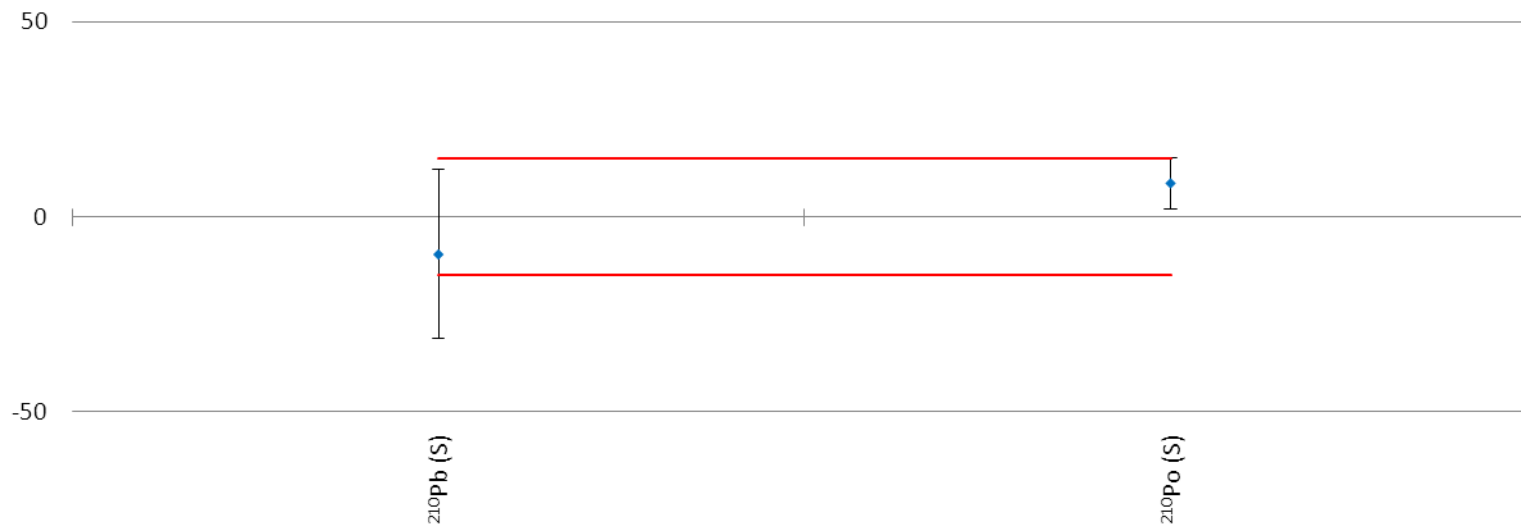
Radionuclide	Laboratory 114	NPL Assigned Value	Deviation /%	Zeta	Z Score
⁶⁰ Co (GL)	17.6 ± 0.7 (± 4 %)	17.68 ± 0.08 (± 0.50 %)	-0.3	-0.08	-0.06
¹³⁴ Cs (GL)	2.19 ± 0.13 (± 6 %)	2.190 ± 0.017 (± 0.8 %)	0.2	0.04	0.04
¹³⁷ Cs (GL)	4.2 ± 0.3 (± 7 %)	4.12 ± 0.04 (± 0.9 %)	0.8	0.13	0.15
⁴⁰ K (GL)	14.9 ± 1.4 (± 10 %)	16.4 ± 0.8 (± 5.0 %)	-9.4	-0.95	-1.61
²¹⁰ Pb (GL)	18.5 ± 2.1 (± 12 %)	19.46 ± 0.22 (± 1.1 %)	-5.1	-0.46	-0.87
⁹⁰ Sr (B2)	0.14 ± 0.03 (± 21 %)	0.1429 ± 0.0003 (± 0.20 %)	-2.0	-0.10	-0.34



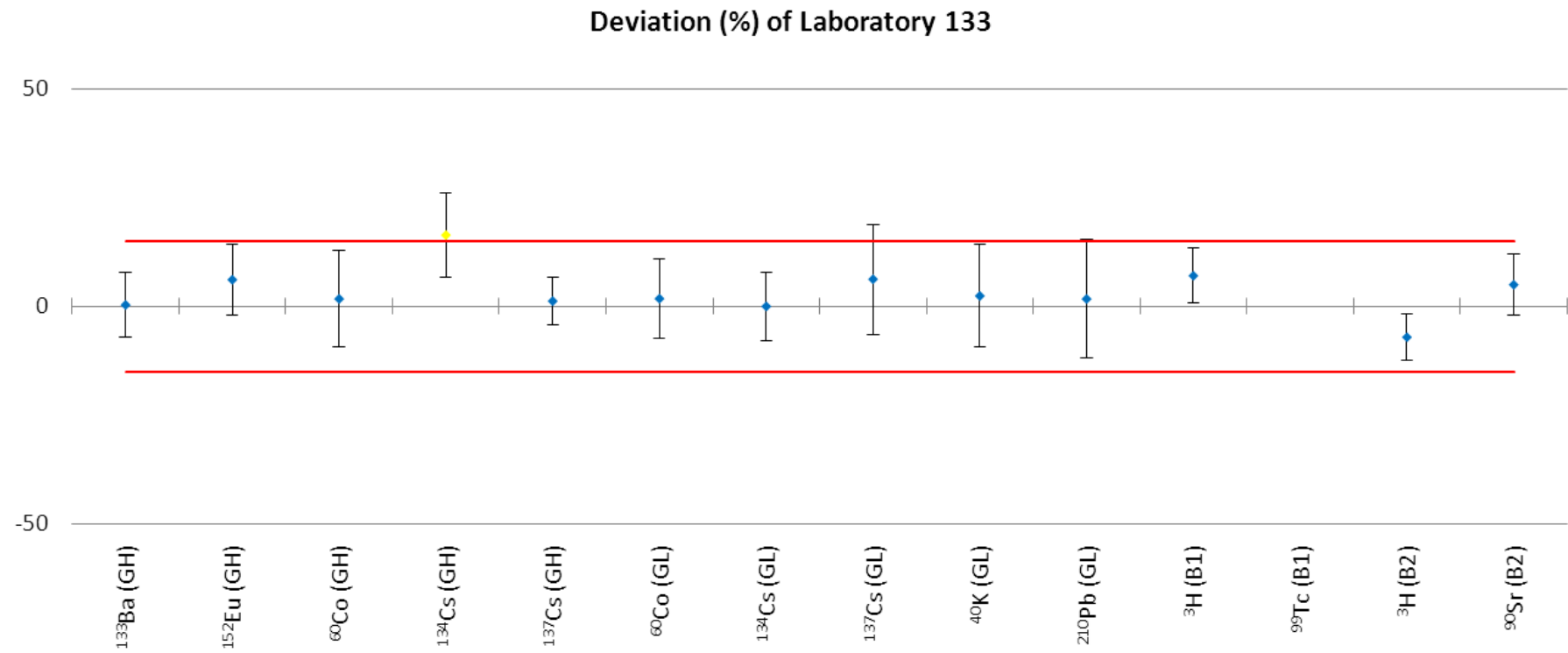
NPL Report IR 28

Radionuclide	Laboratory 120	NPL Assigned Value	Deviation /%	Zeta	Z Score
²⁴¹ Am (AH)	5.3 ± 0.3 (± 5.0 %)	4.449 ± 0.010 (± 0.24 %)	20.0	3.30	3.44
²⁴⁴ Cm (AH)	17.6 ± 0.9 (± 5.0 %)	19.51 ± 0.07 (± 0.4 %)	-9.7	-2.14	-1.66
²³⁸ Pu (AH)	13.9 ± 0.7 (± 5.0 %)	14.950 ± 0.050 (± 0.3 %)	-7.1	-1.47	-1.22
³ H (B1)	1.010 ± 0.050 (± 5.0 %)	1.046 ± 0.008 (± 0.7 %)	-3.4	-0.71	-0.59
¹⁴ C (B1)	0.930 ± 0.050 (± 6 %)	0.968 ± 0.008 (± 0.8 %)	-4.0	-0.76	-0.68
⁹⁹ Tc (B1)	0.140 ± 0.010 (± 7 %)	0.1434 ± 0.0013 (± 0.9 %)	-2.4	-0.34	-0.41

Deviation (%) of Laboratory 132

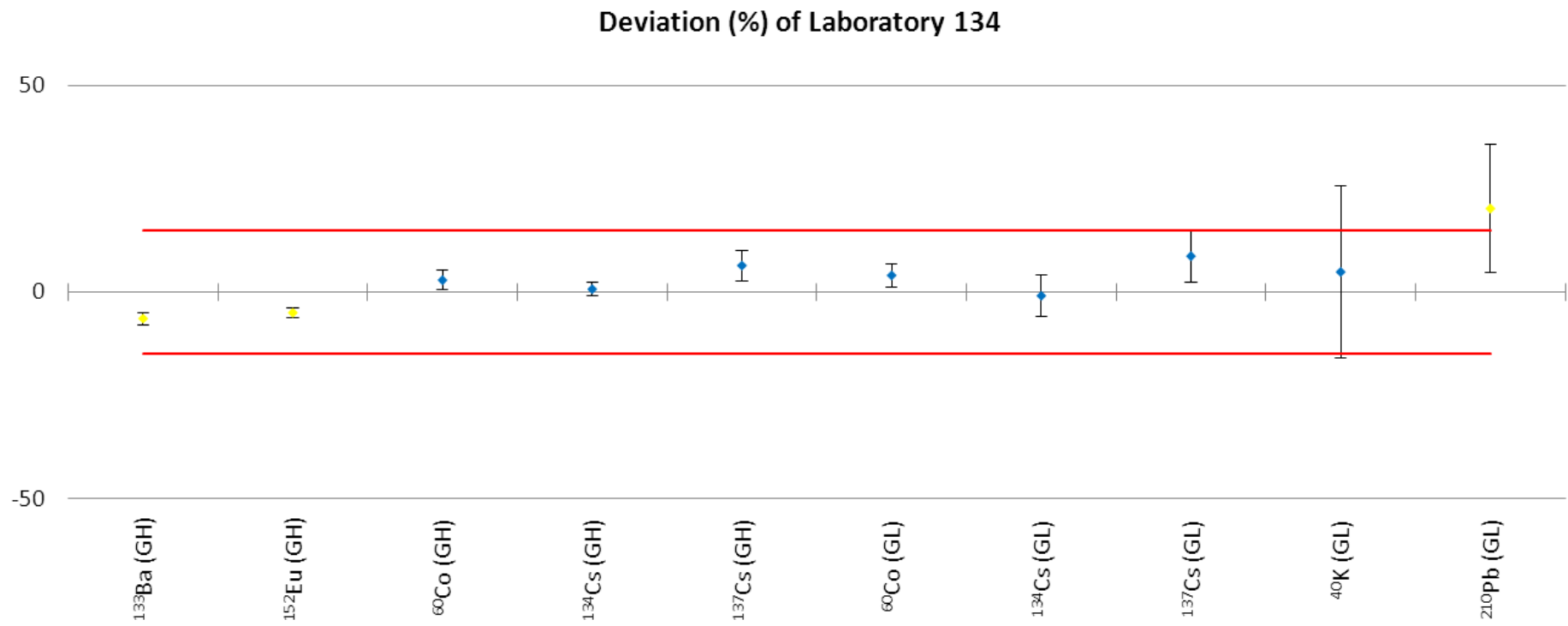


Radionuclide	Laboratory 132	NPL Assigned Value	Deviation /%	Zeta	Z Score
$^{210}\text{Pb (S)}$	42 ± 10 (± 24 %)	46.5 ± 1.4 (± 3 %)	-9.6	-0.44	-1.65
$^{210}\text{Po (S)}$	52 ± 3 (± 6 %)	47.9 ± 0.7 (± 1.5 %)	8.7	1.35	1.49



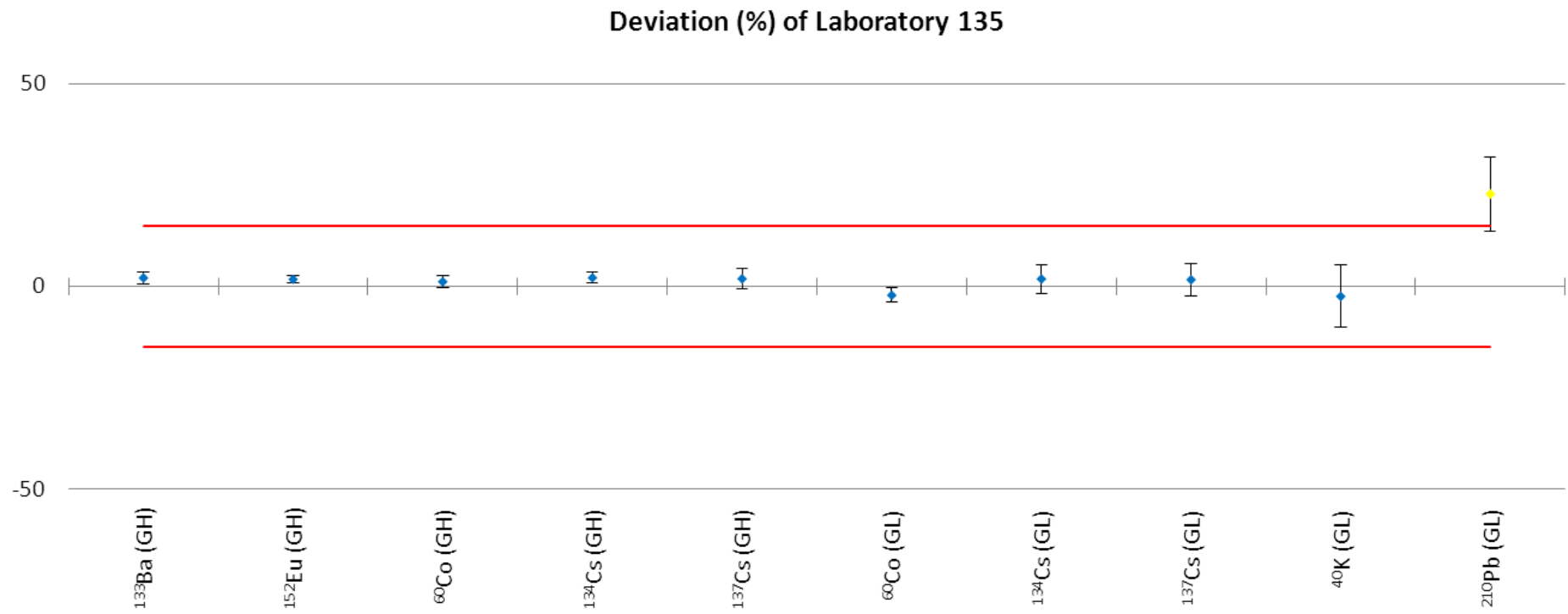
NPL Report IR 28

Radionuclide	Laboratory 133	NPL Assigned Value	Deviation /%	Zeta	Z Score
¹³³ Ba (GH)	7.4 ± 0.6 (± 8 %)	7.410 ± 0.050 (± 0.7 %)	0.3	0.05	0.06
¹⁵² Eu (GH)	16.2 ± 1.2 (± 8 %)	15.26 ± 0.10 (± 0.7 %)	6.1	0.75	1.06
⁶⁰ Co (GH)	5.3 ± 0.6 (± 11 %)	5.229 ± 0.011 (± 0.22 %)	1.7	0.16	0.30
¹³⁴ Cs (GH)	3.3 ± 0.3 (± 8 %)	2.800 ± 0.019 (± 0.7 %)	16.4	1.70	2.82
¹³⁷ Cs (GH)	15.6 ± 0.9 (± 6 %)	15.41 ± 0.06 (± 0.4 %)	1.2	0.22	0.21
⁶⁰ Co (GL)	18.0 ± 1.6 (± 9 %)	17.68 ± 0.08 (± 0.50 %)	1.8	0.20	0.31
¹³⁴ Cs (GL)	2.19 ± 0.17 (± 8 %)	2.190 ± 0.017 (± 0.8 %)	0.0	0.00	0.00
¹³⁷ Cs (GL)	4.40 ± 0.50 (± 12 %)	4.12 ± 0.04 (± 0.9 %)	6.3	0.50	1.08
⁴⁰ K (GL)	16.8 ± 1.8 (± 10 %)	16.4 ± 0.8 (± 5.0 %)	2.4	0.21	0.42
²¹⁰ Pb (GL)	20 ± 3 (± 13 %)	19.46 ± 0.22 (± 1.1 %)	1.7	0.13	0.30
³ H (B1)	1.12 ± 0.07 (± 6 %)	1.046 ± 0.008 (± 0.7 %)	7.1	1.13	1.21
⁹⁹ Tc (B1)	0.79 ± 0.06 (± 7 %)	0.1434 ± 0.0013 (± 0.9 %)	453.0	11.60	77.79
³ H (B2)	1.00 ± 0.06 (± 6 %)	1.076 ± 0.008 (± 0.7 %)	-7.1	-1.33	-1.22
⁹⁰ Sr (B2)	0.150 ± 0.010 (± 7 %)	0.1429 ± 0.0003 (± 0.20 %)	5.0	0.71	0.86



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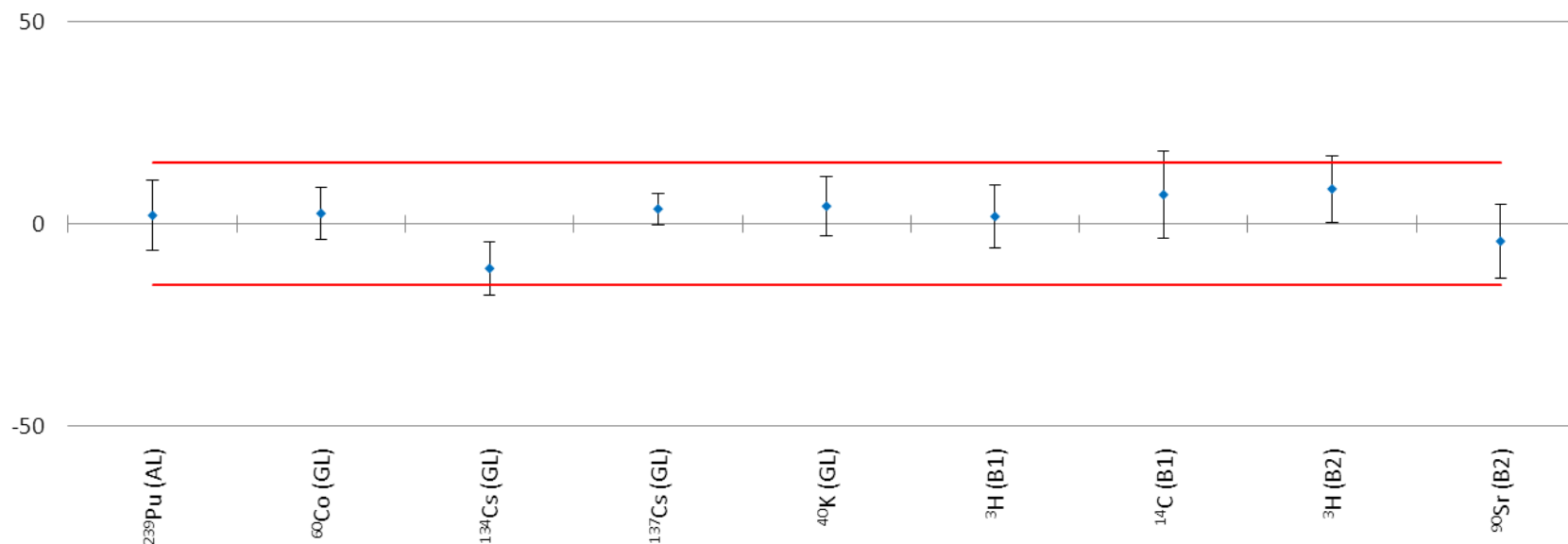
Radionuclide	Laboratory 134	NPL Assigned Value	Deviation /%	Zeta	Z Score
¹³³ Ba (GH)	6.94 ± 0.10 (± 1.4 %)	7.410 ± 0.050 (± 0.7 %)	-6.4	-4.20	-1.10
¹⁵² Eu (GH)	14.50 ± 0.14 (± 1.0 %)	15.26 ± 0.10 (± 0.7 %)	-5.0	-4.36	-0.86
⁶⁰ Co (GH)	5.38 ± 0.12 (± 2.2 %)	5.229 ± 0.011 (± 0.22 %)	2.9	1.25	0.50
¹³⁴ Cs (GH)	2.82 ± 0.04 (± 1.4 %)	2.800 ± 0.019 (± 0.7 %)	0.7	0.45	0.12
¹³⁷ Cs (GH)	16.4 ± 0.6 (± 4 %)	15.41 ± 0.06 (± 0.4 %)	6.4	1.73	1.10
⁶⁰ Co (GL)	18.40 ± 0.50 (± 3 %)	17.68 ± 0.08 (± 0.50 %)	4.1	1.42	0.70
¹³⁴ Cs (GL)	2.17 ± 0.11 (± 5.0 %)	2.190 ± 0.017 (± 0.8 %)	-0.9	-0.18	-0.15
¹³⁷ Cs (GL)	4.5 ± 0.3 (± 6 %)	4.12 ± 0.04 (± 0.9 %)	8.7	1.36	1.49
⁴⁰ K (GL)	17 ± 4 (± 19 %)	16.4 ± 0.8 (± 5.0 %)	4.9	0.23	0.84
²¹⁰ Pb (GL)	23 ± 3 (± 13 %)	19.46 ± 0.22 (± 1.1 %)	20.2	1.30	3.47



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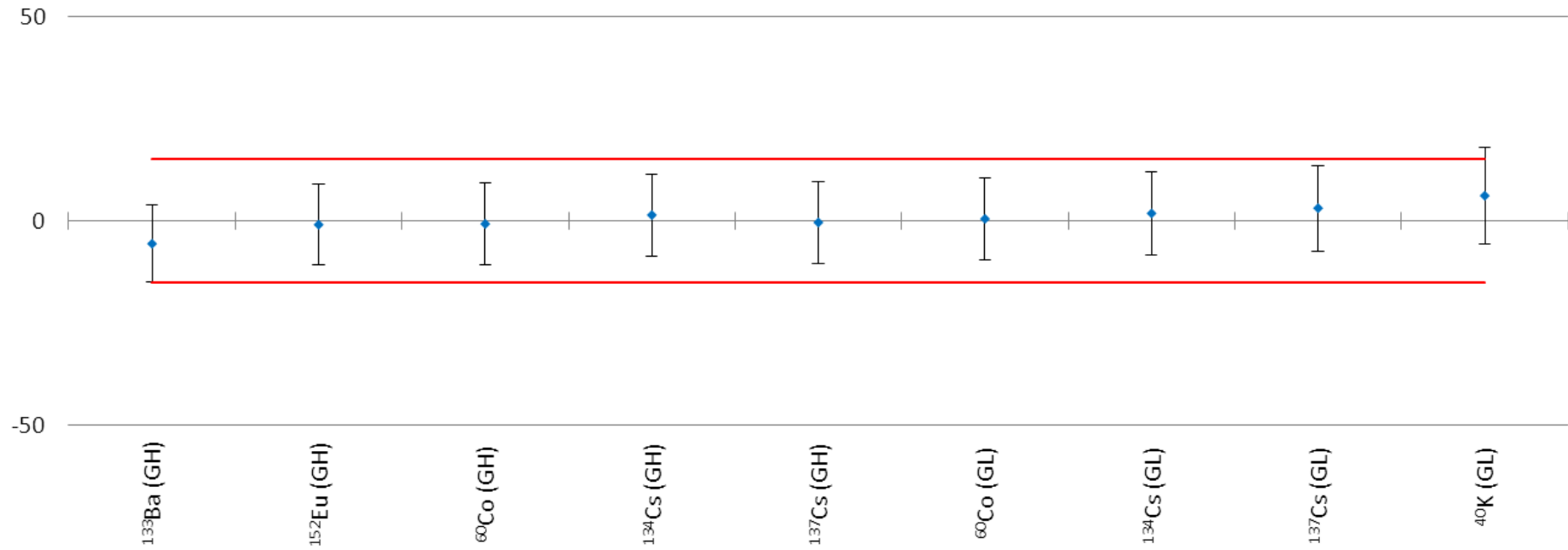
Radionuclide	Laboratory 135	NPL Assigned Value	Deviation /%	Zeta	Z Score
¹³³ Ba (GH)	7.57 ± 0.10 (± 1.3 %)	7.410 ± 0.050 (± 0.7 %)	2.1	1.38	0.36
¹⁵² Eu (GH)	15.53 ± 0.08 (± 0.50 %)	15.26 ± 0.10 (± 0.7 %)	1.8	2.04	0.30
⁶⁰ Co (GH)	5.29 ± 0.08 (± 1.5 %)	5.229 ± 0.011 (± 0.22 %)	1.2	0.75	0.20
¹³⁴ Cs (GH)	2.86 ± 0.03 (± 1.0 %)	2.800 ± 0.019 (± 0.7 %)	2.1	1.68	0.37
¹³⁷ Cs (GH)	15.7 ± 0.4 (± 2.5 %)	15.41 ± 0.06 (± 0.4 %)	1.9	0.72	0.32
⁶⁰ Co (GL)	17.3 ± 0.3 (± 1.7 %)	17.68 ± 0.08 (± 0.50 %)	-2.2	-1.24	-0.37
¹³⁴ Cs (GL)	2.23 ± 0.08 (± 4 %)	2.190 ± 0.017 (± 0.8 %)	1.8	0.52	0.32
¹³⁷ Cs (GL)	4.19 ± 0.16 (± 4 %)	4.12 ± 0.04 (± 0.9 %)	1.7	0.42	0.28
⁴⁰ K (GL)	16.0 ± 1.0 (± 6 %)	16.4 ± 0.8 (± 5.0 %)	-2.5	-0.32	-0.42
²¹⁰ Pb (GL)	23.9 ± 1.8 (± 7 %)	19.46 ± 0.22 (± 1.1 %)	22.8	2.51	3.91

Deviation (%) of Laboratory 136



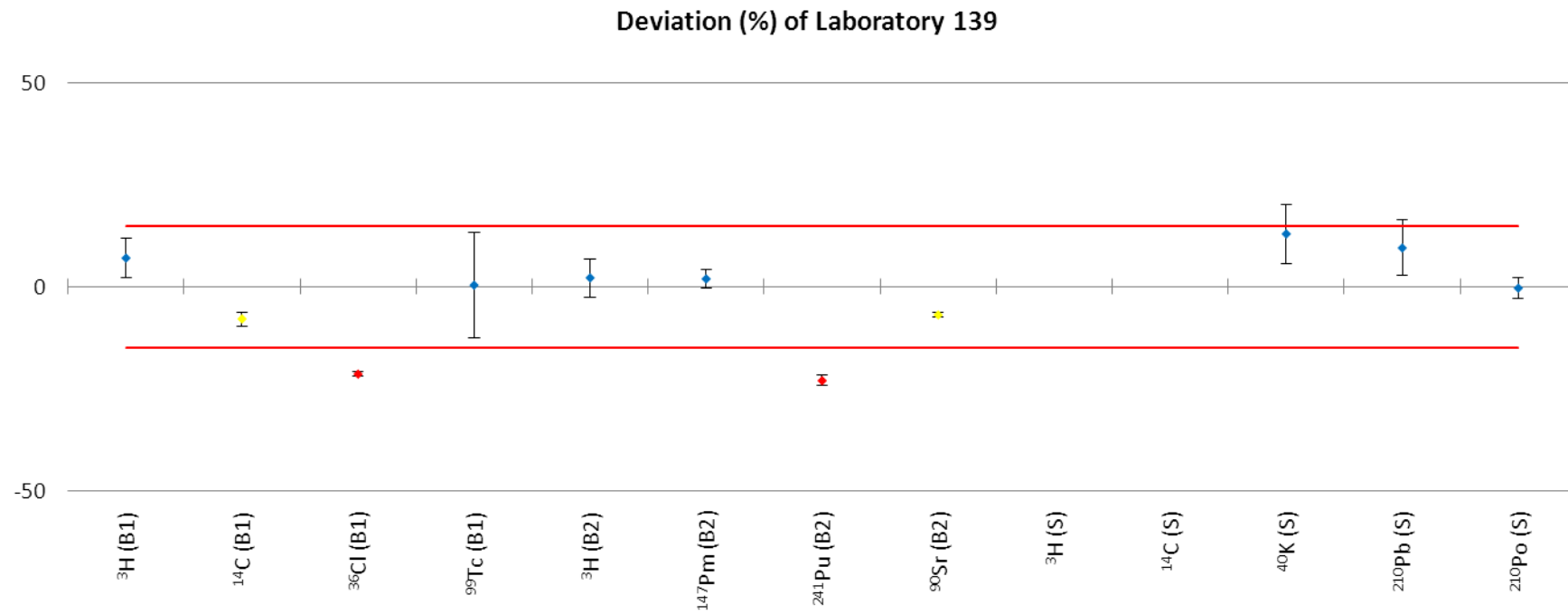
Radionuclide	Laboratory 136	NPL Assigned Value	Deviation /%	Zeta	Z Score
²³⁹ Pu (AL)	12.4 ± 1.0 (± 8 %)	12.1 ± 0.3 (± 2.2 %)	2.1	0.24	0.36
⁶⁰ Co (GL)	18.1 ± 1.2 (± 7 %)	17.68 ± 0.08 (± 0.50 %)	2.6	0.39	0.44
¹³⁴ Cs (GL)	1.95 ± 0.15 (± 8 %)	2.190 ± 0.017 (± 0.8 %)	-11.0	-1.65	-1.89
¹³⁷ Cs (GL)	4.27 ± 0.15 (± 4 %)	4.12 ± 0.04 (± 0.9 %)	3.7	0.95	0.63
⁴⁰ K (GL)	17.1 ± 0.9 (± 5.0 %)	16.4 ± 0.8 (± 5.0 %)	4.3	0.61	0.75
³ H (B1)	1.06 ± 0.08 (± 8 %)	1.046 ± 0.008 (± 0.7 %)	1.8	0.24	0.31
¹⁴ C (B1)	1.04 ± 0.10 (± 10 %)	0.968 ± 0.008 (± 0.8 %)	7.2	0.67	1.24
³ H (B2)	1.17 ± 0.09 (± 8 %)	1.076 ± 0.008 (± 0.7 %)	8.6	1.05	1.48
⁹⁰ Sr (B2)	0.137 ± 0.013 (± 10 %)	0.1429 ± 0.0003 (± 0.20 %)	-4.3	-0.47	-0.74

Deviation (%) of Laboratory 137



NPL Report IR 28

Radionuclide	Laboratory 137	NPL Assigned Value	Deviation /%	Zeta	Z Score
¹³³ Ba (GH)	7.0 ± 0.7 (± 10 %)	7.410 ± 0.050 (± 0.7 %)	-5.6	-0.59	-0.96
¹⁵² Eu (GH)	15.1 ± 1.5 (± 10 %)	15.26 ± 0.10 (± 0.7 %)	-0.9	-0.09	-0.16
⁶⁰ Co (GH)	5.20 ± 0.50 (± 10 %)	5.229 ± 0.011 (± 0.22 %)	-0.7	-0.08	-0.13
¹³⁴ Cs (GH)	2.8 ± 0.3 (± 10 %)	2.800 ± 0.019 (± 0.7 %)	1.4	0.14	0.24
¹³⁷ Cs (GH)	15.4 ± 1.5 (± 10 %)	15.41 ± 0.06 (± 0.4 %)	-0.4	-0.04	-0.07
⁶⁰ Co (GL)	17.8 ± 1.8 (± 10 %)	17.68 ± 0.08 (± 0.50 %)	0.5	0.05	0.08
¹³⁴ Cs (GL)	2.23 ± 0.22 (± 10 %)	2.190 ± 0.017 (± 0.8 %)	1.8	0.18	0.32
¹³⁷ Cs (GL)	4.20 ± 0.50 (± 10 %)	4.12 ± 0.04 (± 0.9 %)	3.1	0.30	0.53
⁴⁰ K (GL)	17.4 ± 1.7 (± 10 %)	16.4 ± 0.8 (± 5.0 %)	6.1	0.53	1.06

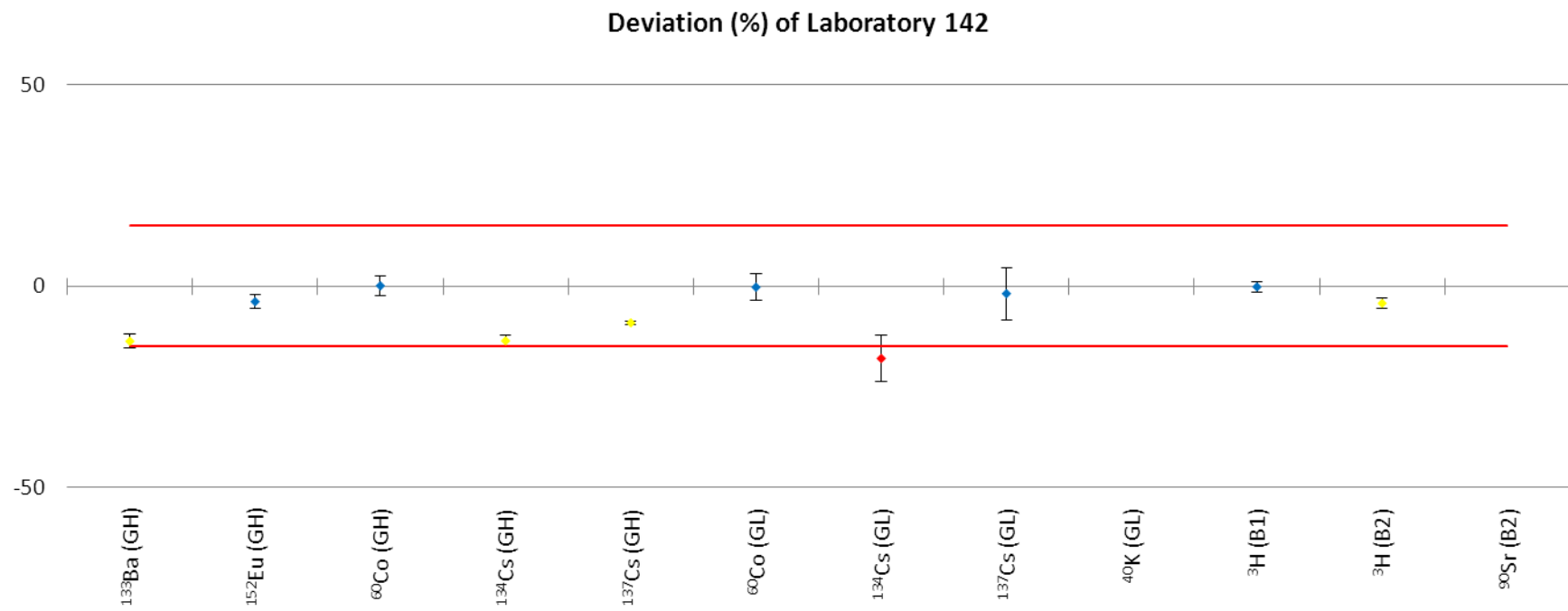


NPL Report IR 28

Radionuclide	Laboratory 139	NPL Assigned Value	Deviation /%	Zeta	Z Score
^3H (B1)	1.12 $\pm$ 0.05 ($\pm$ 5.0 %)	1.046 $\pm$ 0.008 ($\pm$ 0.7 %)	7.1	1.45	1.21
^{14}C (B1)	0.892 $\pm$ 0.015 ($\pm$ 1.7 %)	0.968 $\pm$ 0.008 ($\pm$ 0.8 %)	-7.9	-4.56	-1.35
^{36}Cl (B1)	0.3850 $\pm$ 0.0020 ($\pm$ 0.50 %)	0.4900 $\pm$ 0.0020 ($\pm$ 0.4 %)	-21.4	-37.77	-3.68
^{99}Tc (B1)	0.144 $\pm$ 0.018 ($\pm$ 13 %)	0.1434 $\pm$ 0.0013 ($\pm$ 0.9 %)	0.4	0.03	0.07
^3H (B2)	1.10 $\pm$ 0.05 ($\pm$ 5.0 %)	1.076 $\pm$ 0.008 ($\pm$ 0.7 %)	2.2	0.47	0.38
^{147}Pm (B2)	0.443 $\pm$ 0.010 ($\pm$ 2.2 %)	0.435 $\pm$ 0.004 ($\pm$ 0.9 %)	1.9	0.81	0.33
^{241}Pu (B2)	0.725 $\pm$ 0.009 ($\pm$ 1.2 %)	0.942 $\pm$ 0.010 ($\pm$ 1.1 %)	-23.0	-16.01	-3.96
^{90}Sr (B2)	0.1330 $\pm$ 0.0008 ($\pm$ 0.6 %)	0.1429 $\pm$ 0.0003 ($\pm$ 0.20 %)	-6.9	-11.52	-1.19
^3H (S)	26.40 $\pm$ 0.20 ($\pm$ 0.8 %)	77.1 $\pm$ 1.7 ($\pm$ 2.2 %)	-65.8	-29.43	-11.29
^{14}C (S)	0.423 $\pm$ 0.012 ($\pm$ 3 %)	1.91 $\pm$ 0.05 ($\pm$ 2.5 %)	-77.9	-30.72	-13.38
^{40}K (S)	204 $\pm$ 12 ($\pm$ 6 %)	181 $\pm$ 6 ($\pm$ 3 %)	13.0	1.84	2.23
^{210}Pb (S)	51 $\pm$ 3 ($\pm$ 6 %)	46.5 $\pm$ 1.4 ($\pm$ 3 %)	9.5	1.43	1.64
^{210}Po (S)	47.7 $\pm$ 1.1 ($\pm$ 2.2 %)	47.9 $\pm$ 0.7 ($\pm$ 1.5 %)	-0.3	-0.12	-0.06

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Radionuclide	Laboratory 141	NPL Assigned Value	Deviation /%	Zeta	Z Score
¹³³ Ba (GH)	7.3 ± 0.4 (± 5.0 %)	7.41 ± 0.05 (± 0.7 %)	-1.4	-0.28	-0.24
¹⁵² Eu (GH)	15.7 ± 0.8 (± 5.0 %)	15.26 ± 0.10 (± 0.7 %)	2.6	0.51	0.45
⁶⁰ Co (GH)	5.4 ± 0.3 (± 5.0 %)	5.229 ± 0.011 (± 0.22 %)	3.1	0.59	0.53
¹³⁴ Cs (GH)	2.75 ± 0.14 (± 5.0 %)	2.800 ± 0.019 (± 0.7 %)	-1.9	-0.38	-0.33
¹³⁷ Cs (GH)	15.7 ± 0.8 (± 5.0 %)	15.41 ± 0.06 (± 0.4 %)	2.2	0.42	0.37



Radionuclide	Laboratory 142	NPL Assigned Value	Deviation /%	Zeta	Z Score
¹³³ Ba (GH)	6.40 ± 0.12 (± 1.8 %)	7.41 ± 0.05 (± 0.7 %)	-13.6	-7.97	-2.34
¹⁵² Eu (GH)	14.7 ± 0.3 (± 1.8 %)	15.26 ± 0.10 (± 0.7 %)	-3.8	-2.05	-0.65
⁶⁰ Co (GH)	5.24 ± 0.13 (± 2.4 %)	5.229 ± 0.011 (± 0.22 %)	0.1	0.06	0.03
¹³⁴ Cs (GH)	2.42 ± 0.04 (± 1.5 %)	2.800 ± 0.019 (± 0.7 %)	-13.5	-9.19	-2.32
¹³⁷ Cs (GH)	14.02 ± 0.05 (± 0.3 %)	15.41 ± 0.06 (± 0.4 %)	-9.0	-19.75	-1.55
⁶⁰ Co (GL)	17.6 ± 0.6 (± 4 %)	17.68 ± 0.08 (± 0.50 %)	-0.2	-0.06	-0.03
¹³⁴ Cs (GL)	1.80 ± 0.12 (± 7 %)	2.190 ± 0.017 (± 0.8 %)	-17.9	-3.13	-3.07
¹³⁷ Cs (GL)	4.0 ± 0.3 (± 7 %)	4.12 ± 0.04 (± 0.9 %)	-1.8	-0.28	-0.31
⁴⁰ K (GL)	30 ± 3 (± 9 %)	16.4 ± 0.8 (± 5.0 %)	80.8	4.86	13.88
³ H (B1)	1.045 ± 0.012 (± 1.1 %)	1.046 ± 0.008 (± 0.7 %)	-0.1	-0.09	-0.02
³ H (B2)	1.031 ± 0.010 (± 1.0 %)	1.076 ± 0.008 (± 0.7 %)	-4.2	-3.52	-0.72
⁹⁰ Sr (B2)	0.3386 ± 0.0008 (± 0.24 %)	0.1429 ± 0.0003 (± 0.20 %)	137.0	230.68	23.53

13. CONCLUSIONS

13.1 Alpha Low results

It is noticeable that most of the discrepant and questionable results came from a particular subset of the participants, suggesting possible analytical problems at those laboratories. The reported uncertainties were similar for most of the reported results, probably due to the fact that the uncertainty component arising from counting statistics was the major contribution to the overall uncertainty. Overall performance in this year's exercise for this sample type was significantly lower than that observed in 2011, with only about 50% of results being in agreement with the assigned values (compared with 78% in 2011).

13.2 Alpha High results

In contrast to the Alpha Low dataset, the discrepant/questionable results for Alpha High were not from a particular subset of laboratories. The ^{237}Np results were significantly inferior to those from the 2011 exercise (33% in agreement compared with 86% in 2011).

13.3 Beta One results

There were no discrepant results from tritium analysis. This follows a similarly good performance in the 2011 exercise and suggests good measurement capability amongst the participants. The results for ^{14}C , however, were less good, with only about 60% of the results in agreement with the assigned value, slightly worse than in last year's exercise. Similarly, performance for ^{99}Tc was a little lower than in 2011.

13.4 Beta Two results

The tritium results for this sample type were slightly inferior to those for Beta One; however there are only 3 discrepant results, repeating the pattern of the 2011 exercise. The ^{241}Pu and ^{90}Sr analyses obviously presented difficulties to some of the laboratories with 47% and 33% respectively not being in agreement with the assigned value. There were few ^{147}Pm results submitted, but most were in agreement with the assigned value.

13.5 Gamma Low results

There were very few discrepant results. The only nuclide from which more than one laboratory had reported a discrepant result was ^{210}Pb . The ^{210}Pb and ^{40}K results were inferior to those for the other radionuclides, with 20% and 30% of the results respectively being questionable (compared with only 2% for the other nuclides).

13.6 Gamma High results

Of the 34 sets of results received, only 9 laboratories reported a result classified as discrepant and 9 reported one or more results classified as questionable.

13.7 Solid results

There are insufficient results from this sample to draw significant conclusions. The low number of results in the Largest Consistent Subset (LCS) along with a large range of uncertainties does mean that the weighted mean is in some cases significantly different from a simple arithmetic mean. However it is interesting that the tritium and ^{14}C results show that it is much more difficult to achieve satisfactory results for a solid sample than a solution. However the ^{210}Pb and ^{210}Po datasets were both in good agreement for this solid matrix.

13.8 General points

Some laboratories are still reporting uncertainties significantly lower than those from others; this inevitably increases the possibility that a result will be classified as questionable or discrepant. This is more noticeable in the higher activity samples where the counting statistics do not dominate the uncertainty budget. Similarly, reporting very large uncertainties almost guarantees that the result will be classified as questionable. Laboratories reporting relatively low or high uncertainties should review their uncertainty budgets to ensure all sources of uncertainty are being properly considered.

14. REFERENCE

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