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Environmental Radioactivity Comparison Exercise 2001

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ABSTRACT

The results of the ninth NPL Environmental Radioactivity Comparison Exercise are reported. There continues to be a steady improvement in national metrological performance for many β/γ-emitting nuclides, but the exercise has highlighted problems with others. The reported data suggest that some analysts are still not making cascade summing corrections. Measurements of ^{238}Pu and ^{239}Pu still exhibit a low bias, and the lack of data returned for many β-emitting nuclides make it difficult to assess performance levels. NPL is to address some priority assay problems arising from these exercises in parallel with its next comparison in this series.

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1. INTRODUCTION

This environmental radioactivity comparison was the ninth in a series of similar exercises[1-9] to have been conducted by NPL since 1989. They have evolved over the years in response to the needs of the radioactivity measurement community in the UK and are now well established as part of the analyst's calendar, being particularly important in support of UKAS accreditation in this field. They have also been instrumental in identifying analytical problems and in providing a regular national forum for discussion and technology transfer in this area.

The exercises have been run approximately once every eighteen months by NPL. The range of sample types available for analysis has been mainly aqueous (dilute nitric or hydrochloric acid) although samples based on matrices such as Kaolin[5] or milk[6] have also been offered. In the 2001 exercise, four samples were available for analysis:

i) a 'high-level' mixture of α-, β- and β/γ-emitting radionuclides (@ ~ 2 Bq g^{-1} per radionuclide (apart from ^{3}H, which was @ ~ 20 Bq g^{-1}), in dilute nitric acid);
ii) a 'low-level' mixture of α-, β and β/γ-emitting radionuclides (@ ~ 2.5 Bq kg^{-1} per radionuclide (with ^{3}H @ ~ 25 Bq kg^{-1}), in dilute nitric acid);
iii) a high-level mixture of β/γ-emitting radionuclides (~ 2.5 Bq g^{-1}, in dilute hydrochloric acid);
iv) a 'low-level' mixture of β/γ-emitting radionuclides (~ 2.5 Bq kg^{-1}, in dilute hydrochloric acid).

2. ORGANISATION

2.1 PARTICIPANTS

A total of 27 participants took part in this exercise, 26 of them reporting data. The majority of the samples taken were of the β/γ-emitting mixtures, with 21 participants taking the high-level mixture and 23 taking the low-level mixture. Uptake of the α/β-emitting mixtures was 13 for the high-level mixture and 16 for the low-level mixture.

The participants came from a wide cross-section of the UK measurement community. A full listing is given in Appendix 1.

2.2 SAMPLES

The samples were given the following identifiers:

i) high-level α-, β- and β/γ emitting radionuclide mixture - ABHxx/01
ii) low-level α-, β- and β/γ emitting radionuclide mixture - ABLxx/01
iii) high-level β/γ-emitting radionuclide mixture - BGHxx/00
iv) low-level β/γ-emitting radionuclide mixture - BGLxx/00

Tables 1 - 8 summarise the principal radionuclides in the four sample mixtures made available, along with the impurities present in each mixture.

All the radionuclides used in this exercise are either released by the nuclear industry in the course of normal operations or occur naturally in the environment. The following criteria were looked for when choosing the radionuclides:

(i) that the half-lives were > 50 days;
(ii) that no obscure species were selected (i.e. all could reasonably be found in the environment or in nuclear-licenced site effluent);
(iii) that the α/β-emitter samples contained no radionuclides conventionally used as chemical yield tracers;
(iv) that all the radionuclides were measurable by well-established techniques.

As a result of feedback from the user community, the radionuclides ^{210}Pb and ^{226}Ra were included for the first time in this series of exercises. These nuclides arise both from natural distributive processes in the environment and also from the non-nuclear industrial processing of ores that can be classified as 'Naturally Occurring Radioactive Material' (NORM). Note that the ^{210}Pb was actually mixed with the pure β-emitters and α-emitters, as was the ^{226}Ra. The radionuclides ^{22}Na and ^{207}Bi were also included, in the β/γ mixtures.

The timescales allowed for analyses were short so, as in previous years, a list of the radionuclides present in the α/β mixture was provided in advance of the exercise to reduce the analytical effort required. A similar list was not provided for the γ-emitting mixtures, as these are invariably determined by γ-ray spectrometry, for which the sample pre-treatment required, if any, is minimal.

However the following candidate list of possible γ-emitters was provided:

^{7}Be, ^{22}Na, ^{46}Sc, ^{54}Mn, ^{56}Co, ^{57}Co, ^{58}Co, ^{60}Co, ^{65}Zn, ^{85}Sr, ^{88}Y, ^{95}Zr, ^{95}Nb, ^{106}Ru/^{106}Rh, ^{109}Cd, ^{110m}Ag, ^{113}Sn, ^{124}Sb, ^{125}Sb, ^{133}Ba, ^{134}Cs, ^{137}Cs, ^{139}Ce, ^{144}Ce, ^{153}Gd, ^{154}Eu, ^{155}Eu, ^{160}Tb, ^{170}Tm, ^{203}Hg and ^{207}Bi.

3. CALIBRATION

3.1 ABSOLUTE CALIBRATION

All the nuclides provided in the samples were traceable to primary standards. A primary standard is the highest level standard in any hierarchical measurement system. In most cases, primary standards are also absolute standards.

An absolute standard of radioactivity is one that has been measured directly without reference to any other standard of activity; the activity has been determined from count-rate data alone, without reference to any supplementary data determined from previous experiments. In the case of radioactivity standards, absolute standards are generally derived using the 4π-proportional counter-γ-coincidence counting technique for α/γ and β/γ emitting radionuclides[10]. Those radionuclides decaying by pure α- or pure β-emission can be determined by a variation[11,12] of this technique.

3.2 SECONDARY STANDARDISATION

Absolute counting techniques are labour intensive and this, coupled with the level of operator expertise required, renders it very expensive; also, there is a limit on the lowest amount of activity that can be measured without the associated uncertainties becoming unacceptably high. A simpler, more rapid method is therefore required for routine calibrations, and this is achieved by using an absolutely calibrated solution to calibrate a secondary standard instrument. In the case of α/γ or β/γ emitters and some high energy pure β-emitters, this is usually a well-type ionisation chamber that responds only to the γ-rays emitted (in the case of high-energy pure β-emitters, the ionisation chamber measures the Bremsstrahlung radiation). These instruments are normally very stable; for example, the response of the ionisation chambers maintained at NPL has been found to vary by < 0.1 % over 40 years. Other γ-ray detectors (NaI(Tl) or hyperpure Germanium detectors) are applicable but they do not share the long term stability of ionisation chambers. For pure α-emitters and pure β-emitters, there are no suitable secondary standard instruments that have sufficient long term stability; however, liquid scintillation counters can be used, albeit with counting efficiencies which are dependent on such factors as particle energy, spectral shape, chemical format, etc. Pure β-emitters can also be assayed using an 'efficiency tracing' technique[13] using ^{3}H as a tracer nuclide (known as the 'CIEMAT/NIST method').

4. SOURCE PREPARATION

4.1 PROCUREMENT

The individual radionuclides were obtained from a number of suppliers and had been calibrated in various laboratories, but mostly at NPL. Table 9 summarises the suppliers, the laboratories responsible for the calibrations and the traceability of the measurements.

4.2 PURITY

Each nuclide was checked for impurities either by α-spectrosopy, γ-spectroscopy or by reference to the original calibration certificate; the impurity levels are shown in Tables 2, 4, 6 and 8.

4.3 ACTIVITY CONFIRMATION

The activity concentrations of the original individual radionuclide solutions were determined either from the calibration certificates or from measurement at NPL, using either absolute methods or secondary standard instruments as described above.

4.4 PREPARATION

The β/γ-emitting mixtures were prepared by (i) diluting standard solutions of the individual radionuclides to approximately equal activity concentrations, (ii) mixing the individual radionuclides and (iii) diluting the mixture down to the required activity levels. The final activity concentration for each nuclide was determined by

dividing the initial single-radionuclide activity concentration by the dilution factors as determined from weighing.

Sets of sources (either single-radionuclide or mixed-radionuclide, depending on the dilution stage) were prepared at each dilution stage, for subsequent counting, in order to derive 'radiometric' dilution factor to confirm those derived gravimetrically. A radiometric dilution factor was determined for each principal radionuclide present. These factors were determined using either a NaI(Tl) crystal (single-radionuclide stage) or a hyperpure Ge γ-ray spectrometer (mixed-radionuclide stage).

The α/β mixtures were prepared in the same way, except the single-radionuclide dilutions were checked using liquid scintillation counting and the mixed-radionuclide dilutions were verified, as far as possible, by γ-spectrometric determination of the ^{241}Am component.

4.4.1 The α/β mixture

Standard solutions of ^{3}H, ^{90}Sr, ^{99}Tc, ^{210}Pb, ^{226}Ra, ^{238}Pu, ^{239}Pu and ^{241}Am (10 – 20 ml each, either as extant material at a suitable activity concentration level or material prepared from verified dilutions as described above) were combined and diluted to 7.4 kg with carrier. This diluted mixture was used to make:

a) 50 x 100 g samples @ 2 Bq g^{-1} per nuclide (except for ^{3}H, which was present at 20 Bq g^{-1});
b) 1 x dilution bottle (approximately 100 g diluted to 3 kg).

Bottle (b) was used to make:

c) 1 x dilution bottle (approximately 900 g diluted to 25 kg).

Finally, bottle (c) was used to make:

d) 50 x 500 g samples @ 2.5 Bq kg^{-1} per nuclide (^{3}H present at 25 Bq kg^{-1}).

The carrier used consisted of 50 μg g^{-1} each of bismuth, lead, strontium and yttrium as nitrates in 1.2 M HNO_3. The aqueous matrix acts as a carrier for tritium and there are no suitable carriers for americium, radium, technetium or plutonium.

4.4.2 The β/γ mixture

The stock solutions of the individual radionuclides (approximately 1- 10 g each) were combined and diluted to 11 kg with carrier. This was used to make:

a) 85 x 100 g samples @ 2.5 Bq g^{-1} per nuclide;
b) 1 x dilution bottle (approximately 100 g diluted to 3.7 kg).

Solution (b) was then used to make:

a) 1 x dilution bottle (approximately 1.5 kg diluted to 44 kg).

Finally, solution (c) was then used to make:

d) 85 x 500 g @ 2.5 Bq kg^{-1}.

The carrier used throughout consisted of 50 μg g^{-1} each of antimony, barium, bismuth, caesium, cobalt, europium, sodium, tellurium and zinc in 2.5 M hydrochloric acid.

To further validate the overall gravimetric dilution factors, selected samples of (a) and (d) were assayed by γ-ray spectrometry.

5 TREATMENT OF DATA

5.1 NUMERICAL DATA

As in previous years, data reporting forms were prepared and distributed with the samples, with participants having the additional option of reporting their data electronically. The data returned were used in conjunction with the reference values to calculate two parameters. First, the deviation from the reference value was calculated, as a percentage:

$$\text{Deviation (\%)} = \frac{(\text{Analyst's result} - \text{Reference value}) \times 100}{\text{Reference value}}$$

The value of the u-statistic[14] was also calculated:

$$\text{u-statistic} = \frac{(\text{Analyst's result} - \text{Reference value})}{\sqrt{(\text{Analyst's uncertainty}^2 + \text{Uncertainty on reference value}^2)}}$$

This provides an indication of agreement between the two values. The uncertainty to be used is the standard uncertainty (i.e. with $k = 1$).

This statistic is compared with values in the t-statistic tables[15] and is commonly interpreted using the criteria in Table 10.

Note that, throughout this report, the term 'discrepant' is used to describe data yielding a u-statistic > 3.29.

5.2 UNCERTAINTIES

Uncertainties for the reference values have all been estimated in accordance with the internationally-accepted protocols[16,17]. Unless otherwise stated, all the uncertainties in this report are stated as standard uncertainties with a coverage factor of $k = 1$ (i.e. at the 68 % confidence level).

5.3 NUCLEAR DECAY DATA

The data used by the participants are discussed later; the data used by NPL in preparing and validating the samples are all given in Table 11. In each case, the γ-ray emission probabilities, P_γ, are only given if they exceed 1%.

5.4 PRESENTATION

The results of all the u-tests carried out are summarised in Tables 12 -14.

The participants' results for the radionuclides included in the samples by NPL are tabulated in Tables 15 - 50 and are plotted in Figures 1 - 72. Other radionuclides reported by the participants are given in Table 51.

5.5 CONFIDENTIALITY

As is usual in these exercises, the relationship between the participants and the results remains confidential to NPL.

6 RESULTS FOR α-EMITTERS AND PURE β-EMITTERS

6.1 General comments

In response to feedback from the user community, the same activity levels were offered up for analysis as in the previous comparison, although the nuclidic composition was altered. In particular, ^{55}Fe and ^{63}Ni were dropped due to the paucity of returned data, and ^{210}Pb and ^{226}Ra were included for the first time. In total, 12 data sets were returned for each of the two activity levels offered. One laboratory carried out a complete analysis of a higher-level sample, and another laboratory did likewise with the lower-level type. The overall number of results returned has decreased; this is particularly worrying for ^{90}Sr, where analytical problems have been evident from recent exercises and where wider participation was perhaps expected.

All participants used radiochemical analyses to isolate the individual nuclides from the mixtures. The standards used, when reported, were from national standards laboratories or other centres providing traceability. Similarly, the nuclear data sources cited were recognised centres, and the wide usage of the recently-published Radiochemical Manual[18] was evident.

6.2 ^{3}H

As in previous exercises, participants separated the ^{3}H by distillation, with a few laboratories carrying this out at low-temperature. There were two clear outliers at each activity level, and it is not clear from the supplementary data supplied by participants what the reasons for this are, but the proportion of correct values at each of the two levels is very similar to that observed in the last exercise. The overall biases are high, although it should be noted that these are small data sets and that it is difficult to draw conclusions from them. Two-thirds of laboratories cited their standards, all of these being traceable to national standards of radioactivity.

6.3 ^{90}Sr

Surprisingly few data were reported for this nuclide, at either activity level. It is very difficult, therefore, to draw conclusions concerning the overall level of performance or to discern trends in performance since recent exercises. In preparing the samples for analysis, most laboratories used the basic principle of allowing the yttrium to

ingrow into purified strontium and then separating and counting the yttrium. All used Cerenkov counting to measure their samples, with one laboratory using a gas-flow proportional counter to measure the ^{90}Sr in the low-level sample. The use of ^{85}Sr as a tracer was cited by three laboratories.

Of the data returned, all but one were in good agreement with NPL, the outlier having been overestimated by over 50 %. There is no obvious reason for this discrepancy from the details provided.

Results returned for this nuclide in recent exercises have either been few in number or have exhibited a large spread, and this has prompted NPL to make provision to look into the assay problems associated with this nuclide in its current three-year (2001-4) ionising radiation metrology programme.

6.4 ^{99}Tc

Only three participants opted to analyse this radionuclide so, again, little can be said concerning overall performance. One laboratory analysed at both available activity levels using a gas-flow proportional counter to measure the ^{99}Tc (after separation using a TEVA column (Eichrom Technologies, Inc., Illinois)); both results overestimated the activity by 13 % and were possibly discrepant.

Another participant (also using a TEVA column for separation) analysed at the lower level using ICP-MS, whilst a third laboratory carried out a triplicate determination at this level using ion exchange and isolation of the analyte as the tetraphenyl-arsonium salt prior to assay by β-counting. Rhenium, the vertical homologue of technetium in the periodic table, was used as a yield tracer by both laboratories, and their results agreed well with the NPL reference value.

6.5 ^{210}Pb

This is the first time this radionuclide has been included in this series of exercises. The wide dissemination of ^{210}Pb is due to (i) the long half-life of ^{226}Ra, coupled with the solubility of the latter in fresh water and sea water, (ii) the outgassing of ^{222}Rn, resulting in the atmospheric distribution of this nuclide and its decay products, and (iii) the fairly long half-life of ^{210}Pb and its solubility in aqueous systems. Its prevalence in the environment has been enhanced in recent decades by the processing of ores now classified as ‘Naturally Occuring Radioactive Material’ (NORM).

Very few participants opted to measure this radionuclide. One laboratory measured the separated radionuclide, at both activity levels, using a gas-flow proportional counter. Two others measured the higher- level sample only, one of whom reported that they had used γ-ray spectrometry. This technique yielded a probably-discrepant result, probably owing to the difficulties inherent in accurately defining a γ-ray efficiency calibration curve at low energies.

A further two laboratories measured only at the lower level, both assaying separated ^{210}Po by α-spectrometry; one of these laboratories significantly underestimated the activity concentration.

6.6 ^{226}Ra

As stated above, this radionuclide is both long-lived and water-soluble, and is consequently widely distributed in the environment. Again, this is the first time this radionuclide has been included in this series of comparisons and, again, few participants (five) opted to measure it; however, all reported results agreed well with the reference value.

Of those laboratories who measured the higher-level sample, two used α-spectrometry of separated ^{226}Ra; one used electrodeposition, and the other evaporation, to prepare the samples. One of these laboratories also used carried out a determination using ICP-MS. A third laboratory used γ-ray spectrometry. Only one participant measured the lower-level sample, opting to extract ingrown ^{222}Rn for collection on a charcoal bed prior to transfer to scintillation cells for α-counting. Recognised standards of ^{226}Ra, ^{232}U and mixed γ-ray emitters were used. The small number of reported results precludes any general conclusions.

6.7 ^{238}Pu / ^{239}Pu

The numbers of results returned for these nuclides was generally lower than in the previous exercise. Nearly all participants used ion exchange and/or extraction chromatography to separate the nuclides from the mixture, followed by electrodeposition onto discs and subsequent α-spectrometric assay.

The low biases apparent in the last exercise, for both nuclides and at both levels, are still apparent, being most prominent at the lower activity level. The proportions of discrepant, or possibly discrepant, data are greater. It was expected that the development of primary standards for these nuclides at NPL would have overcome the metrological problems apparent from earlier exercises, and it is worrying that these problems are persisting. Most analysts used ^{236}Pu or ^{242}Pu yield tracers from recognised centres.

The analytical problems evident from these analyses may well be addressed by NPL, along with ^{90}Sr assay problems noted above, in its current ionising radiation metrology programme.

6.8 ^{241}Am

Eight of the participants carried out ion exchange or extraction chromatography to separate the nuclide, followed by electrodeposition prior to assay by α-spectrometry; four opted to use γ-ray spectrometry, one used ICPMS and one used a ZnS scintillation detector. The nuclide ^{243}Am was used as a tracer by many laboratories. There is a high bias evident at the lower activity level, although not if one excludes the outlier at +50%.

7 RESULTS FOR β/γ-EMITTERS

7.1 General comments

The majority of the data returned was from analyses of the β/γ-emitting nuclides, in common with previous exercises. The sample level of 25 Bq kg^{-1} per nuclide offered in the last exercise was dropped following feedback from users. A similar nuclide mix to last time was adopted, with ^{57}Co being dropped, and ^{22}Na and ^{207}Bi being added.

Sample preparation is inevitably simpler than for the α/β analyses. Most participants transferred the sample, without dilution, to a known geometry for γ-ray spectrometry, whilst around one third carried out a dilution, a volume reduction or deposition to a solid matrix prior to homogenisation. All used semiconductor detectors, with p-type and n-type detectors being equally popular. Commercially-available data-handling software was universally used, with 'in-house' data libraries becoming more popular. NPL and IAEA nuclear data were the most widely adopted of several centres cited, and the very wide usage of mixed radionuclide standards from NPL or Amersham continues.

7.2 ^{22}Na

This is a positron emitter (with a 9.5 % electron-capture branch), and is included in this series of exercises for the first time. There is a large proportion of discrepant or dubious data, particularly at the higher of the two activity levels, and some analysts were unable to detect this nuclide. This is doubtless largely due to the presence of ^{154}Eu in the mixture, which also emits γ-rays at approximately 1274 keV and is therefore likely to complicate the analysis. It is possible that, in some cases, a correction has either not been applied or has been applied incorrectly.

7.3 ^{60}Co

This nuclide is well known as an activation product and as a high-energy calibration point for mixed-radionuclide type standards. The data returned are encouraging in two ways: (i) the proportion of discrepant data has clearly diminished, particularly at the higher activity level, and (ii) some 85 % of the data are unambiguously correct. One would reasonably expect a high level of performance for a calibration point nuclide.

7.4 ^{65}Zn

This is an electron-capture nuclide with a small positron branch and gives rise to photons at 511 keV as a result of positron annihilation. Again, the level of discrepant data are lower than for the last exercise, most noticeably at the higher level, and the observed bias is lower at this level.

7.5 ^{124}Sb

This nuclide is formed by activation of ^{123}Sb (which is present in reactor shielding or as a fission product). Performance at the higher level is similar to last time, but there is a clear reduction in the spread of the data at the lower level, despite the fact that the activity of this nuclide at the time of measurement would have been low.

7.6 ^{125}Sb

This is a fission product and is prevalent in waste effluent streams. Although there is noticeably more discrepant data at the higher level than before, there has been a reduction in spread at both activity levels, suggesting that the summing correction require for analysing this nuclide has been widely applied.

7.7 ^{134}Cs

This nuclide occurs in nuclear waste and is present in various ecosystems. This nuclide has been included in many previous exercises on account of its being very widely assayed in environmental samples. The need for cascade summing corrections[19] has been emphasised but, curiously, the low biases of the reported data suggest that they are still not being applied in some cases. The bias is less clear at the lower activity level, probably because of the larger uncertainties on the measurements.

7.8 ^{137}Cs

This is a fission product and is also used as a calibration radionuclide. It occurs widely in the environment. Overall performance is similar to the last exercise: there has been a slight reduction in the levels of discrepant data and a similar proportion (74 %) of the submitted data are unambiguously correct.

7.9 ^{154}Eu

This nuclide is formed by neutron activation of stable europium, and emits γ-rays across the whole γ-ray energy range. It is quite possible to misidentify this nuclide as one of several others, e.g. ^{152}Eu, ^{56}Co, ^{124}Sb, ^{108}Ag, ^{95}Zr and ^{22}Na.

There is a greater proportion of dubious results at the lower level than in the last exercise, possibly due to the presence of ^{22}Na, which was not a component of the mixture last time, and which will contribute to the 1274 keV peak. It is interesting to note that some laboratories reported discrepant data for both nuclides. This nuclide exhibits cascade summing effects and there seems to be an overall small low bias suggesting that some analysts have not applied a correction for this.

7.10 ^{155}Eu

This is another fission product, albeit with a low fission yield. Measurement of this nuclide is complicated by the fact that it emits (low energy) γ-rays in an energy range where the rate of change of detector efficiency with energy is large. The results at the higher level are similar to last time, and performance at the lower level has improved, with fewer discrepant data now being evident.

7.11 ^{207}Bi

This is another electron-capture nuclide, with a very weak positron branch, and this too is included for the first time in this series of exercises. A large proportion of the results are discrepant, particularly at the lower level. One might expect cascade

summing effects to affect the results for this nuclide as well, and there does appear to be a low bias at the higher activity level.

8 DISCUSSION

8.1 α-EMITTERS

The number of measurements of α-emitting radionuclides performed was somewhat lower than in the last exercise. The level of performance for ^{241}Am and the plutonium nuclides was similar to last time, the main finding being that low biases for the plutonium nuclides have again been observed. It was hoped that the recent standardisation of ^{238}Pu and ^{239}Pu at NPL would have resolved previously-found problems with measuring these nuclides, but these problems clearly remain.

The nuclide ^{226}Ra, introduced for the first time, was measured successfully, although only a small number of laboratories assayed this nuclide and this is insufficient data from which to draw any conclusions about performance nationally.

One laboratory used ICPMS (amongst other techniques) for measuring ^{226}Ra, ^{239}Pu and ^{241}Am, obtaining agreement with the reference value in each case, but no conclusions can be drawn on the usefulness of this method on the basis of just one set of results.

It should be noted that NPL recently participated in an international comparison of ^{238}Pu with a number of other national measurement institutes. The final results of this exercise are not yet available, but preliminary data indicate that the NPL value will not differ significantly from the overall mean value, thus giving NPL additional confidence in its standard.

8.2 β-EMITTERS

The number of results returned was disappointingly low for most of these nuclides (the return for tritium being rather better), and, again, it is difficult to draw conclusions about countrywide performance from the corpus of data available. Problems had been evident with ^{90}Sr in the last comparison and it was hoped that significant amounts of data would be returned so that any trends could be monitored. Similarly, it was hoped that more laboratories would attempt ^{210}Pb analyses.

8.3 β / γ-EMITTERS

The results appear to demonstrate several points:

(i) The overall level of discrepant data has fallen, most notably at the higher activity level (2 Bq g^{-1}), suggesting that analysts generally are carrying out more rigorous estimates of uncertainties.
(ii) Some analysts experienced problems with measuring ^{22}Na and ^{207}Bi – in the case of ^{22}Na, this may have been due to the presence of ^{154}Eu.
(iii) Cascade summing effects are still evident, particularly with measurements of ^{134}Cs.
(iv) Performance for the radionuclides used in detector calibration (^{60}Co and ^{137}Cs) has improved still further in that the proportions of unambiguously correct results have clearly increased, now being 85 % and 74 % respectively.

8.4 GENERAL COMMENTS

8.4.1 Nuclear Decay Data

The wide usage of data from internationally recognised sources continues. The vast majority of data cited for the α- and pure β-emitters was taken from the recently-published version of the Radiochemical Manual[18] , but the data for β/γ-emitters was also drawn from other sources, most notably NPL, IAEA, JEF 2.2 and Browne and Firestone. Many participants used 'in-house' data libraries for the assay of the β/γ-emitters; this is sound practice provided that the data used is from a reliable source. A small number of participants used manufacturers' data, which is acceptable practice provided that the user checks the provenance of the data and makes adjustments as necessary.

The number of laboratories using data which are not recommended (or are of unknown origin) is now very small. Analysts having any doubts as to the reliability of their data should consult NPL, who will happily advise.

8.4.2 Standards

Of those laboratories who cited standards, all used β/γ-emitting standards of the mixed radionuclide type for measuring the β/γ-emitters with one laboratory supplementing such a calibration with single nuclide standards; for the α/β assays, the standards and chemical yield tracers cited had been obtained from NPL, NIST, Nycomed Amersham or AEA Technology.

9 CONCLUSIONS

There are mixed conclusions to be drawn from this comparison exercise.

On the positive side, fewer discrepant results were submitted for the β/γ-emitters then in past exercises, possibly as a result of analysts compiling more comprehensive uncertainty budgets than before. Performance in the assay of many β/γ-emitters, including calibration nuclides, continues to improve. The usage of traceable standards and reliable nuclear data remains high.

There are, however, some areas of concern. The assay of the plutonium nuclides are still exhibiting low biases; cascade summing effects are still evident (e.g. for ^{134}Cs

measurements); and the lack of reported data for ^{90}Sr means that the problems evident from the last comparison may still remain.

That said, it is also clear that many laboratories are now measuring β/γ-emitters at these levels, in an aqueous matrix, with little difficulty and, indeed, some have expressed interest in moving on to a non-aqueous matrix to more closely mimic performance for field samples. It may now be appropriate to try such a matrix for the next exercise, perhaps at one activity level and with the less problematic nuclides.

Concluding, it can be said:

(i) there remains scope for improvement in performance for specific β/γ-emitters, notably ^{22}Na, ^{207}Bi and ^{134}Cs;

(ii) more data are required for the β-emitting samples to enable national performance levels to be monitored and any specific metrological problems to be identified;

(iii) NPL needs to address specific assay problems (e.g. ^{90}Sr, plutonium nuclides) in parallel with future comparisons;

(iv) consideration should be given to including a non-aqueous matrix in the next exercise.

10 ACKNOWLEDGEMENTS

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Table 1- ABHxx/01 - principal radionuclides.

Radionuclide	Decay mode	Activity concentration @ 1200 GMT 01/03/01 (Bq g^{-1})	Standard uncertainty (k = 1) (Bq g^{-1})
^{3}H	β^-	20.02	0.21
^{90}Sr	β^-	1.991	0.006
^{99}Tc	β^-	2.031	0.014
^{210}Pb	β^-/γ	3.367	0.048
^{226}Ra	α/γ	2.013	0.026
^{238}Pu	α	2.021	0.011
^{239}Pu	α	2.018	0.017
^{241}Am	α/γ	2.060	0.018

Table 2 - ABHxx/01 - impurities.

Radionuclide	Decay mode	Activity concentration @ 1200 GMT 1/10/99 (Bq g^{-1})	Standard uncertainty (k = 1) (Bq g^{-1})
^{241}Pu	β^-	< 0.04	-
unspecified α-emitters	α	< 0.001	-

Table 3- ABLxx/01 – principal radionuclides.

Radionuclide	Decay mode	Activity concentration @ 1200 GMT 01/03/01 (Bq kg^{-1})	Standard uncertainty (k = 1) (Bq kg^{-1})
^{3}H	β^-	25.03	0.54
^{90}Sr	β^-	2.489	0.048
^{99}Tc	β^-	2.539	0.051
^{210}Pb	β^-/γ	4.210	0.083
^{226}Ra	α/γ	2.517	0.058
^{238}Pu	α	2.526	0.050
^{239}Pu	α	2.523	0.053
^{241}Am	α/γ	2.576	0.054

Table 4 - ABLxx/01 - impurities.

Radionuclide	Decay mode	Activity concentration @ 1200 GMT 1/10/99 (Bq kg^{-1})	Standard uncertainty (k = 1) (Bq kg^{-1})
^{241}Pu	β^-	< 0.05	-
unspecified α-emitters	α	< 0.001	-

Table 5 - Principal radionuclides - BGHxxx/00

Radionuclide	Decay mode	Activity concentration @ 1200 GMT 01/03/01 (Bq g^{-1})	Standard uncertainty (k = 1) (Bq g^{-1})
^{22}Na	e.c., β^+/γ	2.526	0.038
^{60}Co	β^-/γ	2.502	0.023
^{65}Zn	e.c., β^+/γ	2.478	0.068
^{124}Sb	β^-/γ	2.545	0.085
^{125}Sb	β^-/γ	2.628	0.020
^{134}Cs	β^-/γ	2.522	0.018
^{137}Cs	β^-,β^-/γ	2.520	0.018
^{154}Eu	β^-/γ	2.557	0.018
^{155}Eu	β^-/γ	2.566	0.061
^{207}Bi	e.c., β^+/γ	2.551	0.026

Table 6 - BGHxxx/00 impurities

Radionuclide	Decay mode	Activity concentration @1200 GMT 1/10/99 (Bq g^{-1})	Standard uncertainty (k = 1) (Bq kg^{-1})
^{152}Eu	β^-/γ	0.044	0.004

Table 7 - Principal radionuclides – BGLxxx/00

Radionuclide	Decay mode	Activity concentration @ 1200 GMT 01/03/01 (Bq kg^{-1})	Standard uncertainty (k = 1) (Bq kg^{-1})
^{22}Na	e.c., β^+/γ	2.586	0.043
^{60}Co	β/γ	2.562	0.030
^{65}Zn	e.c., β^+/γ	2.537	0.072
^{124}Sb	β/γ	2.605	0.089
^{125}Sb	β/γ	2.691	0.028
^{134}Cs	β/γ	2.583	0.026
^{137}Cs	$\beta,\beta/\gamma$	2.581	0.027
^{154}Eu	β/γ	2.618	0.026
^{155}Eu	β/γ	2.628	0.065
^{207}Bi	e.c., β^+/γ	2.612	0.032

Table 8 - BGLxxx/00 - impurities

Radionuclide	Decay mode	Activity concentration @1200 GMT 1/10/99 (Bq kg^{-1})	Standard uncertainty (k = 1) (Bq kg^{-1})
^{152}Eu	β/γ	0.045	0.004

Table 9 - Radionuclide provenance

Radionuclide	Origin	Calibrating Laboratory	Traceability
^{226}Ra	CMI, Czech Republic	NPL	UK Primary Standard / NPL
^{238}Pu	TENEX, Russia	NPL	UK Primary Standard / NPL
^{239}Pu	TENEX, Russia	NPL	UK Primary Standard / NPL
^{241}Am	NA, UK	NPL	UK Primary Standard / NPL
^{3}H	NA, UK	NPL	UK Primary Standard / NPL
^{90}Sr	NA, UK	NPL	UK Primary Standard / NPL
^{99}Tc	NA, UK	NPL	UK Primary Standard / NPL*
^{210}Pb	DKD, Germany	DKD	German Primary Standard / PTB
^{22}Na	NA, UK	NPL	UK Primary Standard / NPL
^{60}Co	NA, UK	NPL	UK Primary Standard / NPL
^{65}Zn	NA, UK	NPL	UK Primary Standard / NPL
^{124}Sb	NA, UK	NPL	UK Primary Standard / NPL
^{125}Sb	NA, UK	NPL	UK Primary Standard / NPL
^{134}Cs	NA, UK	NPL	UK Primary Standard / NPL
^{137}Cs	NA, UK	NPL	UK Primary Standard / NPL
^{154}Eu	NPL, UK	NPL	UK Primary Standard / NPL
^{155}Eu	IIR, Czech Republic	NPL	UK Primary Standard / NPL
^{207}Bi	NA, UK	NPL	UK Primary Standard / NPL

* Provisional, to be confirmed

CMI: Czech Metrological Institute, Czech Republic
TENEX: TENEX All-Union Foreign Economic Association Techsnabexport, Russia
NA: Nycomed-Amersham, UK
DKD: Deutscher Kalibrierdienst, Germany
PTB: Physikalisch-Technische Bundesanstalt, Germany
IIR: Inspektorát pro Ionizující Záreni, Czech Republic

Table 10- Criteria for u-tests

Value	Conclusion
$u < 1.64$	The values do not differ significantly
$1.64 < u < 1.96$	The values probably do not differ significantly but more data are required to confirm this
$1.96 < u < 2.58$	One cannot say whether there is a significant difference without further data
$2.58 < u < 3.29$	The values probably differ significantly but more data are required to confirm this
$3.29 < u$	The values differ significantly

Table 11 - Nuclear decay data

Nuclide	Half life (days)	Eγ (keV)	Pγ (%)	Reference
^{3}H	4504 ± 8	-	-	[20]
^{22}Na	950.8 ± 0.9	1274.5	99.935 ± 0.015	[21]
^{60}Co	1925.5 ± 0.5	1173.2	99.857 ± 0.022	[21]
		1332.5	99.983 ± 0.006	[21]
^{65}Zn	244.26 ± 0.26	1115.5	50.6 ± 0.24	[21]
^{90}Sr	10460 ± 60	-	-	[22]
^{99}Tc	(7.718 ± 0.040) x 10^{7}	-	-	[22]
^{125m}Te	57.40 ± 0.15	35.5	6.67 ± 0.20	[23]
^{124}Sb	60.24 ± 0.09	602.7	97.80 ± 0.10	[22]
		645.9	7.40 ± 0.07	[22]
		709.3	1.400 ± 0.020	[22]
		713.8	2.340 ± 0.030	[22]
		722.8	10.97 ± 0.12	[22]
		968.2	1.92 ± 0.04	[22]
		1045.1	1.860 ± 0.020	[22]
		1325.5	1.55 ± 0.05	[22]
		1355.2	1.06 ± 0.05	[22]

Nuclide	Half life (days)	Eγ (keV)	Pγ (%)	Reference
		1368.2	2.60 ± 0.08	[22]
		1436.6	1.22 ± 0.07	[22]
		1691.0	48.4 ± 0.6	[22]
		2091.0	5.57 ± 0.06	[22]
^{125}Sb	1007.7 ± 0.6	176.3	6.85 ± 0.07	[21]
		380.5	1.518 ± 0.016	[21]
		427.9	29.7 ± 0.3	[21]
		463.4	10.48 ± 0.11	[21]
		600.6	17.73 ± 0.18	[21]
		606.7	5.00 ± 0.05	[21]
		636.0	11.21 ± 0.12	[21]
^{134}Cs	754.28 ± 0.22	475.4	1.49 ± 0.02	[21]
		563.2	8.36 ± 0.03	[21]
		569.3	15.39 ± 0.06	[21]
		604.7	97.63 ± 0.06	[21]
		795.9	85.4 ± 0.3	[21]
		801.9	8.69 ± 0.03	[21]
		1168.0	1.792 ± 0.007	[21]
		1365.2	3.016 ± 0.011	[21]
^{137}Cs	11020 ± 60	661.7	85.1 ± 0.2	[21]
^{154}Eu	3136.8 ± 2.9	123.1	41.2 ± 0.5	[21]
		247.9	6.95 ± 0.09	[21]
		591.8	4.99 ± 0.06	[21]
		692.4	1.80 ± 0.03	[21]
		723.3	20.2 ± 0.2	[21]
		756.8	4.58 ± 0.06	[21]
		873.2	12.24 ± 0.15	[21]
		996.3	10.48 ± 0.13	[21]
		1004.7	18.2 ± 0.2	[21]
		1274.4	35.0 ± 0.4	[21]

Nuclide	Half life (days)	Eγ (keV)	Pγ (%)	Reference
^{155}Eu	1770 ± 50	60.0	1.13 ± 0.05	[21] / [23]
		86.5	30.7 ± 0.7	[23]
		105.3	21.2± 0.5`	[23]
^{207}Bi	(1.16 ± 0.07) x 10^4	569.7	97.74 ± 0.03	[21]
		1063.7	74.5 ± 0.2	[21]
		1770.2	6.87 ± 0.04	[21]
^{210}Pb	(8.15 ± 0.08) x 10^3	46.5	4.5 ± 0.3	[18]
^{226}Ra	(5.844 ± 0.026) x 10^5	186.0	32.8 ± 0.3	[18]
^{238}Pu	(3.203 ± 0.011) x 10^4	-	-	[24]
^{239}Pu	(8.806 ± 0.011) x 10^6	-	-	[24]
^{241}Am	(1.5785 ± 0.0024) x 10^5	59.5	36.0 ± 0.4	[21]

Table 12 - results of u-tests for α- and α/γ-emitters

NUCLIDE	LIMITS	NUMBER OF RESULTS HIGH LEVEL	NUMBER OF RESULTS LOW LEVEL
^{226}Ra	< 1.64	4	1
	1.64 - 1.96	1	0
	1.96 - 2.58	0	1
	2.58 - 3.29	0	0
	> 3.29	0	0
^{238}Pu	< 1.64	6	4
	1.64 - 1.96	0	0
	1.96 - 2.58	2	3
	2.58 - 3.29	1	0
	> 3.29	0	3
^{239}Pu	< 1.64	7	8
	1.64 - 1.96	0	2
	1.96 - 2.58	1	1
	2.58 - 3.29	1	0
	> 3.29	1	1
^{241}Am	< 1.64	7	6
	1.64 - 1.96	0	0
	1.96 - 2.58	0	2
	2.58 - 3.29	1	0
	> 3.29	2	0

Table 13 - Results of u-tests for β- and β/γ-emitters (in α/β mixture)

NUCLIDE	LIMITS	NUMBER OF RESULTS HIGH LEVEL	NUMBER OF RESULTS LOW LEVEL
^{3}H	< 1.64	6	5
	1.64 - 1.96	2	0
	1.96 - 2.58	1	1
	2.58 - 3.29	0	0
	> 3.29	2	2
^{90}Sr	< 1.64	2	3
	1.64 - 1.96	0	0
	1.96 - 2.58	2	0
	2.58 - 3.29	0	0
	> 3.29	0	1
^{99}Tc	< 1.64	1	2
	1.64 - 1.96	0	0
	1.96 - 2.58	0	2
	2.58 - 3.29	1	0
	> 3.29	0	0
^{210}Pb	< 1.64	2	2
	1.64 - 1.96	0	0
	1.96 - 2.58	0	0
	2.58 - 3.29	1	0
	> 3.29	0	2

Table 14 - Results of u-tests for β/γ-emitters

NUCLIDE	LIMITS	NUMBER OF RESULTS HIGH LEVEL	NUMBER OF RESULTS LOW LEVEL
^{22}Na	< 1.64	7	11
	1.64 - 1.96	3	1
	1.96 - 2.58	2	2
	2.58 - 3.29	2	0
	> 3.29	8	2
	* maximum	0	0
^{60}Co	< 1.64	24	15
	1.64 - 1.96	0	0
	1.96 - 2.58	0	1
	2.58 - 3.29	0	2
	> 3.29	3	1
	* maximum	0	0
^{65}Zn	< 1.64	22	17
	1.64 - 1.96	0	0
	1.96 - 2.58	0	1
	2.58 - 3.29	0	0
	> 3.29	5	0
	* maximum	0	1
^{124}Sb	< 1.64	16	11
	1.64 - 1.96	2	0
	1.96 - 2.58	3	0
	2.58 - 3.29	3	1
	> 3.29	1	0
	* maximum	0	2
^{125}Sb	< 1.64	20	17
	1.64 - 1.96	0	0
	1.96 - 2.58	2	0
	2.58 - 3.29	2	0
	> 3.29	3	0
	* maximum	0	1

* Number of results quoted as maximum values

Table 14 (continued) - Results of u-tests for β / γ-emitters

NUCLIDE	LIMITS	NUMBER OF RESULTS HIGH LEVEL	NUMBER OF RESULTS LOW LEVEL
^{134}Cs	< 1.64	10	11
	1.64 - 1.96	2	3
	1.96 - 2.58	2	1
	2.58 - 3.29	4	1
	> 3.29	9	1
	* maximum	0	1
^{137}Cs	< 1.64	19	15
	1.64 - 1.96	3	0
	1.96 - 2.58	1	2
	2.58 - 3.29	0	0
	> 3.29	4	1
	* maximum	0	1
^{154}Eu	< 1.64	12	10
	1.64 - 1.96	2	1
	1.96 - 2.58	2	1
	2.58 - 3.29	3	4
	> 3.29	4	2
	* maximum	0	0
^{155}Eu	< 1.64	17	17
	1.64 - 1.96	0	1
	1.96 - 2.58	1	1
	2.58 - 3.29	3	0
	> 3.29	3	0
	* maximum	0	0
^{207}Bi	< 1.64	14	12
	1.64 - 1.96	1	0
	1.96 - 2.58	0	2
	2.58 - 3.29	4	3
	> 3.29	5	1
	* maximum	0	0

* Number of results quoted as maximum values

Table 15 – Results for ^{3}H (low level)

Sample	Reference value		Analyst's result		Deviation (%)	u-test statistic
ABL***/01	^{3}H Bq kg^{-1}	± Bq kg^{-1}	^{3}H Bq kg^{-1}	± Bq kg^{-1}		
ABL004/01	25.03	0.54	13.2	2.9	-47.26	4.01
ABL005/01	25.03	0.54	24.8	0.6	-0.92	0.28
ABL006/01	25.03	0.54	28.3	1.2	13.06	2.48
ABL009/01	25.03	0.54	26.46	2.25	5.71	0.62
ABL012/01	25.03	0.54	51.54	5.4	105.91	4.88
ABL014/01	25.03	0.54	25	3.5	-0.12	0.01
ABL015/01	25.03	0.54	28	6	11.87	0.49
ABL019/01	25.03	0.54	29	3	15.86	1.30

Table 16 – Results for ^{90}Sr (low level)

Sample	Reference value		Analyst's result		Deviation (%)	u-test statistic
ABL***/01	^{90}Sr Bq kg^{-1}	± Bq kg^{-1}	^{90}Sr Bq kg^{-1}	± Bq kg^{-1}		
ABL004/01	2.489	0.048	3.9	0.39	56.69	3.59
ABL005/01	2.489	0.048	2.65	0.58	6.47	0.28
ABL009/01	2.489	0.048	2.52	0.5	1.25	0.06
ABL015/01	2.489	0.048	2.39	0.96	-3.98	0.10

Table 17 – Results for ^{99}Tc (low level)

Sample	Reference value		Analyst's result		Deviation (%)	u-test statistic
ABL***/01	^{99}Tc Bq kg^{-1}	± Bq kg^{-1}	^{99}Tc Bq kg^{-1}	± Bq kg^{-1}		
ABL005/01	2.539	0.051	2.89	0.16	13.82	2.09
ABL009/01a	2.539	0.051	2.59	0.16	2.01	0.30
ABL009/01b	2.539	0.051	2.18	0.14	-14.14	2.41
ABL009/01c	2.539	0.051	2.6	0.16	2.40	0.36

Table 18 – Results for ^{210}Pb (low level)

Sample	Reference value		Analyst's result		Deviation (%)	u-test statistic
ABL***/01	^{210}Pb Bq kg^{-1}	± Bq kg^{-1}	^{210}Pb Bq kg^{-1}	± Bq kg^{-1}		
ABL005/01	4.210	0.083	3.88	0.35	-7.84	0.92
ABL009/01a	4.210	0.083	3.22	0.2	-23.52	4.57
ABL009/01b	4.210	0.083	3.23	0.2	-23.28	4.53
ABL010/01	4.210	0.083	3.9	0.2	-7.36	1.43

Table 19 – Results for ^{226}Ra (low level)

Sample	Reference value		Analyst's result		Deviation (%)	u-test statistic
ABL***/01	^{226}Ra Bq kg^{-1}	± Bq kg^{-1}	^{226}Ra Bq kg^{-1}	± Bq kg^{-1}		
ABL009/01a	2.517	0.058	2.62	0.22	4.09	0.45
ABL009/01b	2.517	0.058	3.32	0.38	31.90	2.09

Table 20 – Results for ^{238}Pu (low level)

Sample	Reference value		Analyst's result		Deviation (%)	u-test statistic
ABL***/01	^{238}Pu Bq kg^{-1}	± Bq kg^{-1}	^{238}Pu Bq kg^{-1}	± Bq kg^{-1}		
ABL004/01	2.526	0.050	2.37	0.17	-6.18	0.88
ABL005/01	2.526	0.050	2.28	0.1	-9.74	2.20
ABL009/01	2.526	0.050	2.29	0.54	-9.34	0.44
ABL010/01	2.526	0.050	2.1	0.1	-16.86	3.81
ABL012/01	2.526	0.050	2.246	0.112	-11.08	2.28
ABL014/01	2.526	0.050	2.34	0.06	-7.36	2.38
ABL015/01a	2.526	0.050	2.19	0.2	-13.30	1.63
ABL015/01b	2.526	0.050	2.2	0.2	-12.91	1.58
ABL019/01	2.526	0.050	2.16	0.09	-14.49	3.55
ABL024/01	2.526	0.050	2.011	0.096	-20.39	4.76

Table 21 – Results for ^{239}Pu (low level)

Sample	Reference value		Analyst's result		Deviation (%)	u-test statistic
ABL***/01	^{239}Pu Bq kg^{-1}	± Bq kg^{-1}	^{239}Pu Bq kg^{-1}	± Bq kg^{-1}		
ABL004/01	2.523	0.053	2.68	0.13	6.22	1.12
ABL005/01a	2.523	0.053	2.48	0.1	-1.70	0.38
ABL005/01b	2.523	0.053	2.53	0.18	0.28	0.04
ABL009/01	2.523	0.053	2.38	0.56	-5.67	0.25
ABL010/01	2.523	0.053	2.3	0.1	-8.84	1.97
ABL012/01	2.523	0.053	2.546	0.127	0.91	0.17
ABL014/01	2.523	0.053	1.46	0.05	-42.13	14.59
ABL015/01a	2.523	0.053	2.2	0.2	-12.80	1.56
ABL015/01b	2.523	0.053	2.39	0.2	-5.27	0.64
ABL019/01	2.523	0.053	2.39	0.1	-5.27	1.18
ABL024/01	2.523	0.053	2.306	0.112	-8.60	1.75

Table 22 – Results for ^{241}Am (low level)

Sample	Reference value		Analyst's result		Deviation (%)	u-test statistic
ABL***/01	^{241}Am Bq kg^{-1}	± Bq kg^{-1}	^{241}Am Bq kg^{-1}	± Bq kg^{-1}		
ABL004/01	2.576	0.054	2.99	0.45	16.07	0.91
ABL005/01	2.576	0.054	2.43	0.56	-5.67	0.26
ABL009/01	2.576	0.054	2.59	0.11	0.54	0.11
ABL010/01	2.576	0.054	2.5	0.1	-2.95	0.67
ABL012/01	2.576	0.054	2.8	0.14	8.70	1.49
ABL013/01	2.576	0.054	3.86	0.57	49.84	2.24
ABL019/01	2.576	0.054	2.352	0.08	-8.70	2.32
ABL022/01	2.576	0.054	2.44	0.13	-5.28	0.97

Table 23 – Results for ^{3}H (high level)

Sample	Reference value		Analyst's result		Deviation (%)	u-test statistic
ABH***/01	^{3}H Bq g^{-1}	± Bq g^{-1}	^{3}H Bq g^{-1}	± Bq g^{-1}		
ABH003/01	20.02	0.21	18.338	0.823	-8.40	1.98
ABH004/01	20.02	0.21	12.3	0.56	-38.56	12.91
ABH005/01a	20.02	0.21	20.4	0.5	1.90	0.70
ABH005/01b	20.02	0.21	19.4	0.8	-3.10	0.75
ABH007/01	20.02	0.21	20.87	0.7	4.25	1.16
ABH008/01	20.02	0.21	22.4	2.24	11.89	1.06
ABH010/01	20.02	0.21	20.57	1	2.75	0.54
ABH012/01	20.02	0.21	15.03	0.9	-24.93	5.40
ABH013/01	20.02	0.21	22.9	1.6	14.39	1.78
ABH018/01	20.02	0.21	20.92	0.46	4.50	1.78
ABH019/01	20.02	0.21	20.3	0.85	1.40	0.32

Table 24 – Results for ^{90}Sr (high level)

Sample	Reference value		Analyst's result		Deviation (%)	u-test statistic
ABH***/01	^{90}Sr Bq g^{-1}	± Bq g^{-1}	^{90}Sr Bq g^{-1}	± Bq g^{-1}		
ABH003/01	1.991	0.006	2.12	0.2	6.48	0.64
ABH004/01	1.991	0.006	1.86	0.06	-6.58	2.17
ABH005/01	1.991	0.006	1.89	0.05	-5.07	2.01
ABH012/01	1.991	0.006	1.89	0.2	-5.07	0.50

Table 25 – Results for ^{99}Tc (high level)

Sample	Reference value		Analyst's result		Deviation (%)	u-test statistic
ABH***/00	^{99}Tc Bq g^{-1}	± Bq g^{-1}	^{99}Tc Bq g^{-1}	± Bq g^{-1}		
ABH004/01	2.031	0.014	2.31	0.09	13.74	3.06
ABH007/01	2.031	0.014	2.06	0.13	1.43	0.22

Table 26 – Results for ^{210}Pb (high level)

Sample	Reference value		Analyst's result		Deviation (%)	u-test statistic
ABH***/01	^{210}Pb Bq g^{-1}	± Bq g^{-1}	^{210}Pb Bq g^{-1}	± Bq g^{-1}		
ABH004/01	3.367	0.048	3.5	0.09	3.95	1.30
ABH010/01	3.367	0.048	3.053	0.109	-9.33	2.64
ABH012/01	3.367	0.048	2.9	0.3	-13.87	1.54

Table 27 – Results for ^{226}Ra (high level)

Sample	Reference value		Analyst's result		Deviation (%)	u-test statistic
ABH***/01	^{226}Ra Bq g^{-1}	± Bq g^{-1}	^{226}Ra Bq g^{-1}	± Bq g^{-1}		
ABH004/01a	2.013	0.026	1.93	0.12	-4.12	0.68
ABH004/01b	2.013	0.026	2.3	0.23	14.26	1.24
ABH007/01	2.013	0.026	1.67	0.18	-17.04	1.89
ABH010/01	2.013	0.026	1.902	0.07	-5.51	1.49
ABH012/01	2.013	0.026	2.2	0.2	9.29	0.93

Table 28 – Results for ^{238}Pu (high level)

Sample	Reference value		Analyst's result		Deviation (%)	u-test statistic
ABH***/01	^{238}Pu Bq g^{-1}	± Bq g^{-1}	^{238}Pu Bq g^{-1}	± Bq g^{-1}		
ABH003/01	2.021	0.011	1.844	0.055	-8.76	3.16
ABH004/01	2.021	0.011	1.92	0.26	-5.00	0.39
ABH005/01a	2.021	0.011	1.9	0.06	-5.99	1.98
ABH005/01b	2.021	0.011	1.99	0.04	-1.53	0.75
ABH007/01	2.021	0.011	1.898	0.051	-6.09	2.36
ABH010/01	2.021	0.011	1.937	0.098	-4.16	0.85
ABH012/01a	2.021	0.011	1.82	0.2	-9.95	1.00
ABH012/01b	2.021	0.011	1.79	0.2	-11.43	1.15
ABH017/01	2.021	0.011	1.973	0.051	-2.38	0.92

Table 29 – Results for ^{239}Pu (high level)

Sample	Reference value		Analyst's result		Deviation (%)	u-test statistic
ABH***/01	^{239}Pu Bq g^{-1}	± Bq g^{-1}	^{239}Pu Bq g^{-1}	± Bq g^{-1}		
ABH003/01	2.018	0.017	1.802	0.053	-10.70	3.88
ABH004/01a	2.018	0.017	2.17	0.29	7.53	0.52
ABH004/01b	2.018	0.017	2.14	0.21	6.05	0.58
ABH005/01a	2.018	0.017	1.88	0.06	-6.84	2.21
ABH005/01b	2.018	0.017	2.01	0.04	-0.40	0.18
ABH007/01	2.018	0.017	1.866	0.051	-7.53	2.83
ABH010/01	2.018	0.017	1.926	0.098	-4.56	0.92
ABH012/01a	2.018	0.017	1.87	0.2	-7.33	0.74
ABH012/01b	2.018	0.017	1.86	0.2	-7.83	0.79
ABH017/01	2.018	0.017	1.988	0.052	-1.49	0.55

Table 30 – Results for ^{241}Am (high level)

Sample	Reference value		Analyst's result		Deviation (%)	u-test statistic
ABH***/01	^{241}Am Bq g^{-1}	± Bq g^{-1}	^{241}Am Bq g^{-1}	± Bq g^{-1}		
ABH003/01	2.060	0.018	1.621	0.043	-21.31	9.42
ABH004/01a	2.060	0.018	2.13	0.33	3.40	0.21
ABH004/01b	2.060	0.018	2.03	0.11	-1.46	0.27
ABH004/01c	2.060	0.018	2.11	0.21	2.43	0.24
ABH005/01	2.060	0.018	1.96	0.03	-4.85	2.86
ABH007/01	2.060	0.018	2	0.058	-2.91	0.99
ABH010/01a	2.060	0.018	2.074	0.074	0.68	0.18
ABH010/01b	2.060	0.018	1.942	0.097	-5.73	1.20
ABH011/01	2.060	0.018	2.83	0.14	37.38	5.46
ABH012/01	2.060	0.018	2.1	0.2	1.94	0.20

Table 31 – Results for ^{22}Na (low level)

Sample	Reference value		Analyst's result		Deviation (%)	u-test statistic
BGL***/00	^{22}Na Bq kg^{-1}	± Bq kg^{-1}	^{22}Na Bq kg^{-1}	± Bq kg^{-1}		
BGL004/00	2.586	0.043	3.16	1.01	22.20	0.57
BGL005/00	2.586	0.043	2.36	0.18	-8.74	1.22
BGL006/00	2.586	0.043	2.36	0.18	-8.74	1.22
BGL007/00	2.586	0.043	3.28	0.19	26.84	3.56
BGL008/00	2.586	0.043	2.41	0.11	-6.81	1.49
BGL010/00	2.586	0.043	2.9	0.6	12.14	0.52
BGL012/00	2.586	0.043	3.74	0.31	44.62	3.69
BGL013/00	2.586	0.043	2.67	0.27	3.25	0.31
BGL014/00	2.586	0.043	2.1	1	-18.79	0.49
BGL018/00	2.586	0.043	2.18	0.18	-15.70	2.19
BGL020/00	2.586	0.043	2.2	0.35	-14.93	1.09
BGL021/00	2.586	0.043	2.4	0.11	-7.19	1.57
BGL022/00	2.586	0.043	2.18	0.23	-15.70	1.74
BGL024/00	2.586	0.043	3.061	0.2	18.37	2.32
BGL025/00	2.586	0.043	2.48	0.14	-4.10	0.72
BGL026/00	2.586	0.043	2.38	0.136	-7.97	1.44

Table 32 – Results for ^{60}Co (low level)

Sample	Reference value		Analyst's result		Deviation (%)	u-test statistic
BGL***/00	^{60}Co Bq kg^{-1}	± Bq kg^{-1}	^{60}Co Bq kg^{-1}	± Bq kg^{-1}		
BGL004/00	2.562	0.030	2.84	0.9	10.85	0.31
BGL005/00	2.562	0.030	2.51	0.16	-2.03	0.32
BGL006/00	2.562	0.030	2.51	0.16	-2.03	0.32
BGL007/00	2.562	0.030	3.35	0.3	30.76	2.61
BGL008/00	2.562	0.030	2.66	0.07	3.83	1.29
BGL010/00	2.562	0.030	2.7	0.2	5.39	0.68
BGL011/00	2.562	0.030	3.1393	0.2903	22.53	1.98
BGL012/00	2.562	0.030	2.43	0.17	-5.15	0.76
BGL013/00	2.562	0.030	2.5	0.22	-2.42	0.28
BGL014/00	2.562	0.030	4.1	1	60.03	1.54
BGL018/00	2.562	0.030	2.21	0.13	-13.74	2.64
BGL019/00	2.562	0.030	2.33	0.17	-9.06	1.34
BGL020/00	2.562	0.030	2.56	0.25	-0.08	0.01
BGL021/00	2.562	0.030	2.7	0.1	5.39	1.32
BGL022/00	2.562	0.030	2.62	0.18	2.26	0.32
BGL024/00	2.562	0.030	1.902	0.131	-25.76	4.91
BGL025/00	2.562	0.030	2.61	0.084	1.87	0.54
BGL026/00	2.562	0.030	2.549	0.138	-0.51	0.09
BGL027/00	2.562	0.030	2.7	0.2	5.39	0.68

Table 33 – Results for ^{65}Zn (low level)

Sample	Reference value		Analyst's result		Deviation (%)	u-test statistic
BGL***/00	^{65}Zn Bq kg^{-1}	± Bq kg^{-1}	^{65}Zn Bq kg^{-1}	± Bq kg^{-1}		
BGL004/00	2.537	0.072	3.69	1.18	45.45	0.98
BGL005/00	2.537	0.072	2.88	0.3	13.52	1.11
BGL006/00	2.537	0.072	2.88	0.3	13.52	1.11
BGL007/00	2.537	0.072	2.71	0.39	6.82	0.44
BGL008/00	2.537	0.072	2.65	0.15	4.45	0.68
BGL010/00	2.537	0.072	2.7	0.3	6.42	0.53
BGL011/00	2.537	0.072	2.5309	0.6235	-0.24	0.01
BGL012/00	2.537	0.072	2.19	0.46	-13.68	0.75
BGL013/00	2.537	0.072	2.7	0.7	6.42	0.23
BGL014/00	2.537	0.072	< 7	-	-	-
BGL018/00	2.537	0.072	2.27	0.33	-10.52	0.79
BGL019/00	2.537	0.072	2.44	0.22	-3.82	0.42
BGL020/00	2.537	0.072	3.38	0.35	33.23	2.36
BGL021/00	2.537	0.072	2.3	0.23	-9.34	0.98
BGL022/00	2.537	0.072	2.65	0.45	4.45	0.25
BGL024/00	2.537	0.072	2.694	0.847	6.19	0.18
BGL025/00	2.537	0.072	2.28	0.23	-10.13	1.07
BGL026/00	2.537	0.072	2.794	0.297	10.13	0.84
BGL027/00	2.537	0.072	3.1	0.6	22.19	0.93

Table 34 – Results for ^{124}Sb (low level)

Sample	Reference value		Analyst's result		Deviation (%)	u-test statistic
BGL***/00	^{124}Sb Bq kg^{-1}	± Bq kg^{-1}	^{124}Sb Bq kg^{-1}	± Bq kg^{-1}		
BGL004/00	2.605	0.089	16.82	5.37	545.68	2.65
BGL005/00	2.605	0.089	2.91	0.71	11.71	0.43
BGL006/00	2.605	0.089	2.91	0.71	11.71	0.43
BGL007/00	2.605	0.089	< 3.83	-	-	-
BGL008/00	2.605	0.089	2.72	0.25	4.41	0.43
BGL010/00	2.605	0.089	2.9	0.6	11.32	0.49
BGL011/00	2.605	0.089	3.3446	1.5668	28.39	0.47
BGL012/00	2.605	0.089	< 0.1	-	-	-
BGL019/00	2.605	0.089	2.4	0.38	-7.87	0.53
BGL021/00	2.605	0.089	2.67	0.54	2.50	0.12
BGL024/00	2.605	0.089	2.324	0.501	-10.79	0.55
BGL025/00	2.605	0.089	2.37	0.31	-9.02	0.73
BGL026/00	2.605	0.089	3.29	0.952	26.30	0.72
BGL027/00	2.605	0.089	2.5	0.9	-4.03	0.12

Table 35 – Results for ^{125}Sb (low level)

Sample	Reference value		Analyst's result		Deviation (%)	u-test statistic
BGL***/00	^{125}Sb Bq kg^{-1}	± Bq kg^{-1}	^{125}Sb Bq kg^{-1}	± Bq kg^{-1}		
BGL005/00	2.691	0.028	2.76	0.29	2.56	0.24
BGL006/00	2.691	0.028	2.76	0.29	2.56	0.24
BGL007/00	2.691	0.028	3.04	0.34	12.97	1.02
BGL008/00	2.691	0.028	2.78	0.15	3.31	0.58
BGL010/00	2.691	0.028	2.8	0.3	4.05	0.36
BGL011/00	2.691	0.028	3.7056	0.6802	37.70	1.49
BGL012/00	2.691	0.028	3.16	0.37	17.43	1.26
BGL013/00	2.691	0.028	3	0.44	11.48	0.70
BGL014/00	2.691	0.028	< 5	-	-	-
BGL018/00	2.691	0.028	2.38	0.29	-11.56	1.07
BGL019/00	2.691	0.028	2.86	0.31	6.28	0.54
BGL020/00	2.691	0.028	2.48	0.3	-7.84	0.70
BGL021/00	2.691	0.028	2.8	0.18	4.05	0.60
BGL022/00	2.691	0.028	2.75	0.32	2.19	0.18
BGL024/00	2.691	0.028	3.154	0.419	17.21	1.10
BGL025/00	2.691	0.028	2.53	0.14	-5.98	1.13
BGL026/00	2.691	0.028	2.659	0.235	-1.19	0.14
BGL027/00	2.691	0.028	2.7	0.4	0.33	0.02

Table 36 – Results for ^{134}Cs (low level)

Sample	Reference value		Analyst's result		Deviation (%)	u-test statistic
BGL***/00	^{134}Cs Bq kg^{-1}	± Bq kg^{-1}	^{134}Cs Bq kg^{-1}	± Bq kg^{-1}		
BGL004/00	2.583	0.026	3.81	1.21	47.50	1.01
BGL005/00	2.583	0.026	2.68	0.16	3.76	0.60
BGL006/00	2.583	0.026	2.68	0.16	3.76	0.60
BGL007/00	2.583	0.026	2.35	0.13	-9.02	1.76
BGL008/00	2.583	0.026	2.58	0.08	-0.12	0.04
BGL010/00	2.583	0.026	2.4	0.2	-7.08	0.91
BGL011/00	2.583	0.026	2.5952	0.2424	0.47	0.05
BGL012/00	2.583	0.026	2.6	0.2	0.66	0.08
BGL013/00	2.583	0.026	2.04	0.18	-21.02	2.99
BGL014/00	2.583	0.026	< 3	-	-	-
BGL018/00	2.583	0.026	2.24	0.18	-13.28	1.89
BGL019/00	2.583	0.026	2.36	0.14	-8.63	1.57
BGL020/00	2.583	0.026	2.46	0.15	-4.76	0.81
BGL021/00	2.583	0.026	2.4	0.07	-7.08	2.45
BGL022/00	2.583	0.026	2.71	0.18	4.92	0.70
BGL024/00	2.583	0.026	1.952	0.118	-24.43	5.22
BGL025/00	2.583	0.026	2.66	0.068	2.98	1.06
BGL026/00	2.583	0.026	2.544	0.147	-1.51	0.26
BGL027/00	2.583	0.026	2.2	0.2	-14.83	1.90

Table 37 – Results for ^{137}Cs (low level)

Sample	Reference value		Analyst's result		Deviation (%)	u-test statistic
BGL***/00	^{137}Cs Bq kg^{-1}	± Bq kg^{-1}	^{137}Cs Bq kg^{-1}	± Bq kg^{-1}		
BGL004/00	2.581	0.027	2.81	0.89	8.87	0.26
BGL005/00	2.581	0.027	2.52	0.16	-2.36	0.38
BGL006/00	2.581	0.027	2.52	0.16	-2.36	0.38
BGL007/00	2.581	0.027	2.99	0.16	15.85	2.52
BGL008/00	2.581	0.027	2.55	0.07	-1.20	0.41
BGL010/00	2.581	0.027	2.8	0.2	8.49	1.09
BGL011/00	2.581	0.027	2.6292	0.267	1.87	0.18
BGL012/00	2.581	0.027	17.56	0.97	580.36	15.44
BGL013/00	2.581	0.027	2.49	0.19	-3.53	0.47
BGL014/00	2.581	0.027	< 3	-	-	-
BGL018/00	2.581	0.027	2.53	0.17	-1.98	0.30
BGL019/00	2.581	0.027	2.51	0.14	-2.75	0.50
BGL020/00	2.581	0.027	2.44	0.3	-5.46	0.47
BGL021/00	2.581	0.027	2.7	0.08	4.61	1.41
BGL022/00	2.581	0.027	2.39	0.19	-7.40	1.00
BGL024/00	2.581	0.027	2.095	0.245	-18.83	1.97
BGL025/00	2.581	0.027	2.63	0.11	1.90	0.43
BGL026/00	2.581	0.027	2.521	0.103	-2.32	0.56
BGL027/00	2.581	0.027	2.7	0.2	4.61	0.59

Table 38 – Results for ^{154}Eu (low level)

Sample	Reference value		Analyst's result		Deviation (%)	u-test statistic
BGL***/00	^{154}Eu Bq kg^{-1}	± Bq kg^{-1}	^{154}Eu Bq kg^{-1}	± Bq kg^{-1}		
BGL005/00	2.618	0.026	2.35	0.2	-10.24	1.33
BGL006/00	2.618	0.026	2.35	0.2	-10.24	1.33
BGL007/00	2.618	0.026	2.34	0.16	-10.62	1.72
BGL008/00	2.618	0.026	2.2	0.07	-15.97	5.60
BGL010/00	2.618	0.026	2.5	0.2	-4.51	0.59
BGL011/00	2.618	0.026	3.7047	0.4893	41.51	2.22
BGL012/00	2.618	0.026	5.83	1.06	122.69	3.03
BGL013/00	2.618	0.026	1.84	0.21	-29.72	3.68
BGL014/00	2.618	0.026	2.3	1.1	-12.15	0.29
BGL018/00	2.618	0.026	2.19	0.16	-16.35	2.64
BGL019/00	2.618	0.026	2.45	0.23	-6.42	0.73
BGL020/00	2.618	0.026	2.22	0.25	-15.20	1.58
BGL021/00	2.618	0.026	2.4	0.18	-8.33	1.20
BGL022/00	2.618	0.026	2.41	0.21	-7.94	0.98
BGL024/00	2.618	0.026	1.919	0.254	-26.70	2.74
BGL025/00	2.618	0.026	2.36	0.083	-9.85	2.97
BGL026/00	2.618	0.026	2.646	0.724	1.07	0.04
BGL027/00	2.618	0.026	2.4	0.2	-8.33	1.08

Table 39 – Results for ^{155}Eu (low level)

Sample	Reference value		Analyst's result		Deviation (%)	u-test statistic
BGL***/00	^{155}Eu Bq kg^{-1}	± Bq kg^{-1}	^{155}Eu Bq kg^{-1}	± Bq kg^{-1}		
BGL004/00	2.628	0.065	3.05	0.97	16.06	0.43
BGL005/00	2.628	0.065	2.72	0.39	3.50	0.23
BGL006/00	2.628	0.065	2.72	0.39	3.50	0.23
BGL007/00	2.628	0.065	2.65	0.28	0.84	0.08
BGL008/00	2.628	0.065	2.64	0.11	0.46	0.09
BGL010/00	2.628	0.065	2.1	0.3	-20.09	1.72
BGL011/00	2.628	0.065	1.8518	0.7099	-29.54	1.09
BGL012/00	2.628	0.065	3.27	0.31	24.43	2.03
BGL013/00	2.628	0.065	2.65	0.5	0.84	0.04
BGL014/00	2.628	0.065	5.1	2.5	94.06	0.99
BGL018/00	2.628	0.065	2.41	0.24	-8.30	0.88
BGL019/00	2.628	0.065	2.52	0.15	-4.11	0.66
BGL020/00	2.628	0.065	2.84	0.35	8.07	0.60
BGL021/00	2.628	0.065	2.4	0.25	-8.68	0.88
BGL022/00	2.628	0.065	2.6	0.4	-1.07	0.07
BGL024/00	2.628	0.065	2.466	0.175	-6.16	0.87
BGL025/00	2.628	0.065	2.71	0.24	3.12	0.33
BGL026/00	2.628	0.065	2.614	0.117	-0.53	0.10
BGL027/00	2.628	0.065	2.9	0.3	10.35	0.89

Table 40 – Results for ^{207}Bi (low level)

Sample	Reference value		Analyst's result		Deviation (%)	u-test statistic
BGL***/00	^{207}Bi Bq kg^{-1}	± Bq kg^{-1}	^{207}Bi Bq kg^{-1}	± Bq kg^{-1}		
BGL004/00	2.612	0.032	3.1	0.99	18.68	0.49
BGL005/00	2.612	0.032	2.68	0.18	2.60	0.37
BGL006/00	2.612	0.032	2.68	0.18	2.60	0.37
BGL007/00	2.612	0.032	2.25	0.15	-13.86	2.36
BGL008/00	2.612	0.032	2.94	0.1	12.56	3.12
BGL010/00	2.612	0.032	2.9	0.2	11.03	1.42
BGL011/00	2.612	0.032	2.6101	0.2582	-0.07	0.01
BGL012/00	2.612	0.032	3.07	0.23	17.53	1.97
BGL013/00	2.612	0.032	2.4	0.26	-8.12	0.81
BGL014/00	2.612	0.032	3.3	1.6	26.34	0.43
BGL018/00	2.612	0.032	2.66	0.21	1.84	0.23
BGL019/00	2.612	0.032	2.71	0.18	3.75	0.54
BGL020/00	2.612	0.032	2.21	0.15	-15.39	2.62
BGL021/00	2.612	0.032	2.7	0.16	3.37	0.54
BGL022/00	2.612	0.032	1.86	0.18	-28.79	4.11
BGL024/00	2.612	0.032	2.483	0.164	-4.94	0.77
BGL026/00	2.612	0.032	2.192	0.139	-16.08	2.94
BGL027/00	2.612	0.032	2.5	0.2	-4.29	0.55

Table 41 – Results for ^{22}Na (high level)

Sample	Reference value		Analyst's result		Deviation (%)	u-test statistic
BGH***/00	^{22}Na Bq g^{-1}	± Bq g^{-1}	^{22}Na Bq g^{-1}	± Bq g^{-1}		
BGH003/00	2.526	0.038	2.566	0.82	1.58	0.05
BGH005/00	2.526	0.038	2.28	0.12	-9.74	1.95
BGH006/00a	2.526	0.038	3.14	0.034	24.31	12.04
BGH006/00b	2.526	0.038	3.1	0.024	22.72	12.77
BGH006/00c	2.526	0.038	3.3	0.03	30.64	15.99
BGH007/00	2.526	0.038	3.2	0.35	26.68	1.91
BGH008/00	2.526	0.038	2.37	0.24	-6.18	0.64
BGH010/00	2.526	0.038	2.3	0.071	-8.95	2.81
BGH012/00	2.526	0.038	2.41	0.24	-4.59	0.48
BGH014/00	2.526	0.038	2.4	0.2	-4.99	0.62
BGH018/00	2.526	0.038	2.29	0.05	-9.34	3.76
BGH019/00	2.526	0.038	2.55	0.1	0.95	0.22
BGH020/00	2.526	0.038	4.07	0.22	61.12	6.92
BGH021/00	2.526	0.038	3.163	0.162	25.22	3.83
BGH022/00	2.526	0.038	1.959	0.056	-22.45	8.38
BGH024/00a	2.526	0.038	2.325	0.093	-7.96	2.00
BGH024/00b	2.526	0.038	2.341	0.088	-7.32	1.93
BGH024/00c	2.526	0.038	2.287	0.067	-9.46	3.10
BGH024/00d	2.526	0.038	2.116	0.066	-16.23	5.38
BGH024/00e	2.526	0.038	2.716	0.074	7.52	2.28
BGH026/00	2.526	0.038	2.2	0.35	-12.91	0.93
BGH029/00	2.526	0.038	2.609	0.157	3.29	0.51

Table 42 – Results for ^{60}Co (high level)

Sample	Reference value		Analyst's result		Deviation (%)	u-test statistic
BGH***/00	^{60}Co Bq g^{-1}	± Bq g^{-1}	^{60}Co Bq g^{-1}	± Bq g^{-1}		
BGH003/00	2.502	0.023	2.789	0.89	11.47	0.32
BGH005/00	2.502	0.023	2.49	0.13	-0.48	0.09
BGH006/00a	2.502	0.023	2.53	0.049	1.12	0.52
BGH006/00b	2.502	0.023	2.43	0.06	-2.88	1.12
BGH006/00c	2.502	0.023	2.45	0.05	-2.08	0.94
BGH007/00	2.502	0.023	2.6	0.3	3.92	0.33
BGH008/00	2.502	0.023	2.54	0.18	1.52	0.21
BGH010/00	2.502	0.023	2.459	0.044	-1.72	0.87
BGH011/00	2.502	0.023	2.4408	0.1806	-2.45	0.34
BGH012/00	2.502	0.023	2.4	0.24	-4.08	0.42
BGH014/00	2.502	0.023	2.5	0.2	-0.08	0.01
BGH015/00a	2.502	0.023	2.52	0.015	0.72	0.66
BGH015/00b	2.502	0.023	2.75	0.01	9.91	9.89
BGH015/00c	2.502	0.023	2.64	0.01	5.52	5.50
BGH017/00	2.502	0.023	2.41	0.11	-3.68	0.82
BGH018/00	2.502	0.023	2.53	0.05	1.12	0.51
BGH019/00	2.502	0.023	2.63	0.1	5.12	1.25
BGH020/00	2.502	0.023	3.04	0.16	21.50	3.33
BGH021/00	2.502	0.023	2.437	0.125	-2.60	0.51
BGH022/00	2.502	0.023	2.572	0.067	2.80	0.99
BGH024/00a	2.502	0.023	2.521	0.06	0.76	0.30
BGH024/00b	2.502	0.023	2.45	0.058	-2.08	0.83
BGH024/00c	2.502	0.023	2.488	0.072	-0.56	0.19
BGH024/00d	2.502	0.023	2.413	0.067	-3.56	1.26
BGH024/00e	2.502	0.023	2.405	0.064	-3.88	1.43
BGH026/00	2.502	0.023	2.35	0.25	-6.08	0.61
BGH029/00	2.502	0.023	2.708	0.157	8.23	1.30

Table 43 – Results for ^{65}Zn (high level)

Sample	Reference value		Analyst's result		Deviation (%)	u-test statistic
BGH***/00	^{65}Zn Bq g^{-1}	± Bq g^{-1}	^{65}Zn Bq g^{-1}	± Bq g^{-1}		
BGH003/00	2.478	0.068	2.969	0.95	19.81	0.52
BGH005/00	2.478	0.068	2.4	0.12	-3.15	0.57
BGH006/00a	2.478	0.068	2.73	0.15	10.17	1.53
BGH006/00b	2.478	0.068	2.59	0.15	4.52	0.68
BGH006/00c	2.478	0.068	2.5	0.14	0.89	0.14
BGH007/00	2.478	0.068	2.9	0.35	17.03	1.18
BGH008/00	2.478	0.068	2.51	0.18	1.29	0.17
BGH010/00	2.478	0.068	2.392	0.062	-3.47	0.93
BGH011/00	2.478	0.068	2.524	0.1869	1.86	0.23
BGH012/00	2.478	0.068	2.4	0.24	-3.15	0.31
BGH014/00	2.478	0.068	2.5	0.2	0.89	0.10
BGH015/00a	2.478	0.068	2.1	0.021	-15.25	5.31
BGH015/00b	2.478	0.068	2.82	0.017	13.80	4.88
BGH015/00c	2.478	0.068	2.72	0.016	9.77	3.46
BGH017/00	2.478	0.068	2.5	0.13	0.89	0.15
BGH018/00	2.478	0.068	2.76	0.05	11.38	3.34
BGH019/00	2.478	0.068	2.58	0.1	4.12	0.84
BGH020/00	2.478	0.068	3.41	0.18	37.61	4.84
BGH021/00	2.478	0.068	2.693	0.146	8.68	1.33
BGH022/00	2.478	0.068	2.441	0.038	-1.49	0.47
BGH024/00a	2.478	0.068	2.563	0.093	3.43	0.74
BGH024/00b	2.478	0.068	2.565	0.101	3.51	0.71
BGH024/00c	2.478	0.068	2.46	0.085	-0.73	0.17
BGH024/00d	2.478	0.068	2.531	0.086	2.14	0.48
BGH024/00e	2.478	0.068	2.423	0.077	-2.22	0.54
BGH026/00	2.478	0.068	2.32	0.25	-6.38	0.61
BGH029/00	2.478	0.068	2.934	0.293	18.40	1.52

Table 44 – Results for ^{124}Sb (high level)

Sample	Reference value		Analyst's result		Deviation (%)	u-test statistic
BGH***/00	^{124}Sb Bq g^{-1}	± Bq g^{-1}	^{124}Sb Bq g^{-1}	± Bq g^{-1}		
BGH003/00	2.545	0.085	3.44	1.1	35.17	0.81
BGH005/00	2.545	0.085	2.6	0.14	2.16	0.34
BGH006/00a	2.545	0.085	2.62	0.16	2.95	0.41
BGH006/00b	2.545	0.085	2.37	0.14	-6.88	1.07
BGH006/00c	2.545	0.085	2.57	0.15	0.98	0.15
BGH007/00	2.545	0.085	1.8	0.2	-29.27	3.43
BGH008/00	2.545	0.085	2.83	0.22	11.20	1.21
BGH010/00	2.545	0.085	2.312	0.095	-9.16	1.83
BGH011/00	2.545	0.085	2.2767	0.1715	-10.54	1.40
BGH012/00	2.545	0.085	2.44	0.24	-4.13	0.41
BGH015/00a	2.545	0.085	2.81	0.053	10.41	2.65
BGH015/00b	2.545	0.085	2.83	0.048	11.20	2.92
BGH015/00c	2.545	0.085	2.8	0.039	10.02	2.73
BGH017/00	2.545	0.085	2.47	0.13	-2.95	0.48
BGH019/00	2.545	0.085	2.29	0.1	-10.02	1.94
BGH020/00	2.545	0.085	2.76	0.16	8.45	1.19
BGH021/00	2.545	0.085	2.482	0.132	-2.48	0.40
BGH022/00	2.545	0.085	2.294	0.07	-9.86	2.28
BGH024/00a	2.545	0.085	2.534	0.162	-0.43	0.06
BGH024/00b	2.545	0.085	2.381	0.1	-6.44	1.25
BGH024/00c	2.545	0.085	2.233	0.126	-12.26	2.05
BGH024/00d	2.545	0.085	2.338	0.125	-8.13	1.37
BGH024/00e	2.545	0.085	2.278	0.096	-10.49	2.08
BGH026/00	2.545	0.085	2.62	0.6	2.95	0.12
BGH029/00	2.545	0.085	2.695	0.156	5.89	0.84

Table 45 – Results for ^{125}Sb (high level)

Sample	Reference value		Analyst's result		Deviation (%)	u-test statistic
BGH***/00	^{125}Sb Bq g^{-1}	± Bq g^{-1}	^{125}Sb Bq g^{-1}	± Bq g^{-1}		
BGH003/00	2.628	0.020	2.937	0.94	11.76	0.33
BGH005/00	2.628	0.020	2.72	0.14	3.50	0.65
BGH006/00a	2.628	0.020	2.5	0.15	-4.87	0.85
BGH006/00b	2.628	0.020	2.58	0.16	-1.83	0.30
BGH006/00c	2.628	0.020	2.55	0.16	-2.97	0.48
BGH007/00	2.628	0.020	2.7	0.3	2.74	0.24
BGH008/00	2.628	0.020	2.74	0.2	4.26	0.56
BGH010/00	2.628	0.020	2.6	0.069	-1.07	0.39
BGH011/00	2.628	0.020	2.5746	0.1908	-2.03	0.28
BGH012/00	2.628	0.020	2.54	0.25	-3.35	0.35
BGH014/00	2.628	0.020	2.4	0.2	-8.68	1.13
BGH015/00a	2.628	0.020	2.59	0.016	-1.45	1.48
BGH015/00b	2.628	0.020	3.12	0.015	18.72	19.68
BGH015/00c	2.628	0.020	2.79	0.014	6.16	6.64
BGH017/00	2.628	0.020	2.6	0.13	-1.07	0.21
BGH018/00	2.628	0.020	2.6	0.05	-1.07	0.52
BGH019/00	2.628	0.020	2.56	0.1	-2.59	0.67
BGH020/00	2.628	0.020	3.51	0.18	33.56	4.87
BGH021/00	2.628	0.020	2.658	0.134	1.14	0.22
BGH022/00	2.628	0.020	2.508	0.057	-4.57	1.99
BGH024/00a	2.628	0.020	2.53	0.078	-3.73	1.22
BGH024/00b	2.628	0.020	2.626	0.087	-0.08	0.02
BGH024/00c	2.628	0.020	2.571	0.088	-2.17	0.63
BGH024/00d	2.628	0.020	2.628	0.092	0.00	0.00
BGH024/00e	2.628	0.020	2.411	0.08	-8.26	2.63
BGH026/00	2.628	0.020	1.95	0.25	-25.80	2.70
BGH029/00	2.628	0.020	2.936	0.15	11.72	2.04

Table 46 – Results for ^{134}Cs (high level)

Sample	Reference value		Analyst's result		Deviation (%)	u-test statistic
BGH***/00	^{134}Cs Bq g^{-1}	± Bq g^{-1}	^{134}Cs Bq g^{-1}	± Bq g^{-1}		
BGH003/00	2.522	0.018	2.55	0.81	1.11	0.03
BGH005/00	2.522	0.018	2.37	0.12	-6.03	1.25
BGH006/00a	2.522	0.018	2.2	0.12	-12.77	2.65
BGH006/00b	2.522	0.018	2.15	0.12	-14.75	3.07
BGH006/00c	2.522	0.018	2.27	0.13	-9.99	1.92
BGH007/00	2.522	0.018	2.5	0.3	-0.87	0.07
BGH008/00	2.522	0.018	2.64	0.19	4.68	0.62
BGH010/00	2.522	0.018	2.374	0.04	-5.87	3.37
BGH011/00	2.522	0.018	2.299	0.1701	-8.84	1.30
BGH012/00	2.522	0.018	1.99	0.2	-21.09	2.65
BGH014/00	2.522	0.018	2.8	0.3	11.02	0.93
BGH015/00a	2.522	0.018	2.02	0.01	-19.90	24.38
BGH015/00b	2.522	0.018	2.6	0.008	3.09	3.96
BGH015/00c	2.522	0.018	2.42	0.006	-4.04	5.38
BGH017/00	2.522	0.018	2.56	0.13	1.51	0.29
BGH018/00	2.522	0.018	2.3	0.05	-8.80	4.18
BGH019/00	2.522	0.018	2.51	0.1	-0.48	0.12
BGH020/00	2.522	0.018	2.89	0.15	14.59	2.44
BGH021/00	2.522	0.018	2.24	0.114	-11.18	2.44
BGH022/00	2.522	0.018	2.456	0.077	-2.62	0.83
BGH024/00a	2.522	0.018	2.362	0.058	-6.34	2.63
BGH024/00b	2.522	0.018	2.207	0.054	-12.49	5.53
BGH024/00c	2.522	0.018	2.256	0.064	-10.55	4.00
BGH024/00d	2.522	0.018	2.125	0.062	-15.74	6.15
BGH024/00e	2.522	0.018	2.206	0.06	-12.53	5.04
BGH026/00	2.522	0.018	2.15	0.21	-14.75	1.76
BGH029/00	2.522	0.018	2.578	0.074	2.22	0.74

Table 47 – Results for ^{137}Cs (high level)

Sample	Reference value		Analyst's result		Deviation (%)	u-test statistic
BGH***/00	^{137}Cs Bq g^{-1}	± Bq g^{-1}	^{137}Cs Bq g^{-1}	± Bq g^{-1}		
BGH003/00	2.520	0.018	2.873	0.92	14.01	0.38
BGH005/00	2.520	0.018	2.43	0.12	-3.57	0.74
BGH006/00a	2.520	0.018	2.54	0.06	0.79	0.32
BGH006/00b	2.520	0.018	2.4	0.06	-4.76	1.92
BGH006/00c	2.520	0.018	2.42	0.06	-3.97	1.60
BGH007/00	2.520	0.018	2.8	0.35	11.11	0.80
BGH008/00	2.520	0.018	2.64	0.19	4.76	0.63
BGH010/00	2.520	0.018	2.427	0.044	-3.69	1.96
BGH011/00	2.520	0.018	2.5645	0.1898	1.77	0.23
BGH012/00	2.520	0.018	2.47	0.25	-1.98	0.20
BGH014/00	2.520	0.018	2.5	0.2	-0.79	0.10
BGH015/00a	2.520	0.018	2.21	0.009	-12.30	15.40
BGH015/00b	2.520	0.018	2.92	0.008	15.87	20.31
BGH015/00c	2.520	0.018	2.71	0.007	7.54	9.84
BGH017/00	2.520	0.018	2.58	0.12	2.38	0.49
BGH018/00	2.520	0.018	2.62	0.05	3.97	1.88
BGH019/00	2.520	0.018	2.66	0.1	5.56	1.38
BGH020/00	2.520	0.018	3.41	0.17	35.32	5.21
BGH021/00	2.520	0.018	2.415	0.124	-4.17	0.84
BGH022/00	2.520	0.018	2.507	0.029	-0.52	0.38
BGH024/00a	2.520	0.018	2.538	0.067	0.71	0.26
BGH024/00b	2.520	0.018	2.465	0.063	-2.18	0.84
BGH024/00c	2.520	0.018	2.439	0.07	-3.21	1.12
BGH024/00d	2.520	0.018	2.478	0.069	-1.67	0.59
BGH024/00e	2.520	0.018	2.461	0.066	-2.34	0.86
BGH026/00	2.520	0.018	2.42	0.2	-3.97	0.50
BGH029/00	2.520	0.018	2.816	0.146	11.75	2.01

Table 48 – Results for ^{154}Eu (high level)

Sample	Reference value		Analyst's result		Deviation (%)	u-test statistic
BGH***/00	^{154}Eu Bq g^{-1}	± Bq g^{-1}	^{154}Eu Bq g^{-1}	± Bq g^{-1}		
BGH003/00	2.557	0.018	2.598	0.83	1.60	0.05
BGH005/00	2.557	0.018	2.5	0.13	-2.23	0.43
BGH006/00a	2.557	0.018	2.17	0.12	-15.13	3.19
BGH006/00b	2.557	0.018	2.15	0.13	-15.92	3.10
BGH006/00c	2.557	0.018	2.31	0.13	-9.66	1.88
BGH007/00	2.557	0.018	2.6	0.3	1.68	0.14
BGH008/00	2.557	0.018	2.65	0.19	3.64	0.49
BGH010/00	2.557	0.018	2.431	0.089	-4.93	1.39
BGH011/00	2.557	0.018	2.5283	0.1884	-1.12	0.15
BGH012/00	2.557	0.018	2.17	0.22	-15.13	1.75
BGH014/00	2.557	0.018	2.3	0.2	-10.05	1.28
BGH017/00	2.557	0.018	2.4	0.12	-6.14	1.29
BGH018/00	2.557	0.018	2.24	0.05	-12.40	5.97
BGH019/00	2.557	0.018	2.54	0.1	-0.66	0.17
BGH020/00	2.557	0.018	4.59	0.79	79.51	2.57
BGH021/00	2.557	0.018	2.411	0.122	-5.71	1.18
BGH022/00	2.557	0.018	2.759	0.3	7.90	0.67
BGH024/00a	2.557	0.018	2.397	0.078	-6.26	2.00
BGH024/00b	2.557	0.018	2.203	0.07	-13.84	4.90
BGH024/00c	2.557	0.018	2.238	0.061	-12.48	5.02
BGH024/00d	2.557	0.018	2.303	0.068	-9.93	3.61
BGH024/00e	2.557	0.018	2.38	0.064	-6.92	2.66
BGH026/00	2.557	0.018	2.07	0.24	-19.05	2.02
BGH029/00	2.557	0.018	2.498	0.099	-2.31	0.59

Table 49 – Results for ^{155}Eu (high level)

Sample	Reference value		Analyst's result		Deviation (%)	u-test statistic
BGH***/00	^{155}Eu Bq g^{-1}	± Bq g^{-1}	^{155}Eu Bq g^{-1}	± Bq g^{-1}		
BGH003/00	2.566	0.061	2.815	0.9	9.70	0.28
BGH005/00	2.566	0.061	2.54	0.13	-1.01	0.18
BGH006/00a	2.566	0.061	2.59	0.18	0.94	0.13
BGH006/00b	2.566	0.061	2.46	0.17	-4.13	0.59
BGH006/00c	2.566	0.061	2.53	0.17	-1.40	0.20
BGH007/00	2.566	0.061	2.8	0.35	9.12	0.66
BGH008/00	2.566	0.061	2.47	0.18	-3.74	0.51
BGH010/00	2.566	0.061	2.475	0.038	-3.55	1.27
BGH011/00	2.566	0.061	2.5777	0.1908	0.46	0.06
BGH012/00	2.566	0.061	2.48	0.25	-3.35	0.33
BGH014/00	2.566	0.061	3.3	0.3	28.60	2.40
BGH017/00	2.566	0.061	2.45	0.13	-4.52	0.81
BGH018/00	2.566	0.061	2.65	0.1	3.27	0.72
BGH019/00	2.566	0.061	2.32	0.4	-9.59	0.61
BGH020/00	2.566	0.061	3.61	0.19	40.69	5.23
BGH021/00	2.566	0.061	2.677	0.135	4.33	0.75
BGH022/00	2.566	0.061	2.192	0.062	-14.58	4.30
BGH024/00a	2.566	0.061	2.533	0.069	-1.29	0.36
BGH024/00b	2.566	0.061	2.264	0.059	-11.77	3.56
BGH024/00c	2.566	0.061	2.333	0.064	-9.08	2.64
BGH024/00d	2.566	0.061	2.299	0.067	-10.41	2.95
BGH024/00e	2.566	0.061	2.334	0.064	-9.04	2.62
BGH026/00	2.566	0.061	2.48	0.26	-3.35	0.32
BGH029/00	2.566	0.061	2.757	0.109	7.44	1.53

Table 50 – Results for ^{207}Bi (high level)

Sample	Reference value		Analyst's result		Deviation (%)	u-test statistic
BGH***/00	^{207}Bi Bq g^{-1}	± Bq g^{-1}	^{207}Bi Bq g^{-1}	± Bq g^{-1}		
BGH003/00	2.551	0.026	2.72	0.87	6.62	0.19
BGH005/00	2.551	0.026	2.57	0.12	0.74	0.15
BGH006/00a	2.551	0.026	2.49	0.027	-2.39	1.63
BGH006/00b	2.551	0.026	2.39	0.023	-6.31	4.64
BGH006/00c	2.551	0.026	2.48	0.04	-2.78	1.49
BGH007/00	2.551	0.026	2.6	0.3	1.92	0.16
BGH008/00	2.551	0.026	2.69	0.2	5.45	0.69
BGH010/00	2.551	0.026	2.376	0.035	-6.86	4.01
BGH011/00	2.551	0.026	2.4576	0.1819	-3.66	0.51
BGH012/00	2.551	0.026	2.44	0.24	-4.35	0.46
BGH014/00	2.551	0.026	2.3	0.2	-9.84	1.24
BGH017/00	2.551	0.026	2.62	0.13	2.70	0.52
BGH018/00	2.551	0.026	2.4	0.05	-5.92	2.68
BGH019/00	2.551	0.026	2.66	0.4	4.27	0.27
BGH020/00	2.551	0.026	3.41	0.17	33.67	4.99
BGH021/00	2.551	0.026	2.455	0.125	-3.76	0.75
BGH022/00	2.551	0.026	2.218	0.054	-13.05	5.56
BGH024/00a	2.551	0.026	2.381	0.06	-6.66	2.60
BGH024/00b	2.551	0.026	2.343	0.062	-8.15	3.09
BGH024/00c	2.551	0.026	2.415	0.066	-5.33	1.92
BGH024/00d	2.551	0.026	2.289	0.062	-10.27	3.90
BGH024/00e	2.551	0.026	2.38	0.059	-6.70	2.65
BGH026/00	2.551	0.026	2.3	0.23	-9.84	1.08
BGH029/00	2.551	0.026	2.647	0.193	3.76	0.49

Table 51 – Other reported radionuclides

Sample Identifier	Radionuclide	Reported activity concentration	Overall uncertainty
ABL22/01	Gross α measurement	4.04 Bq/kg	2 %
ABL22/01	Gross β measurement	8.51 Bq/kg	1 %
BGH15/00 (participant's Detector 1)	^{40}K	1.09 Bq/g	0.029 Bq/g
BGH15/00 (participant's Detector 1)	^{46}Sc	0.13 Bq/g	0.014 Bq/g
BGH15/00 (participant's Detector 1)	^{241}Am	0.88 Bq/g	0.011 Bq/g
BGH15/00 (participant's Detector 2)	^{95}Zr	0.99 Bq/g	0.029 Bq/g
BGH15/00 (participant's Detector 2)	^{40}K	0.66 Bq/g	0.051 Bq/g
BGH15/00 (participant's Detector 3)	^{95}Zr	0.87 Bq/g	0.027 Bq/g
BGH15/00 (participant's Detector 3)	^{40}K	0.56 Bq/g	0.059 Bq/g
BGH15/00 (participant's Detector 3)	^{241}Am	0.12 Bq/g	0.0206 Bq/g
BGH17/00	^{109}Cd	1.85 Bq/g	0.16 Bq/g
BGL19/00	^{109}Cd	3.79 Bq/kg	1.09 Bq/kg
BGL21/00	^{85}Sr	2.5 Bq/kg	0.34 Bq/kg
BGL22/00	^{241}Am	Trace	-
BGL27/00	^{85}Sr	2.3 Bq/kg	0.8 Bq/kg

Figure 1 - Reported ^{3}H results (low level)

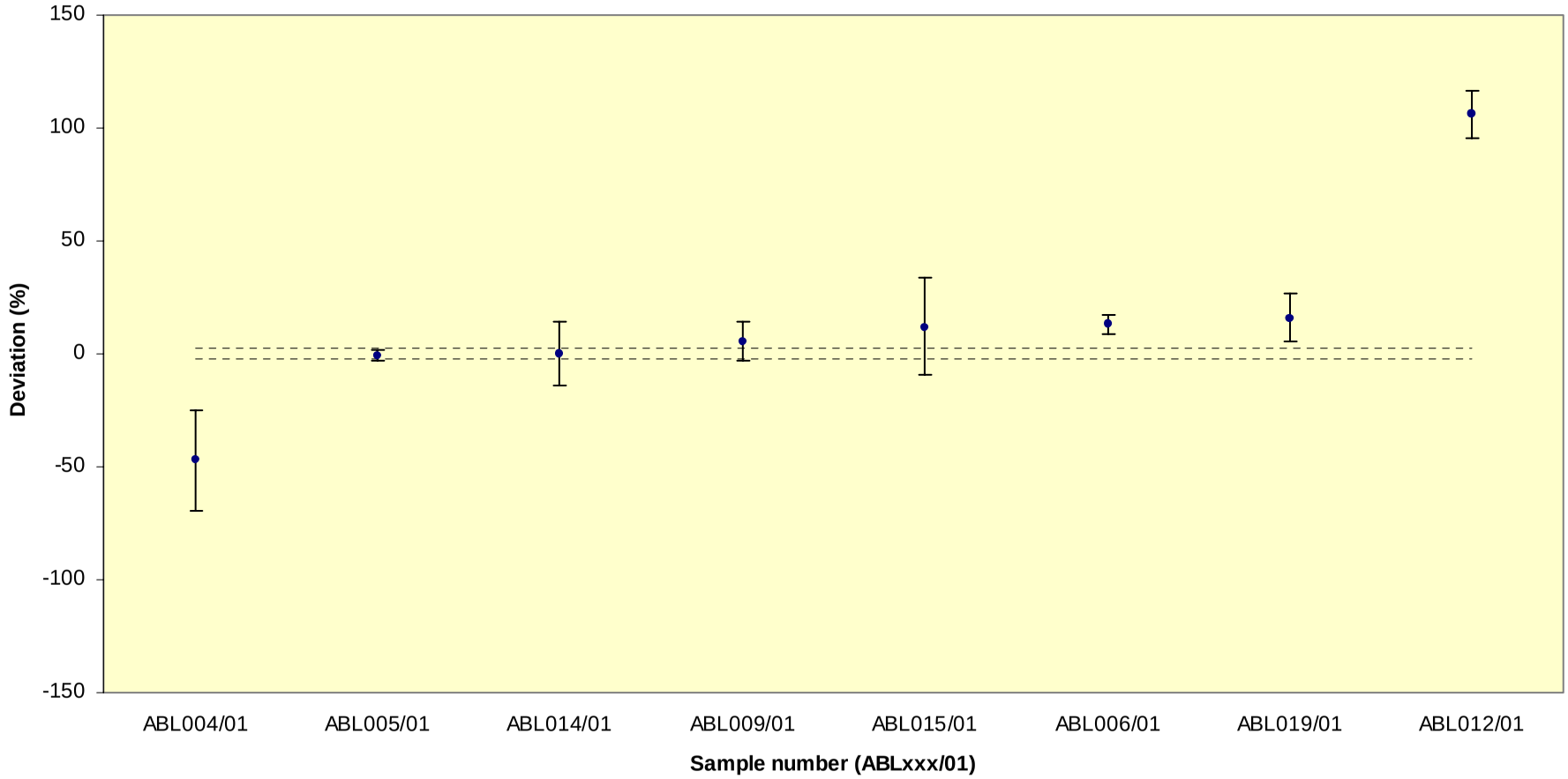


Figure 2 ^{3}H low level results

(Two outside limits of plot)

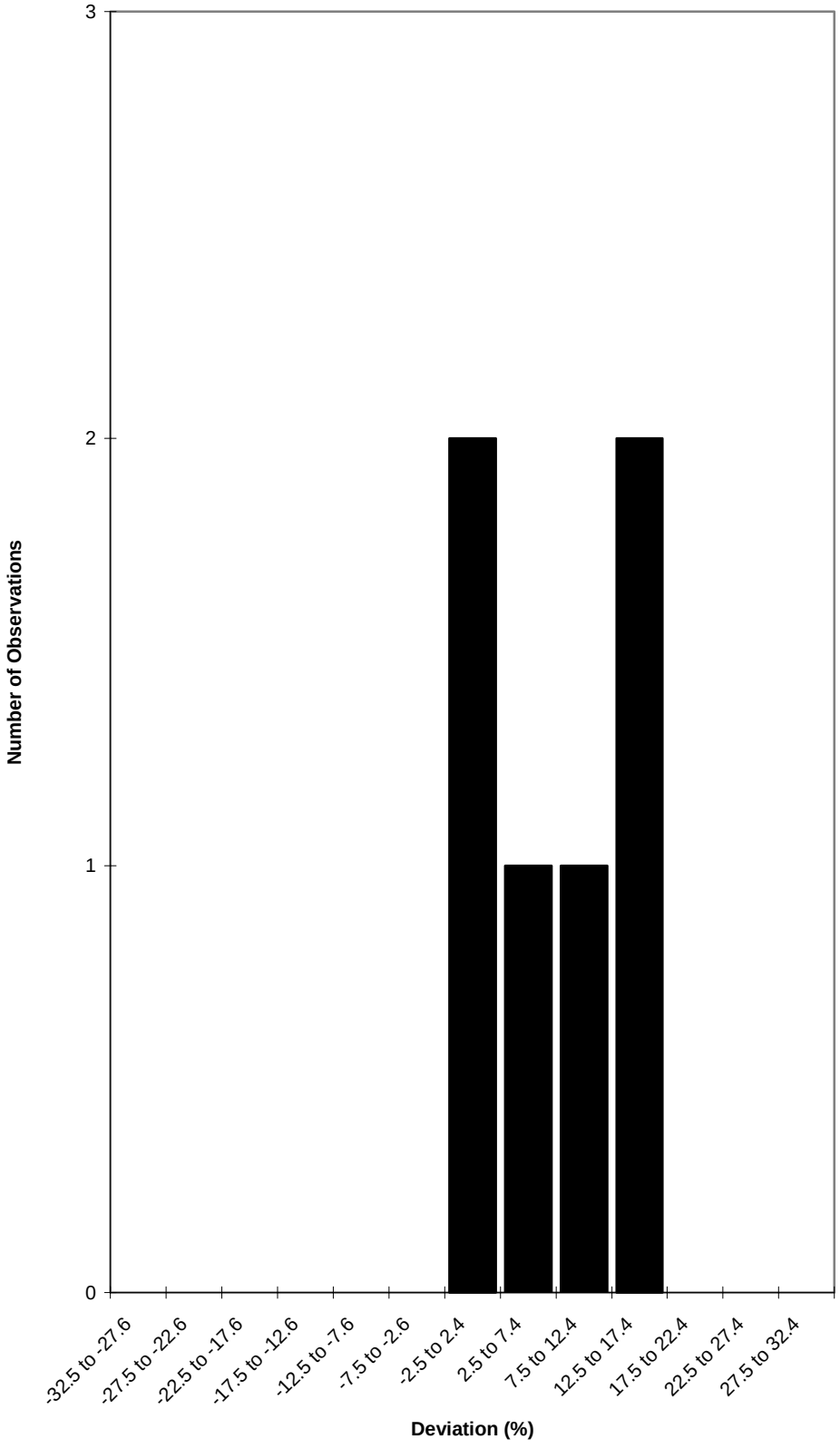


Figure 3 - Reported ^{90}Sr results (low level)

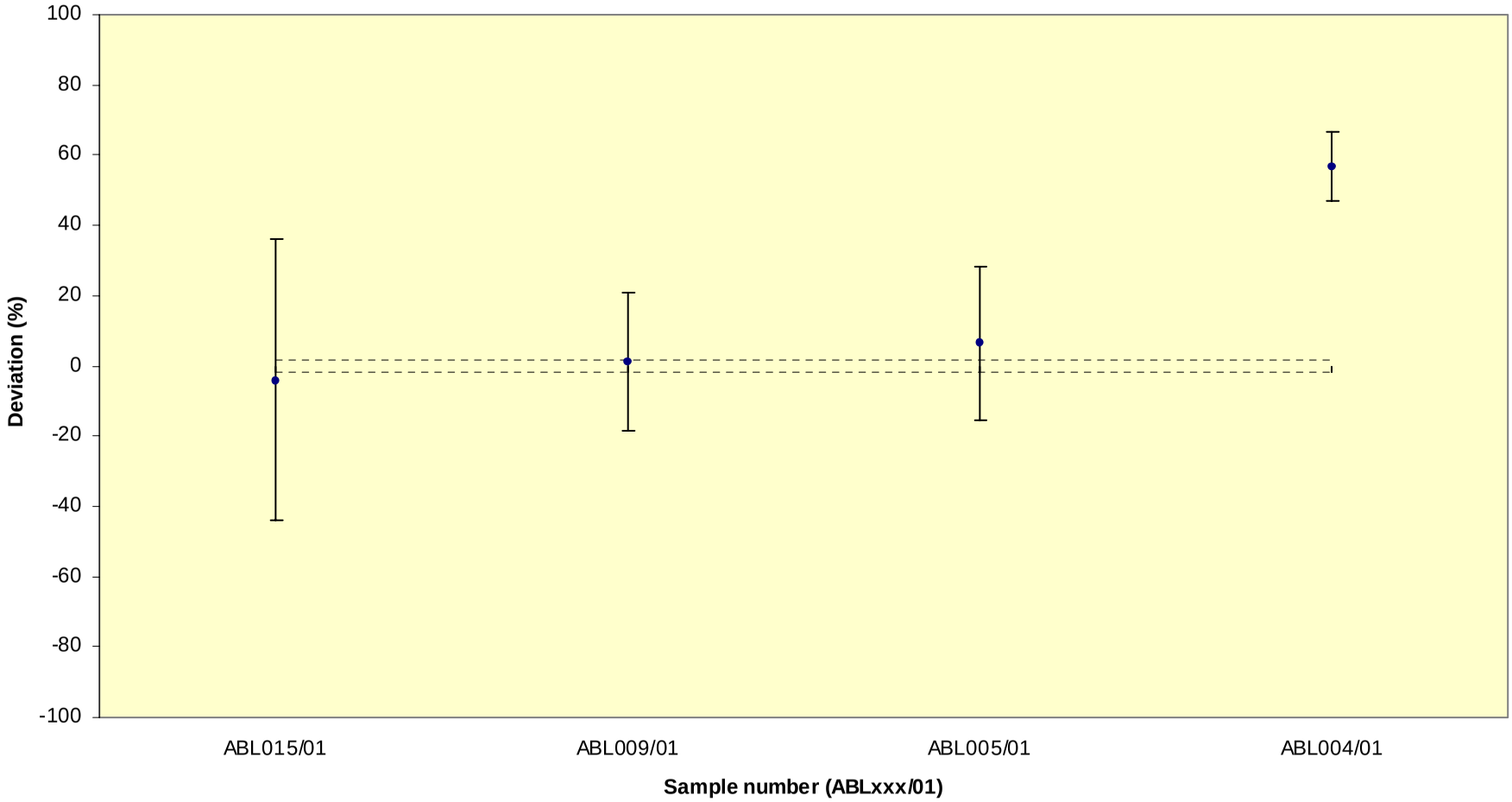


Figure 4 ^{90}Sr low level results

(One outside limits of plot)

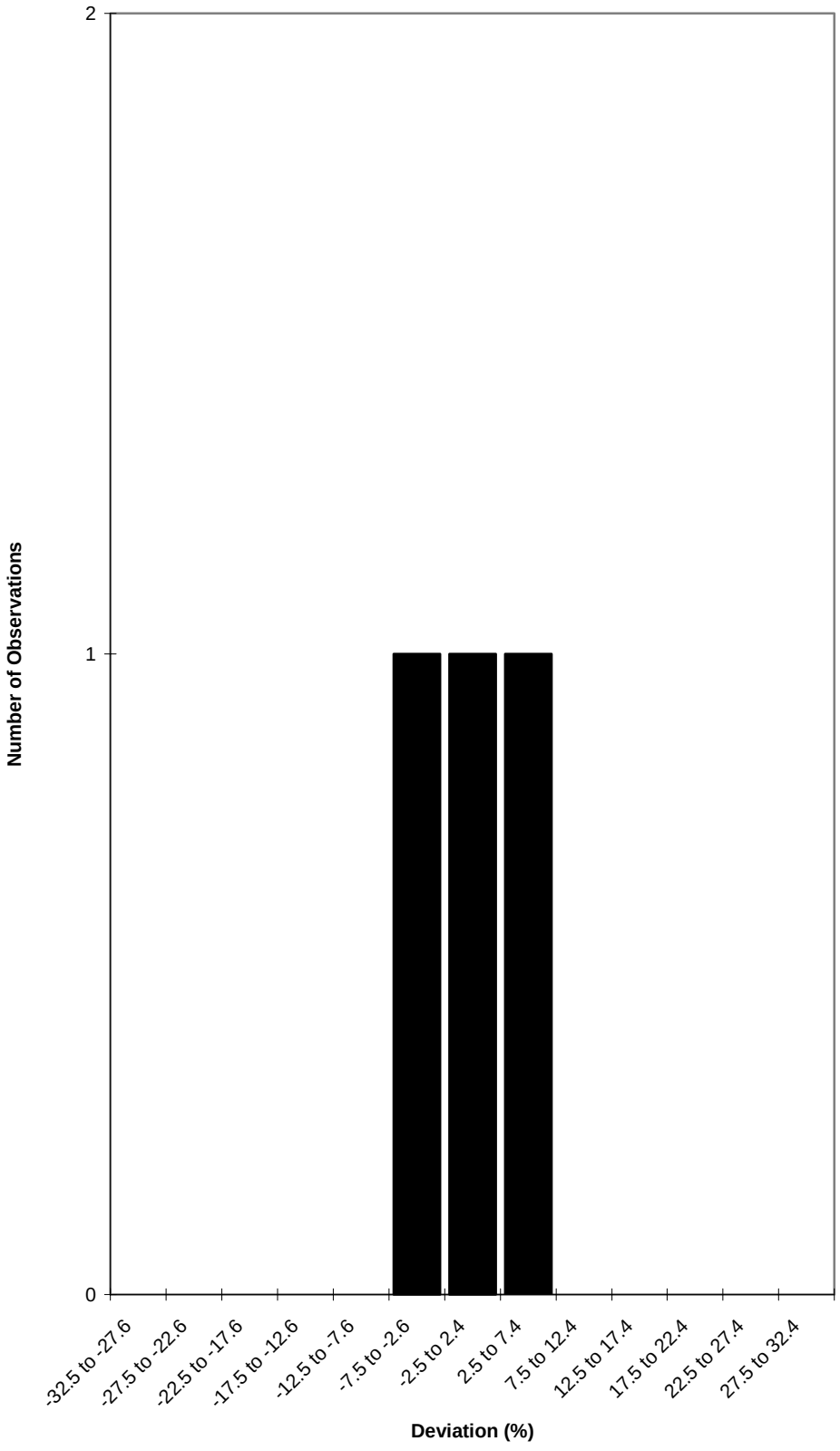


Figure 5 - Reported ^{99}Tc results (low level)

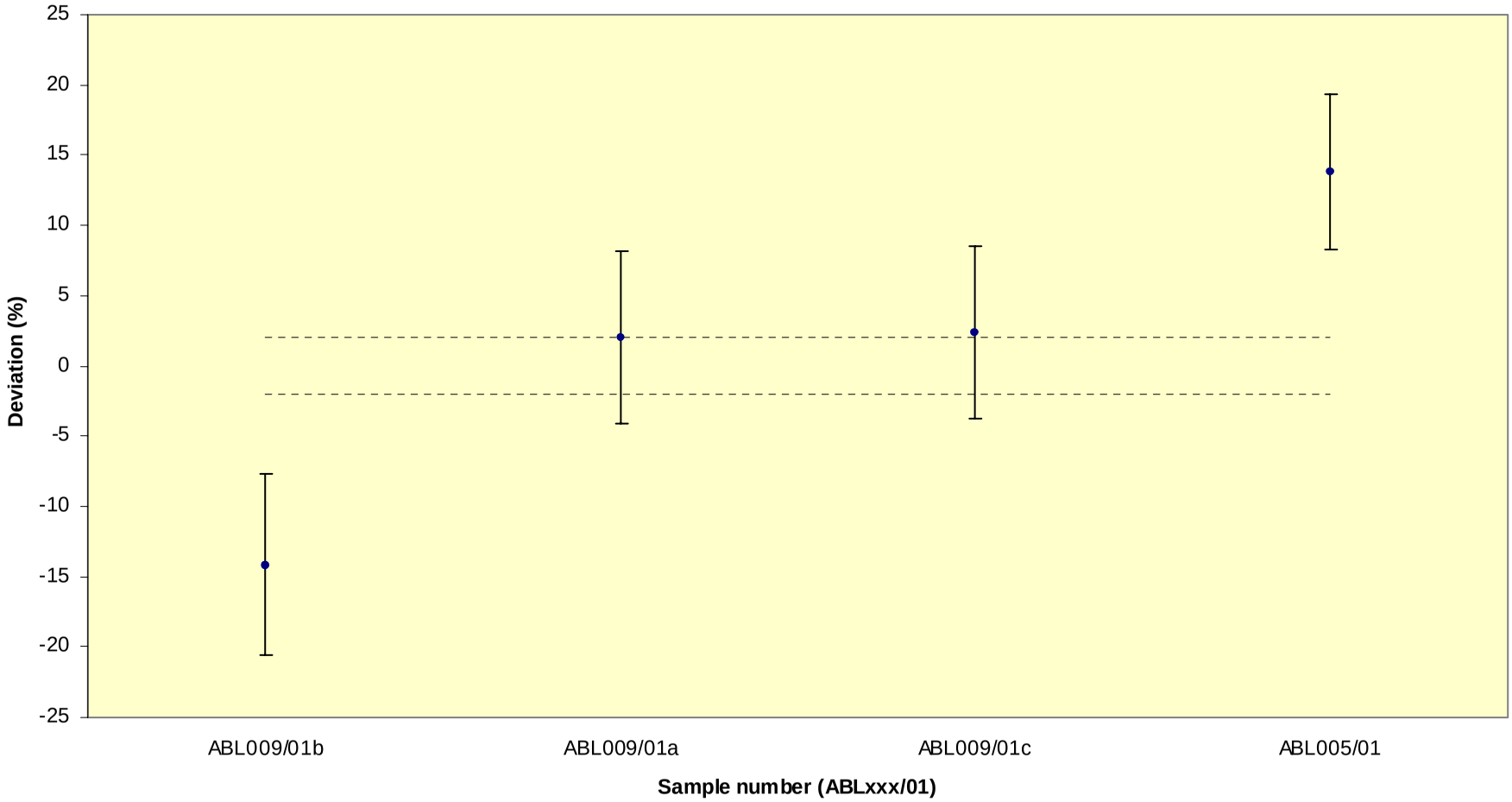


Figure 6 ^{99}Tc low level results

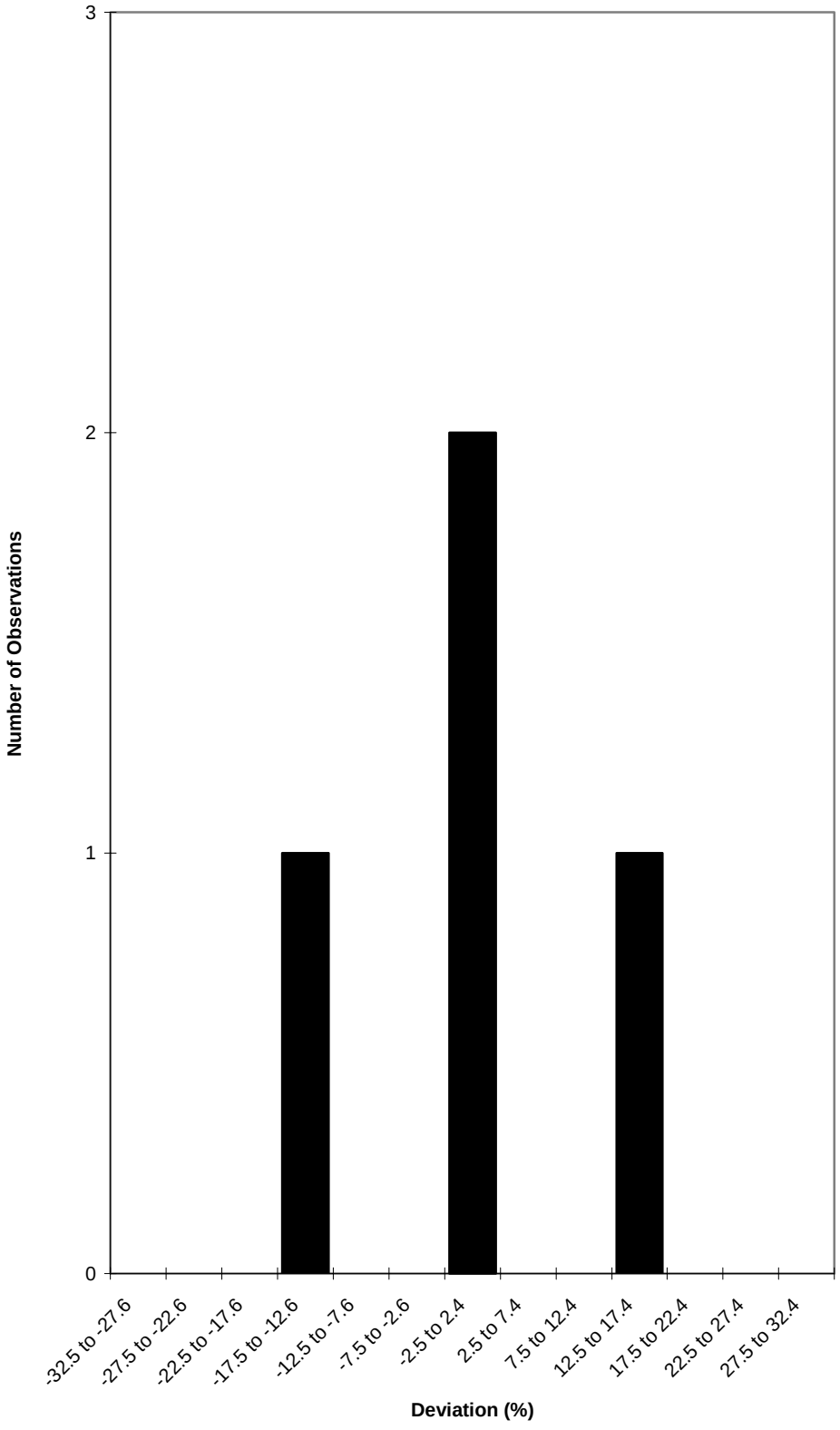


Figure 7 - Reported ^{210}Pb results (low level)

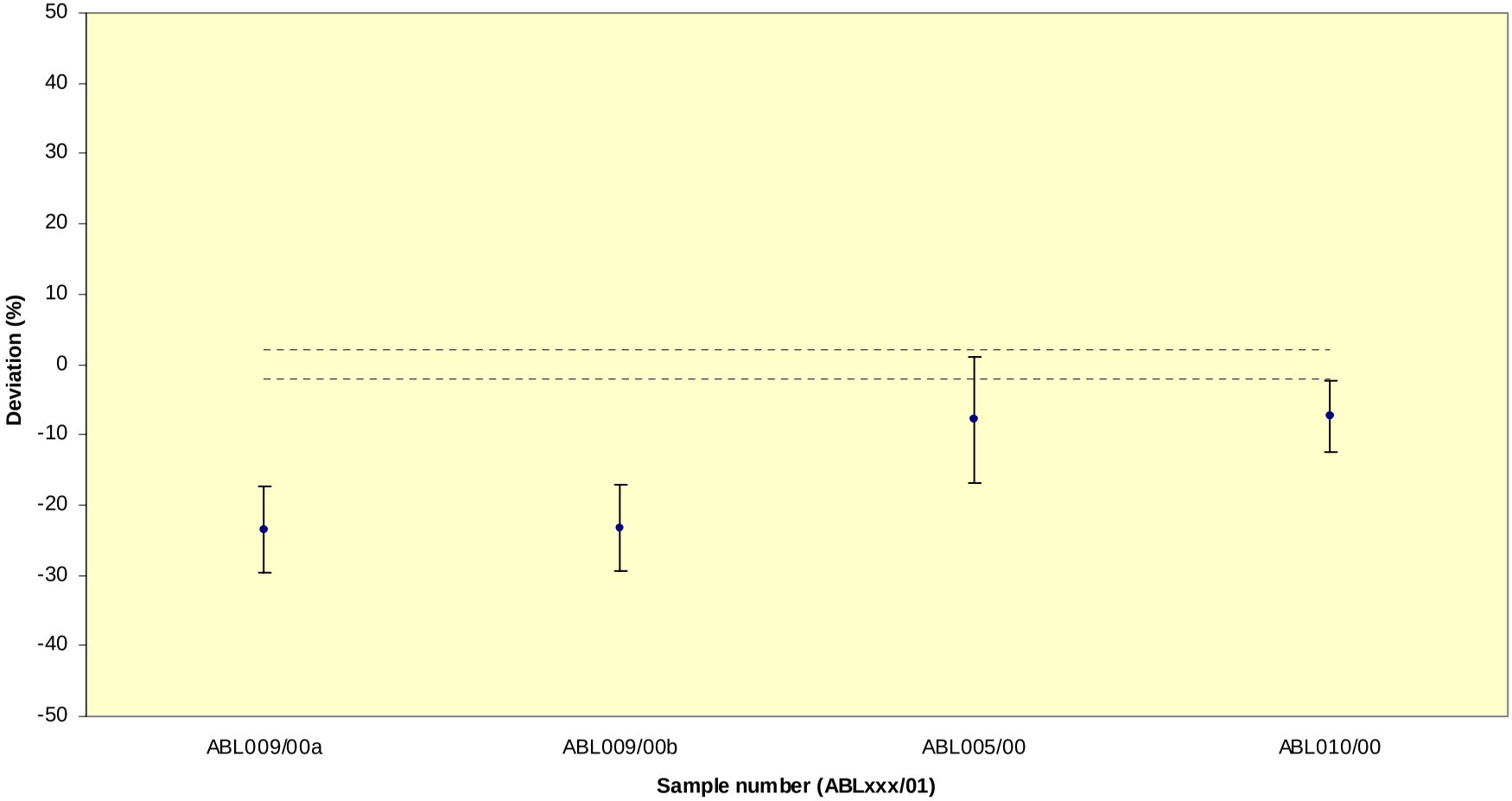


Figure 8 ^{210}Pb low level results

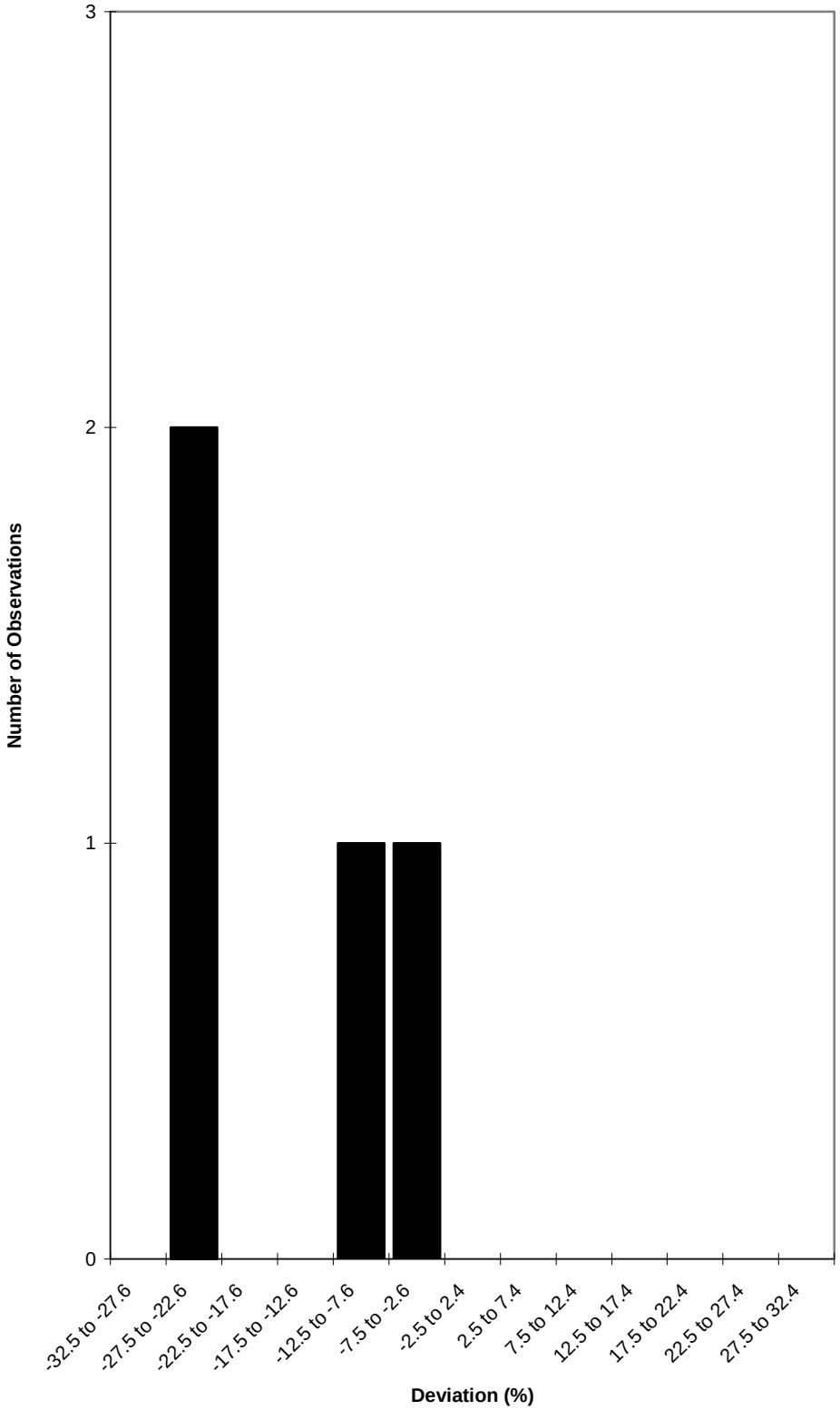


Figure 9 - Reported ^{226}Ra results (low level)

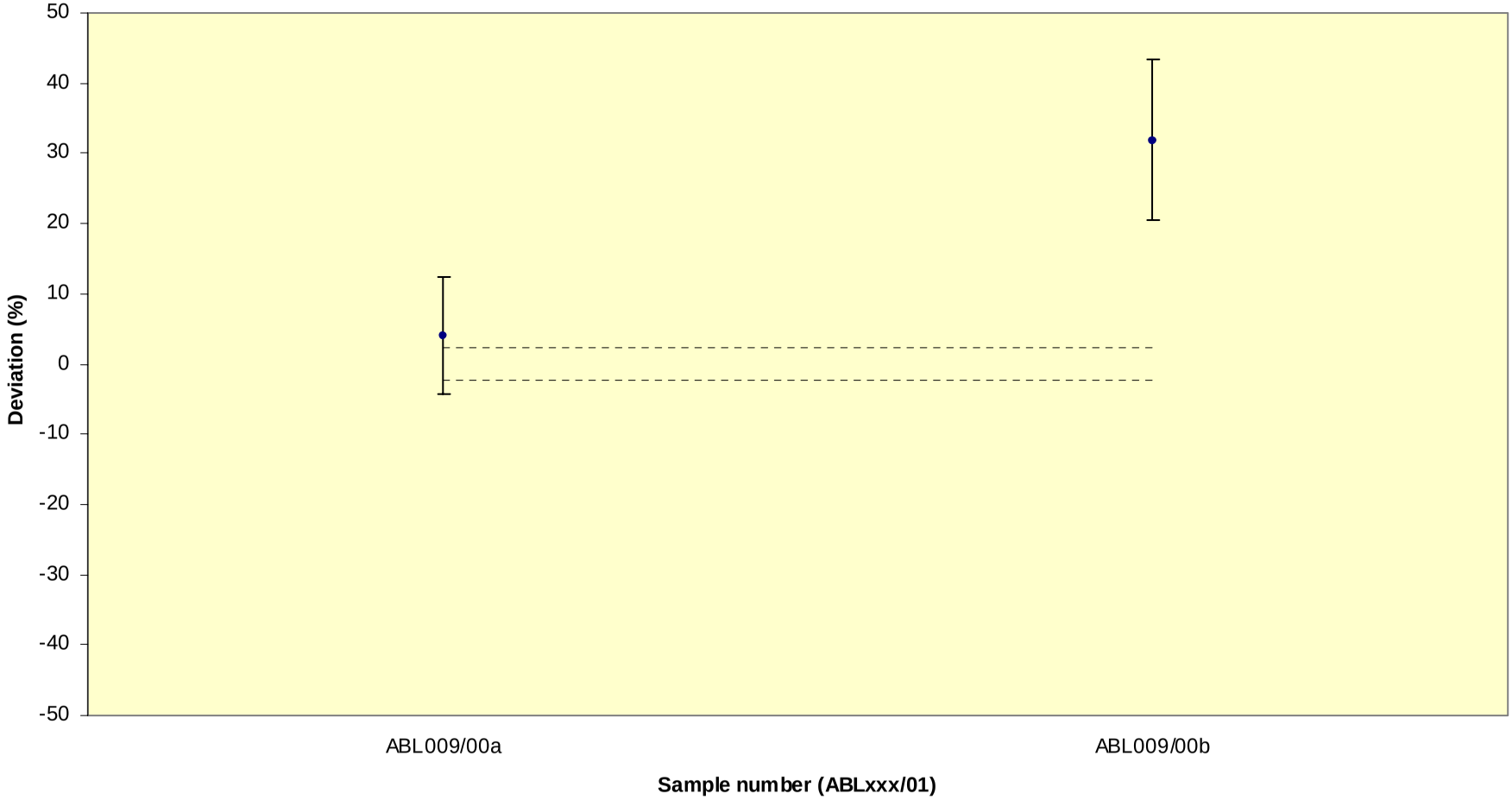


Figure 10 ^{226}Ra low level results

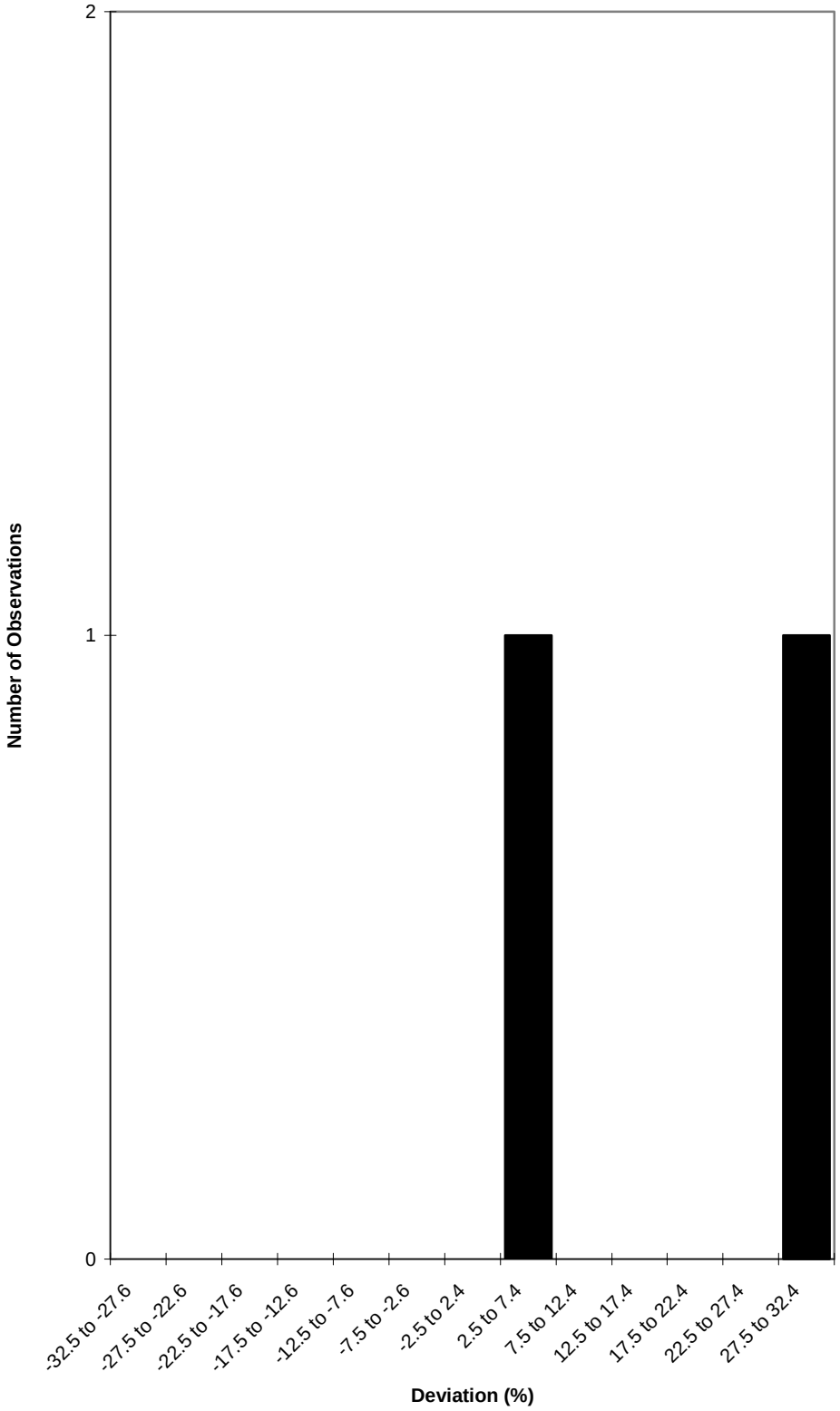


Figure 11 - Reported ^{238}Pu results (low level)

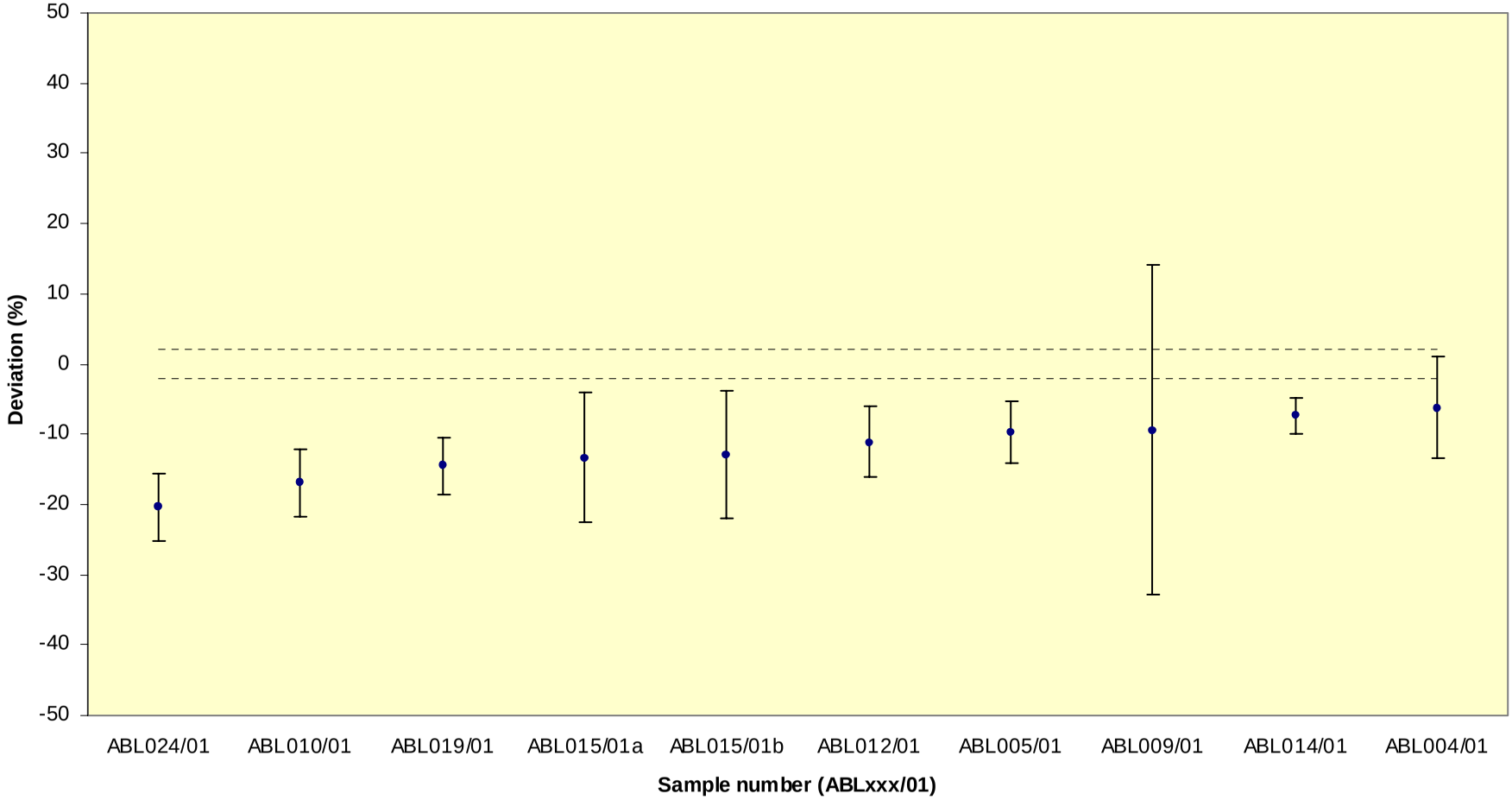


Figure 12 ^{238}Pu low level results

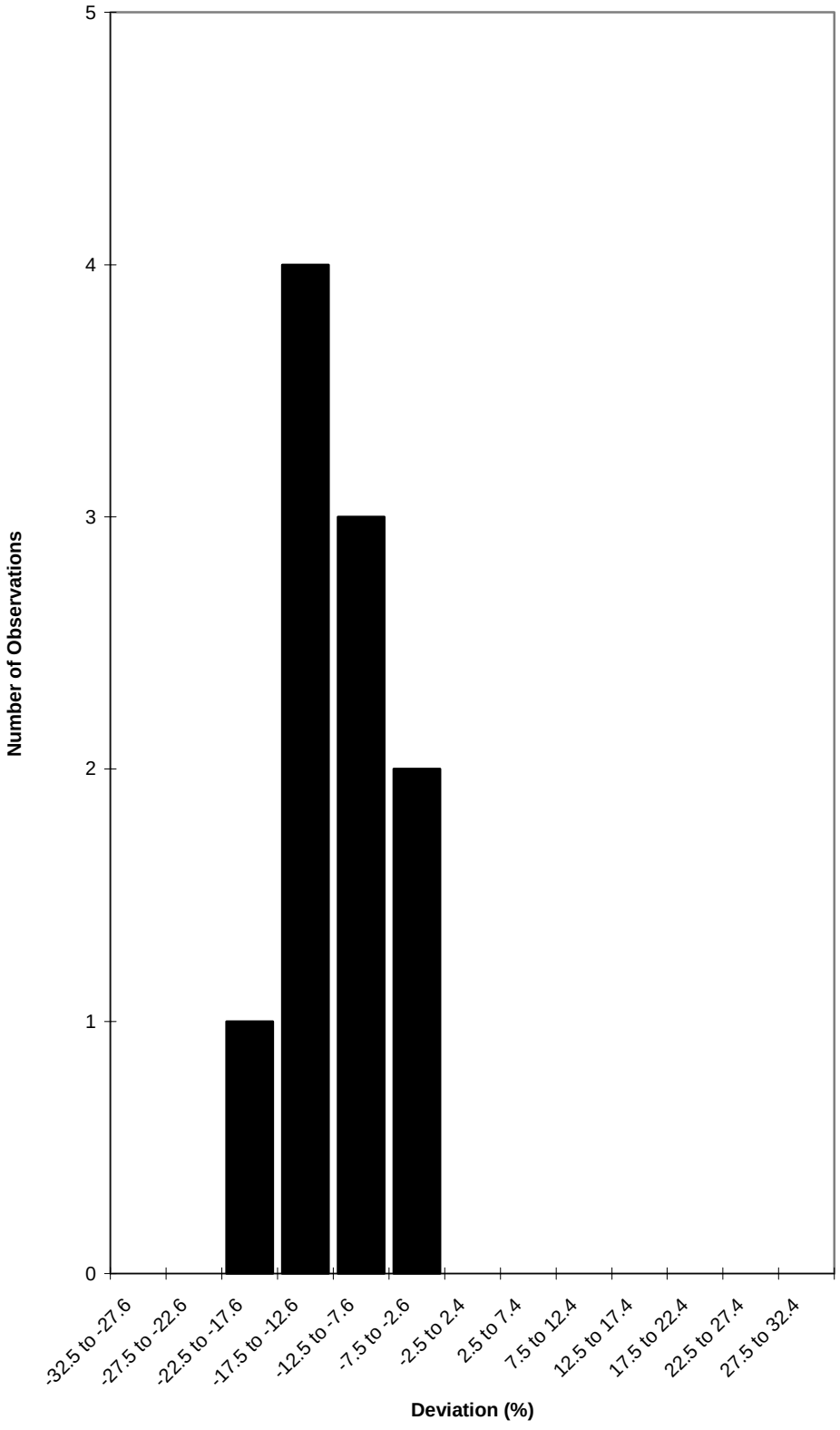


Figure 13 - Reported ^{239}Pu results (low level)

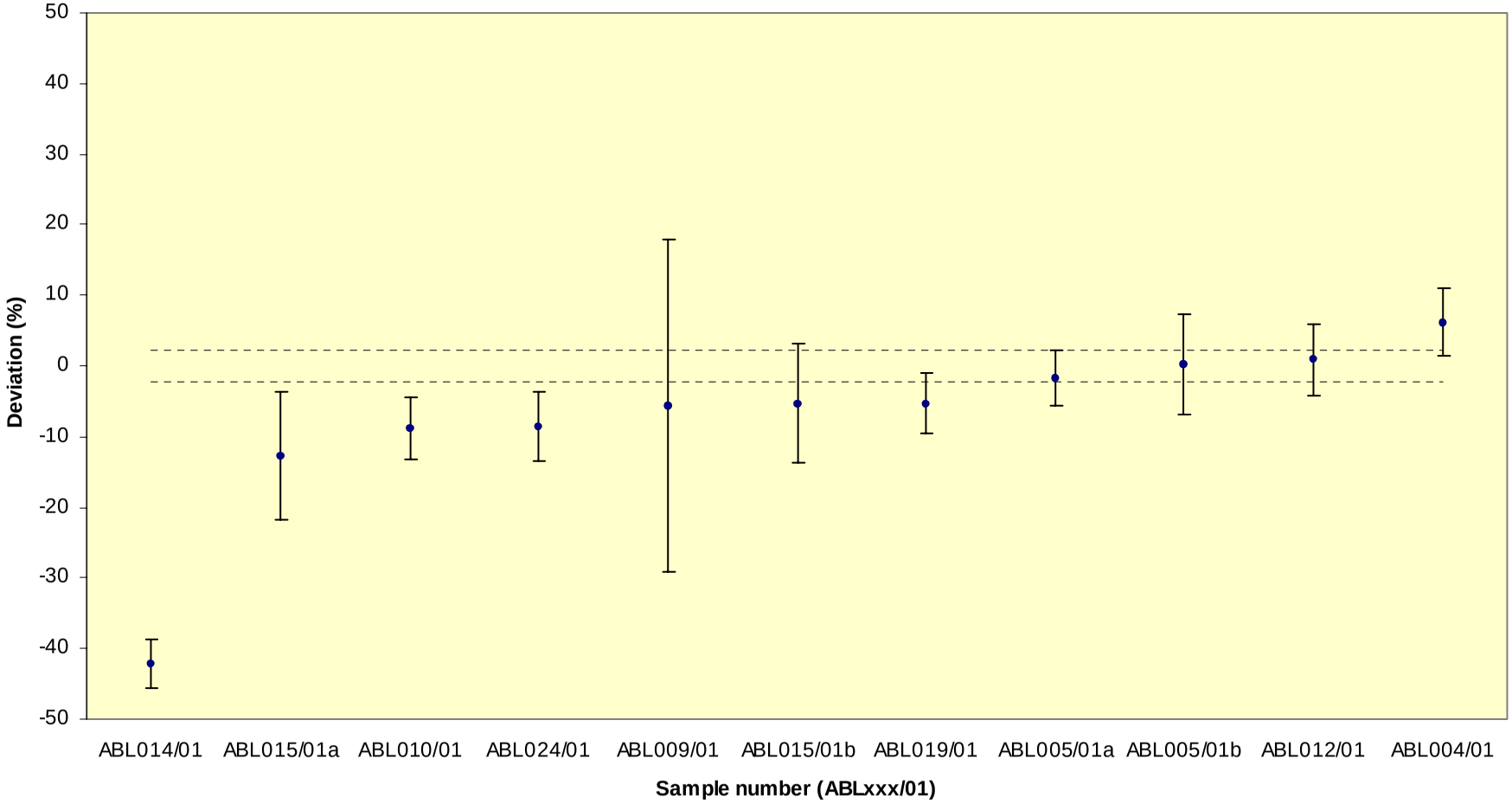


Figure 14 ^{239}Pu low level results

(One outside limits of plot)

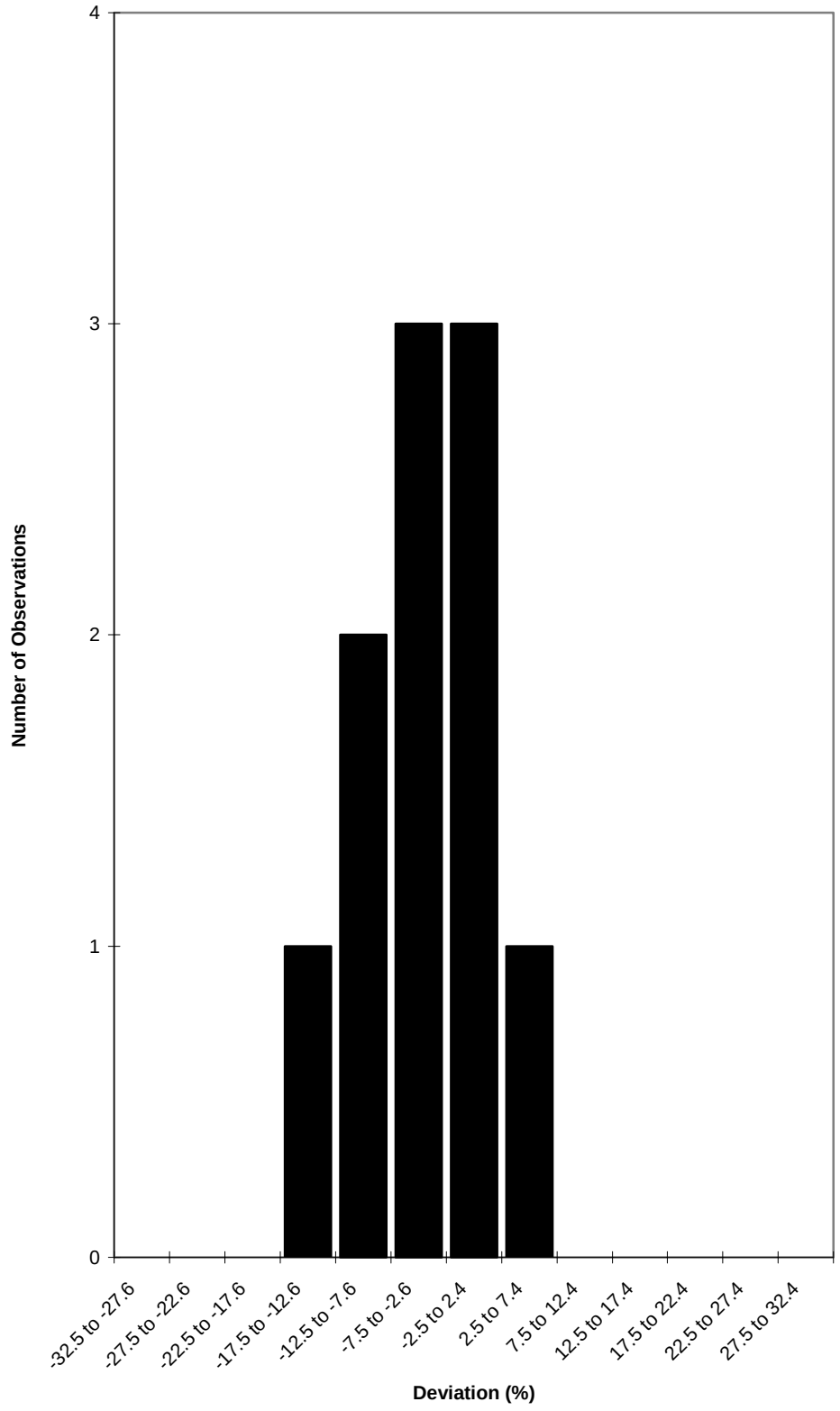


Figure 15 - Reported ^{241}Am results (low level)
(x = alpha spectrometry; o = gamma spectrometry)

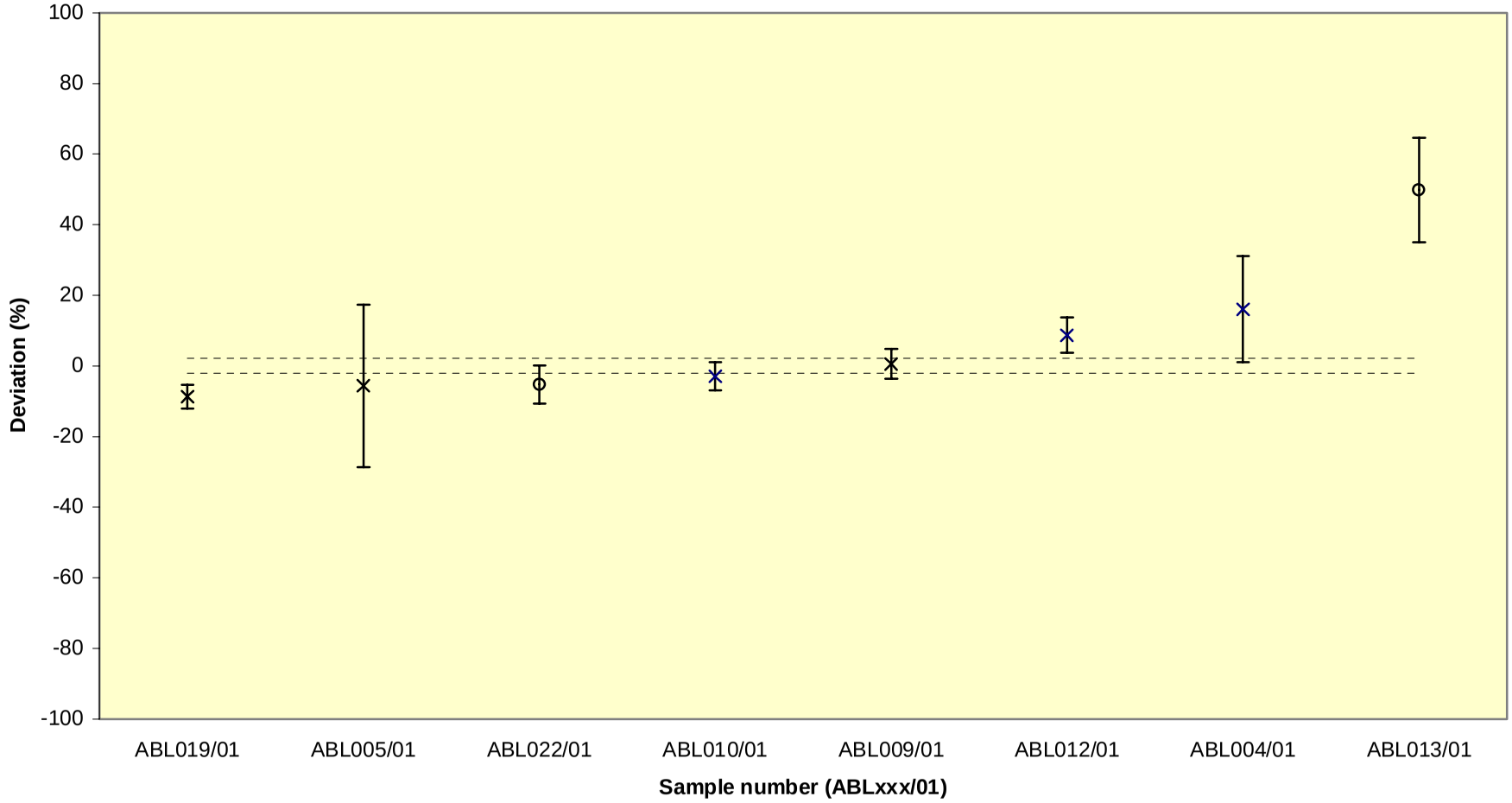


Figure 16 ^{241}Am low level results

(One outside limits of plot)

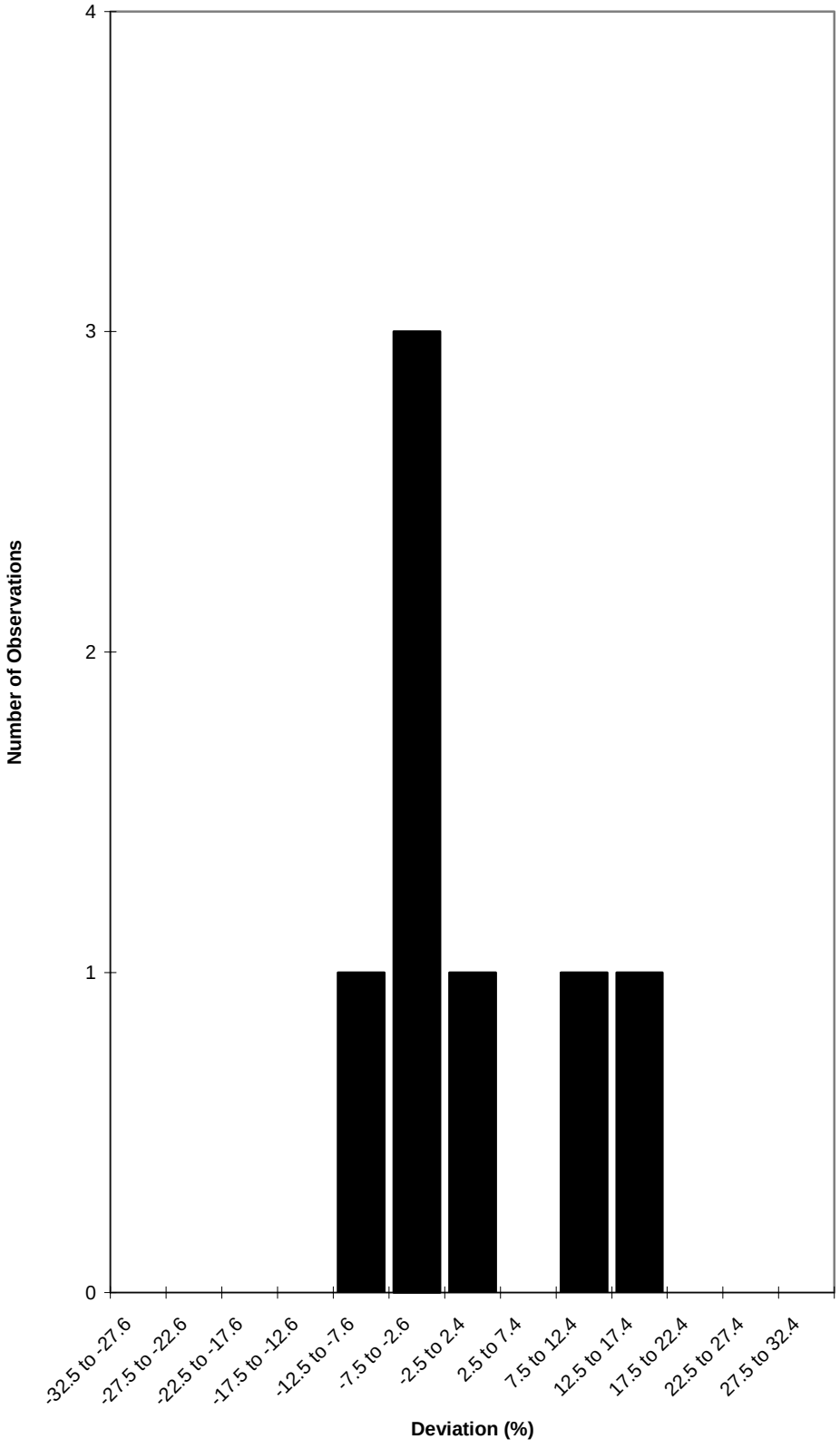


Figure 17 - Reported ^{3}H results (high level)

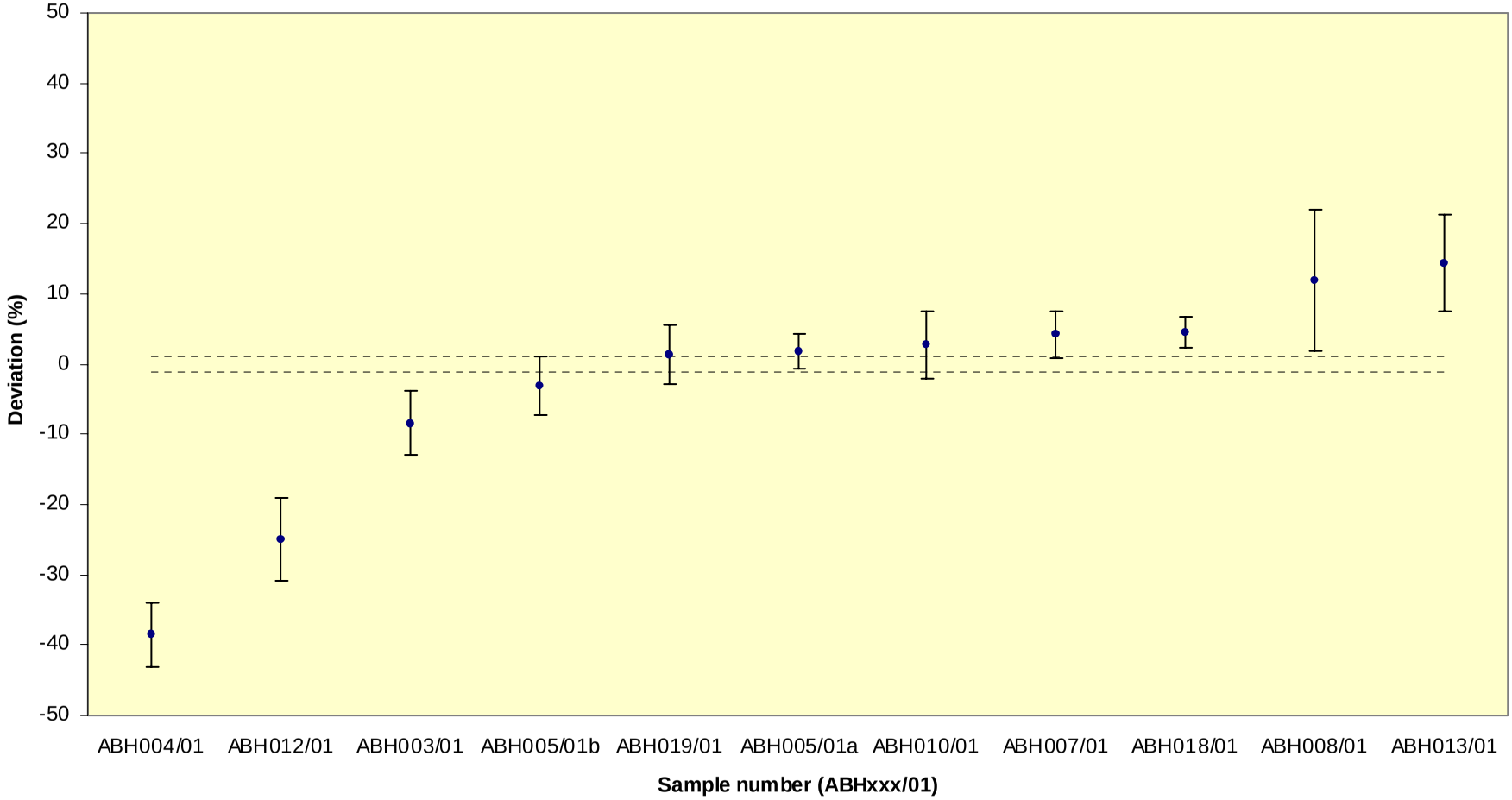


Figure 18 ^{3}H high level results

(One outside limits of plot)

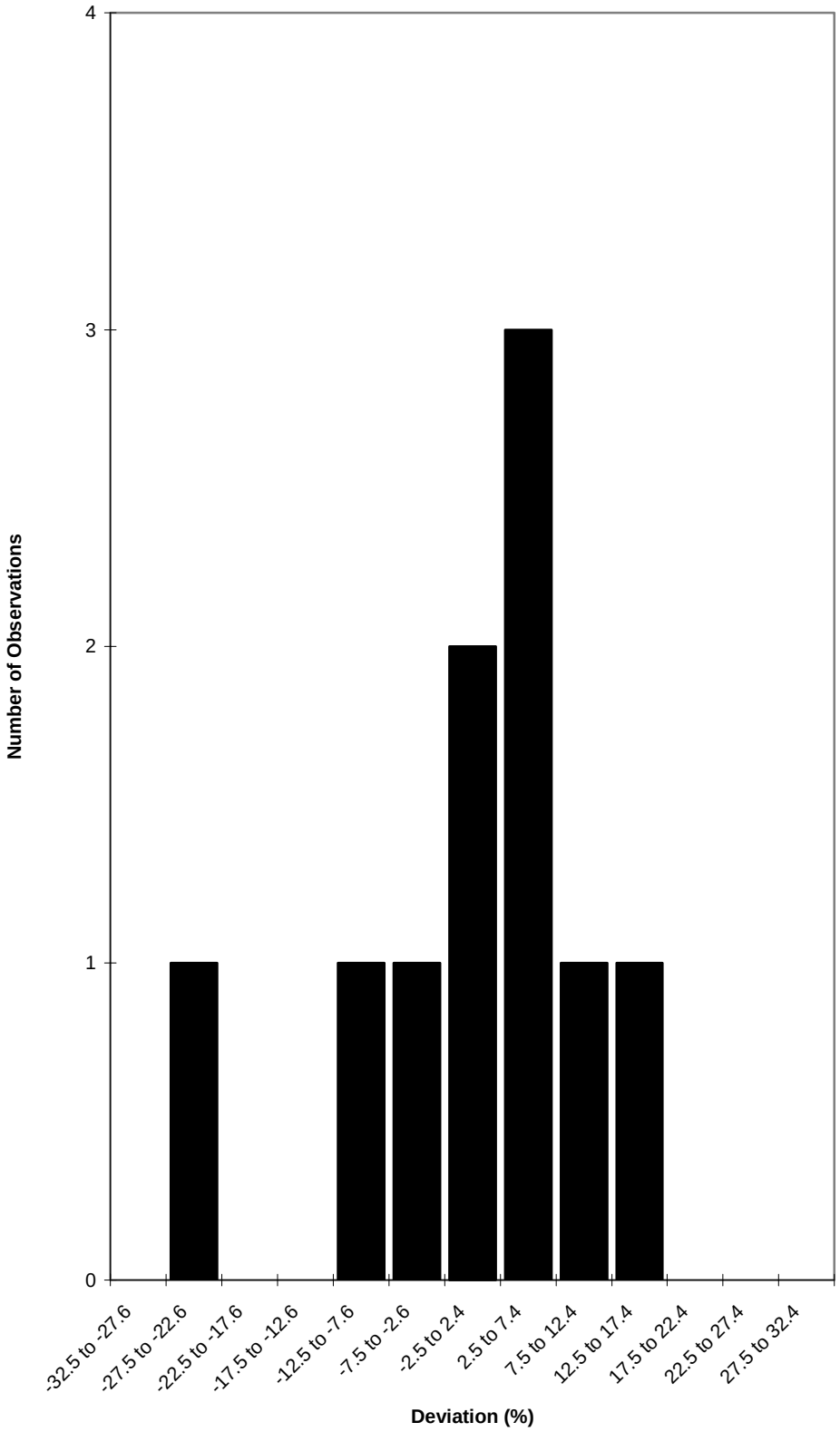


Figure 19 - Reported ^{90}Sr results (high level)

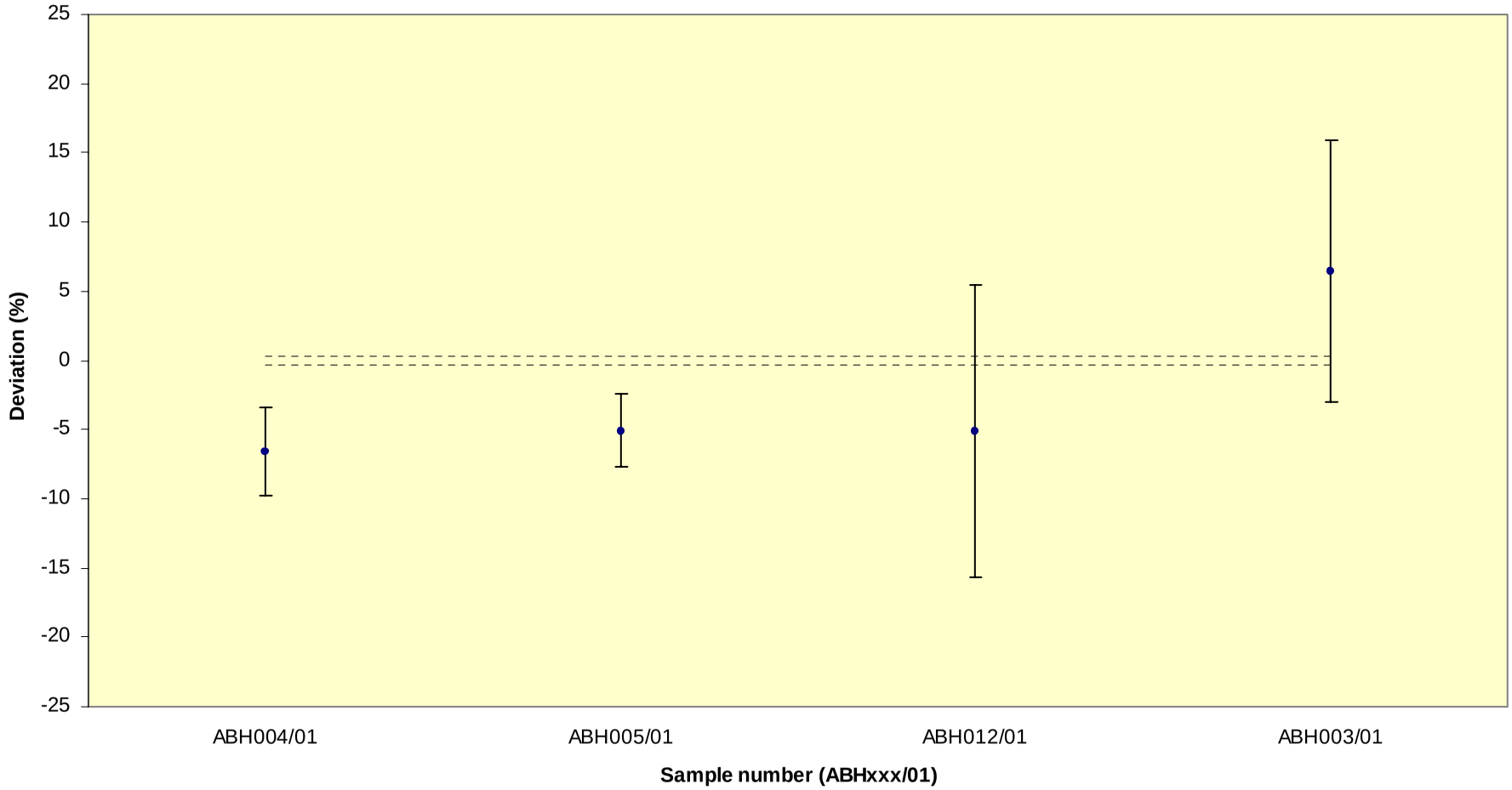


Figure 20 ^{90}Sr high level results

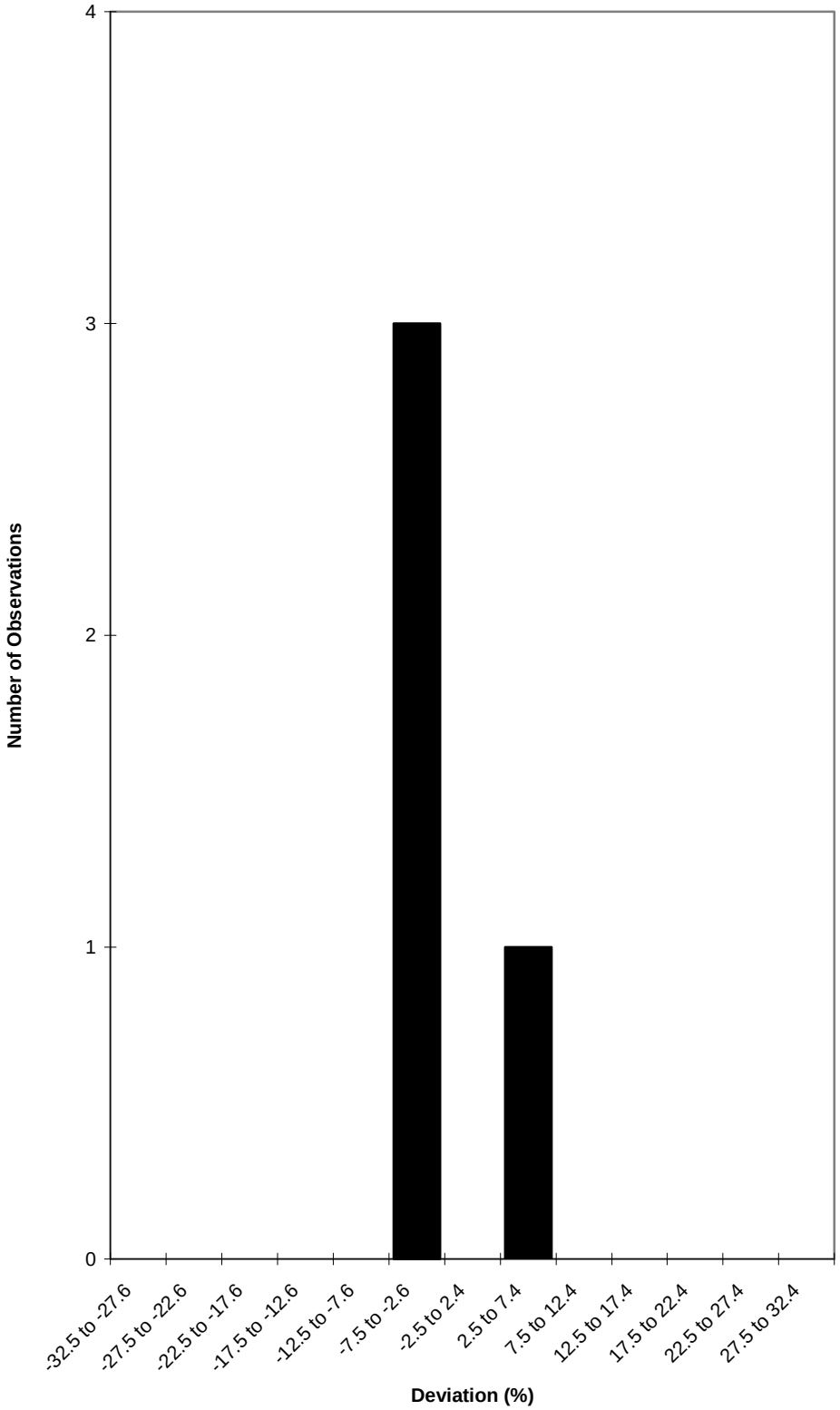


Figure 21 - Reported ^{99}Tc results (high level)

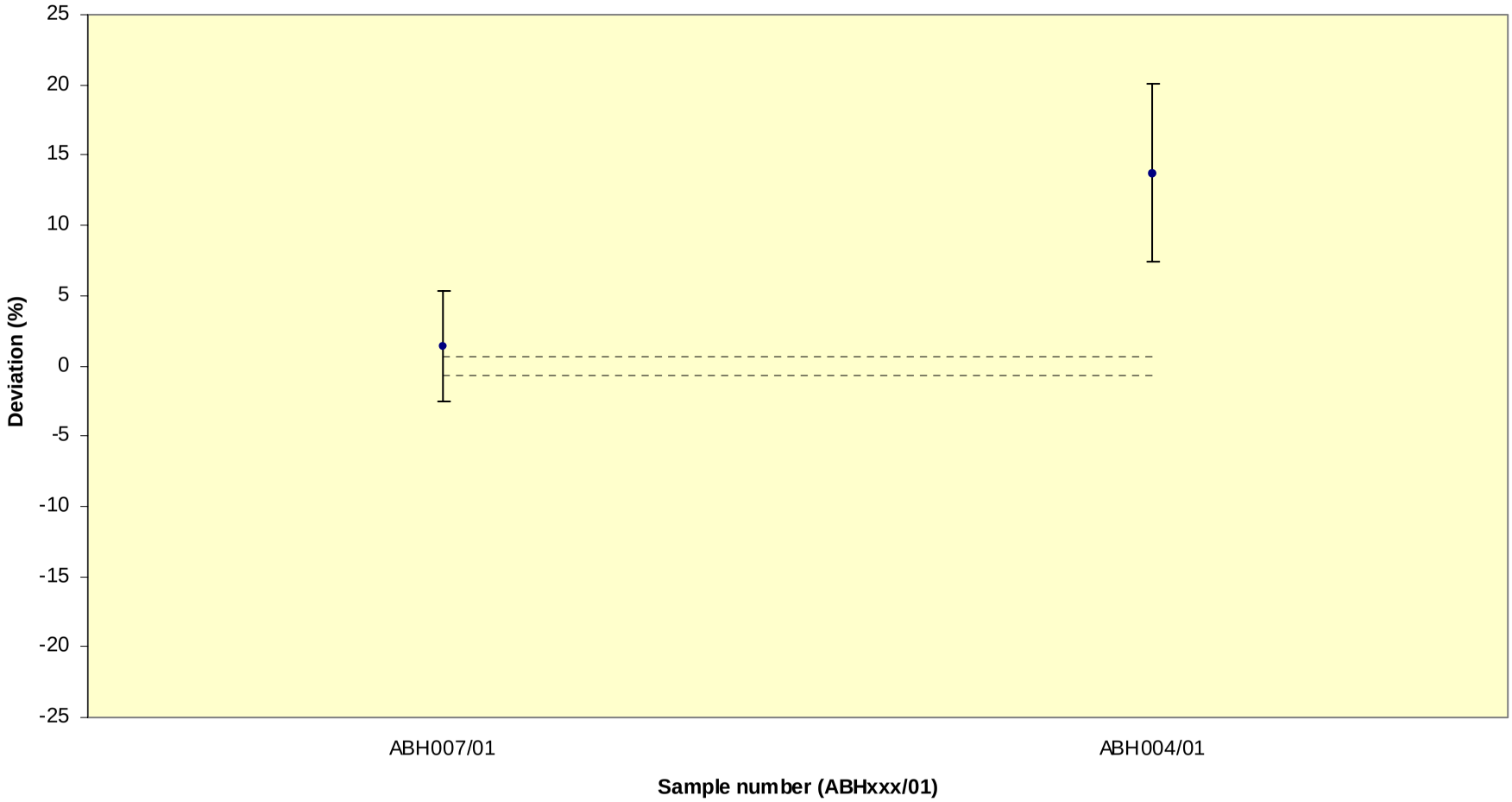


Figure 22 ^{99}Tc high level results

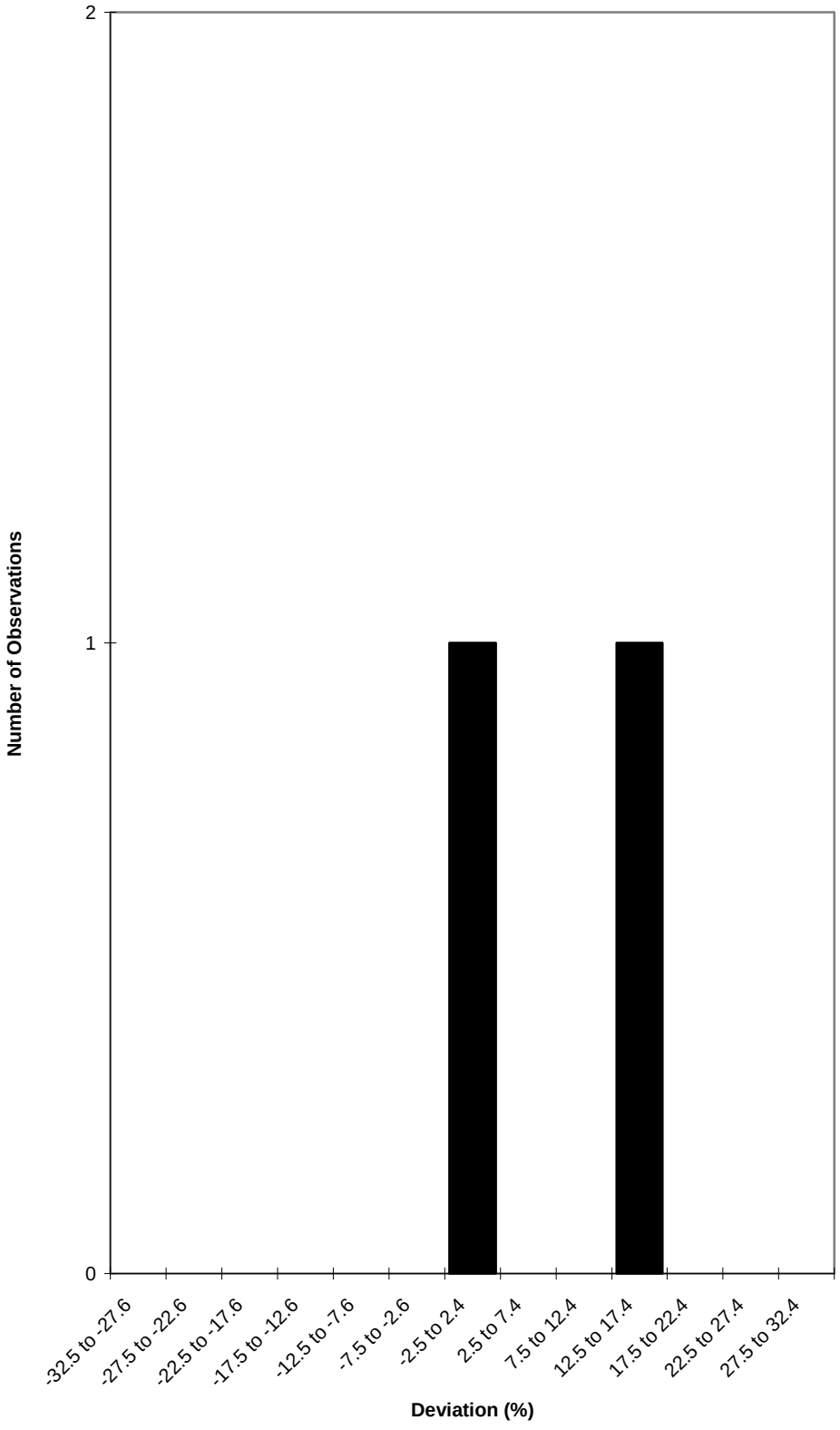


Figure 23 - Reported ^{210}Pb results (high level)

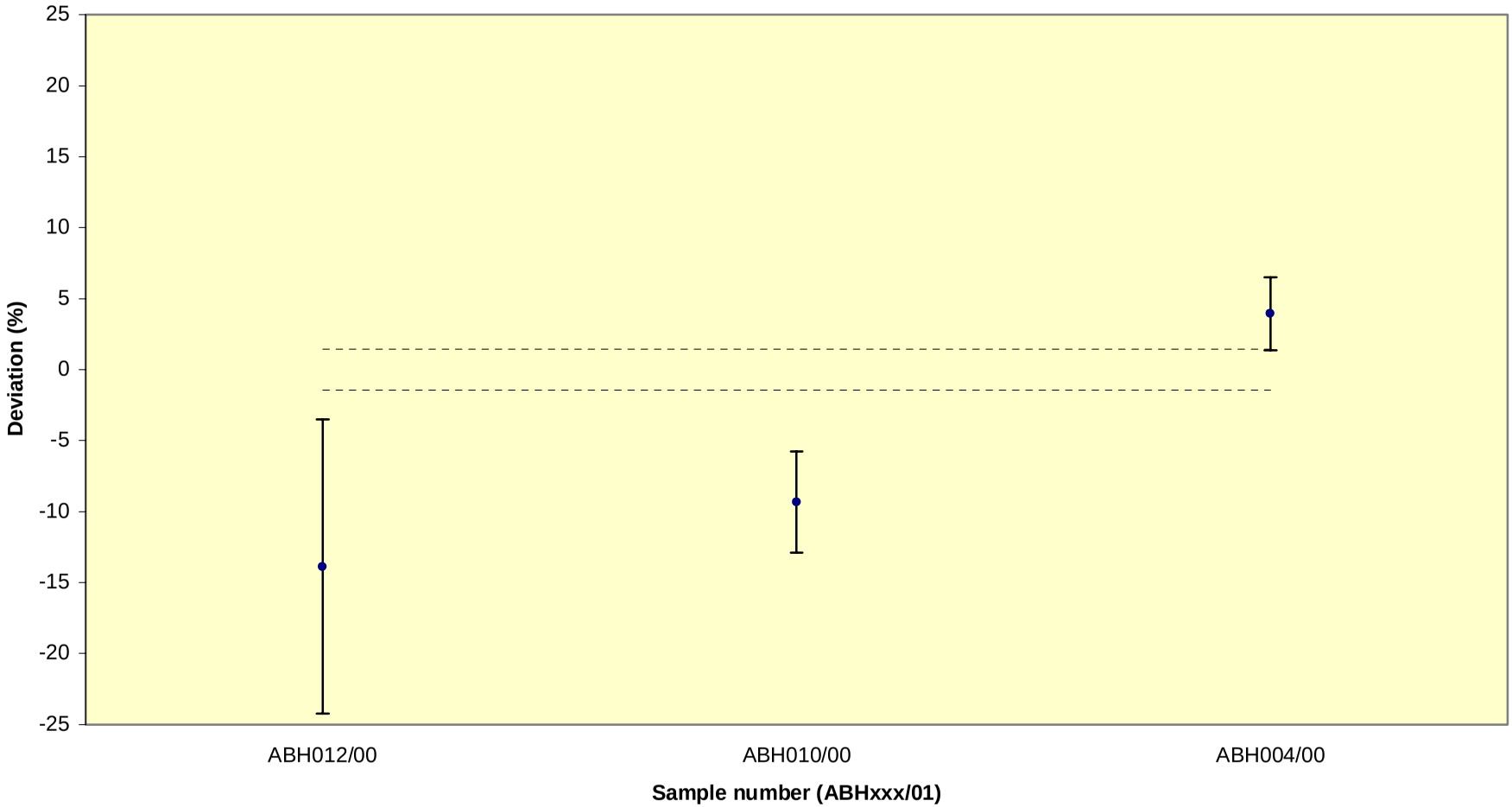


Figure 24 ^{210}Pb high level results

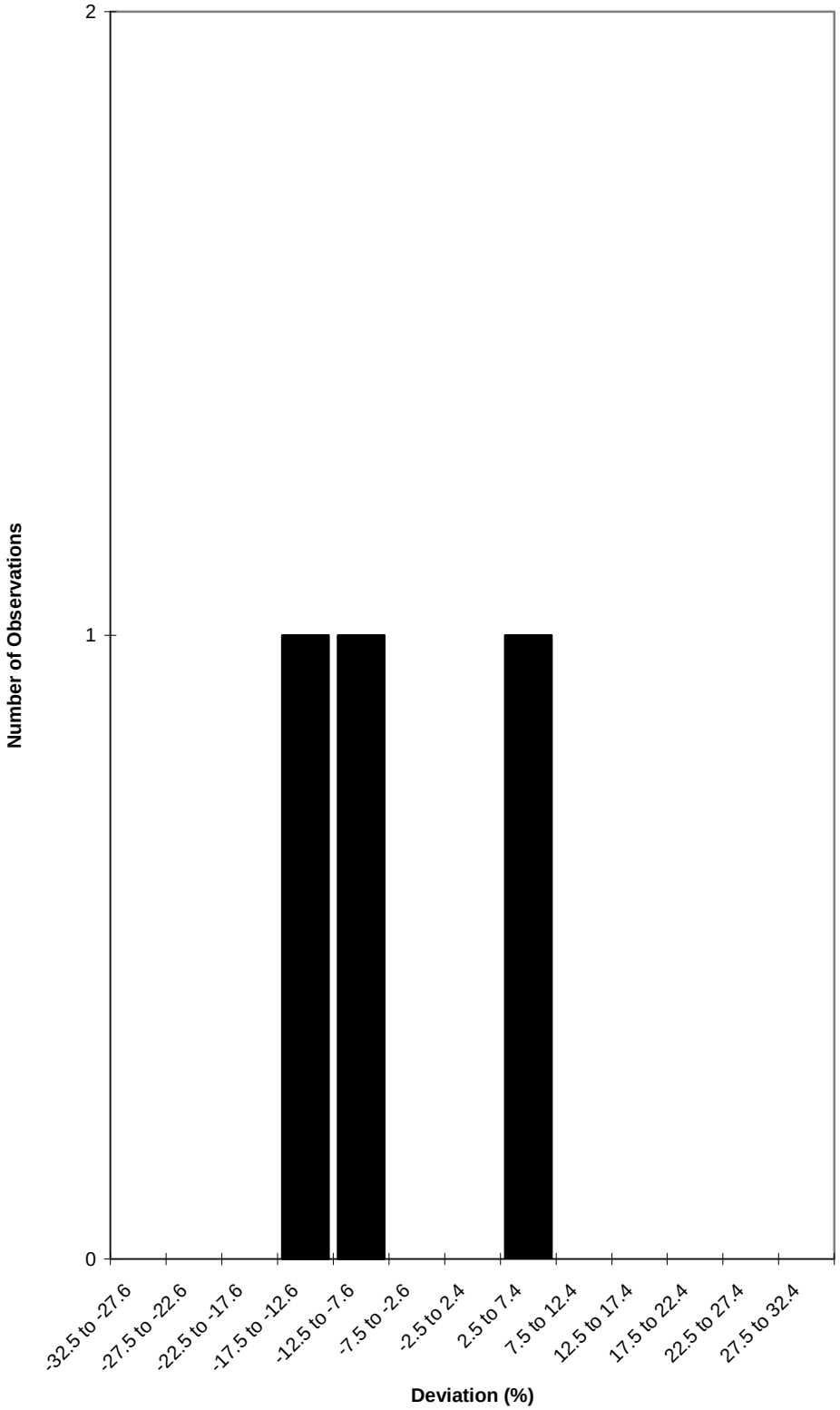


Figure 25 - Reported ^{226}Ra results (high level)

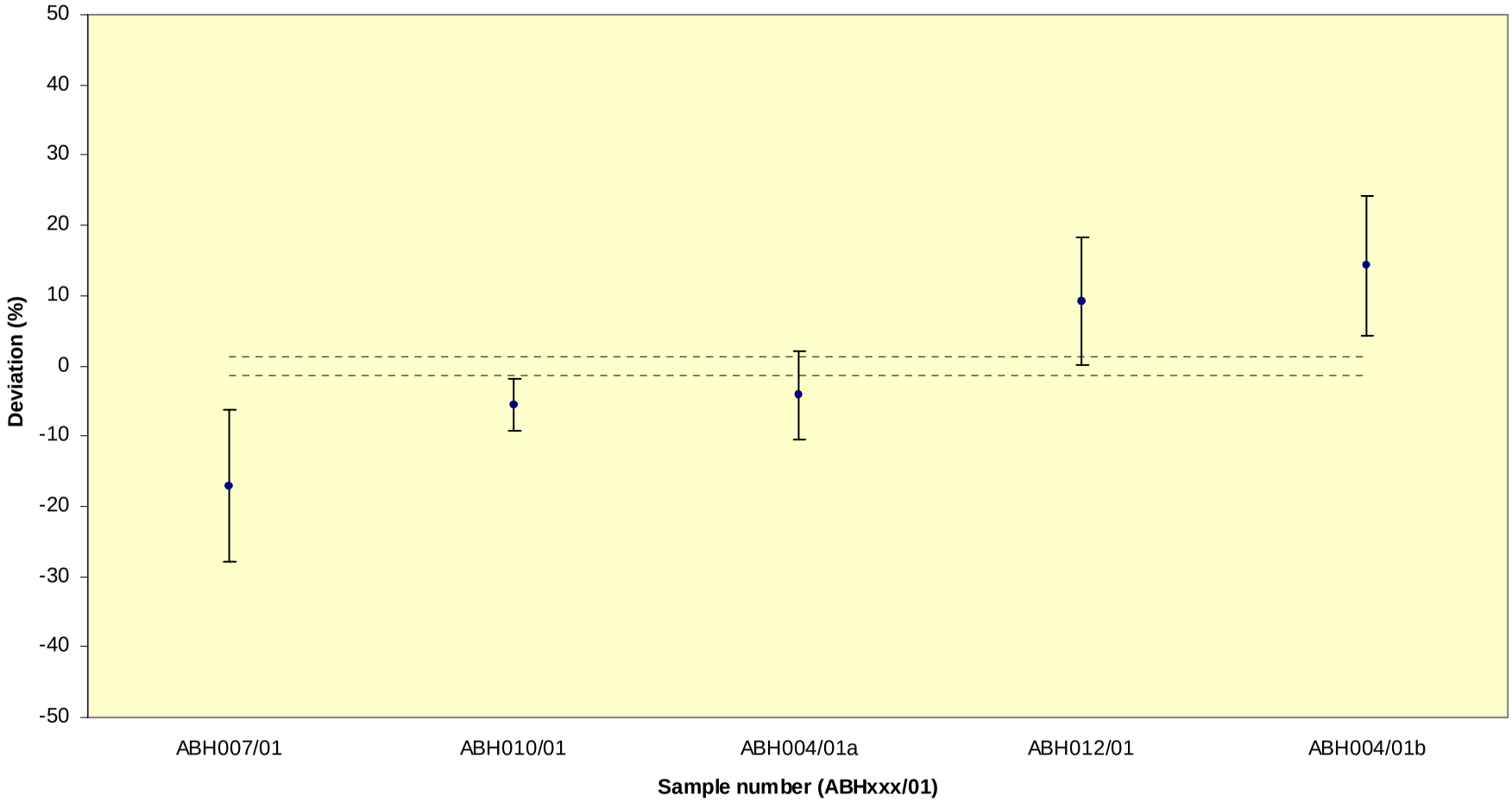


Figure 26 ^{226}Ra high level results

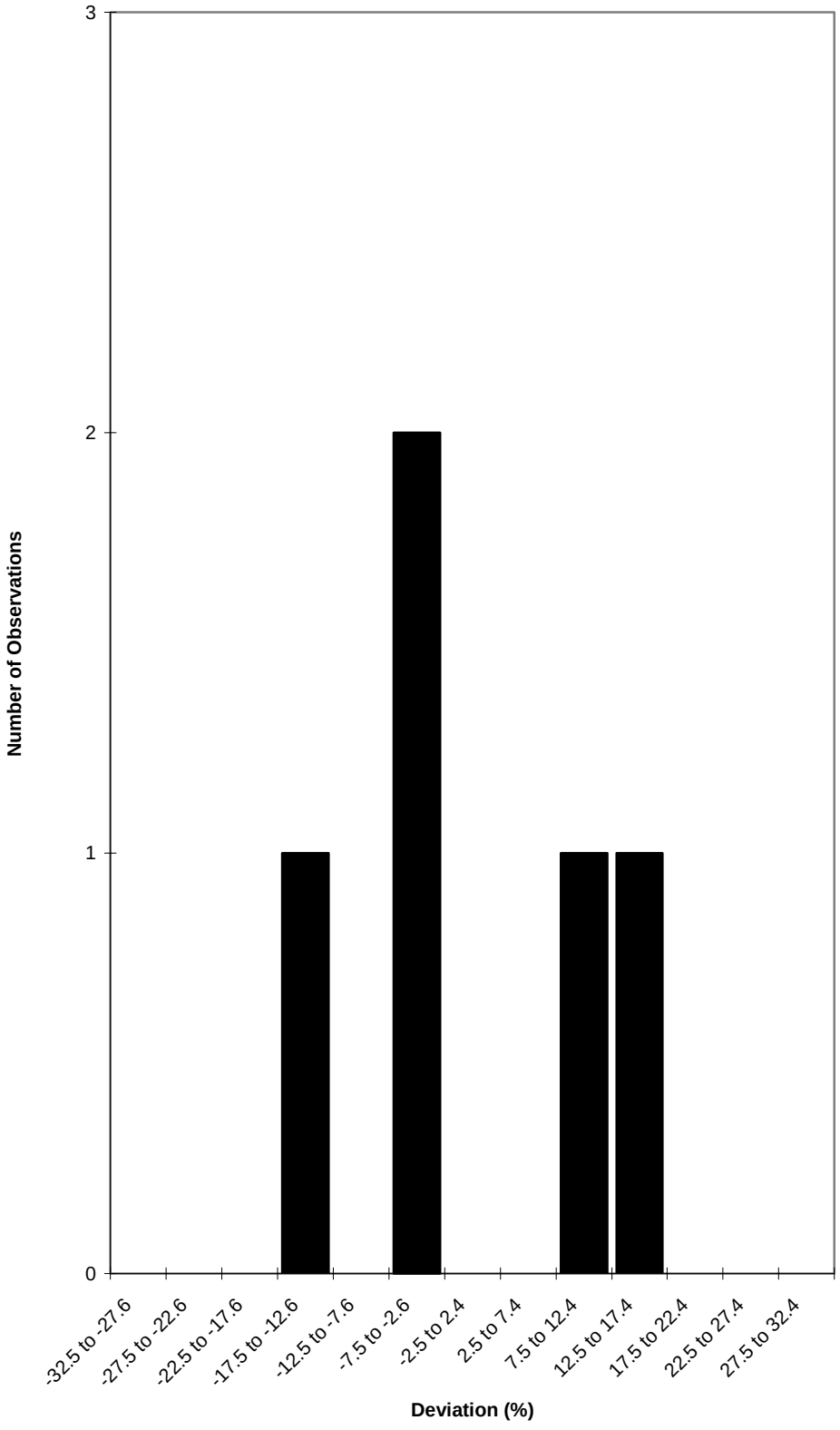


Figure 27 - Reported ^{238}Pu results (high level)

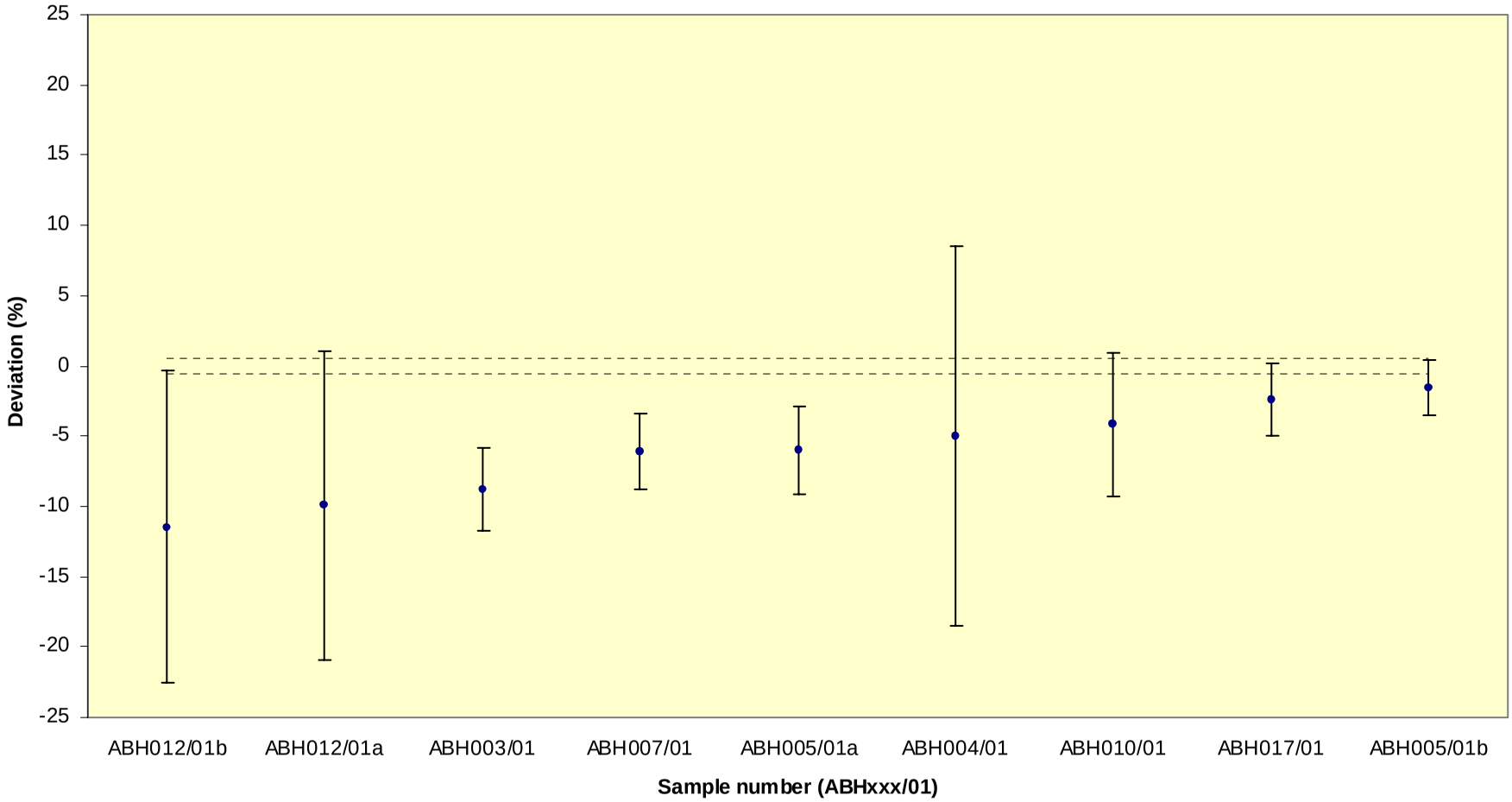


Figure 28 ^{238}Pu high level results

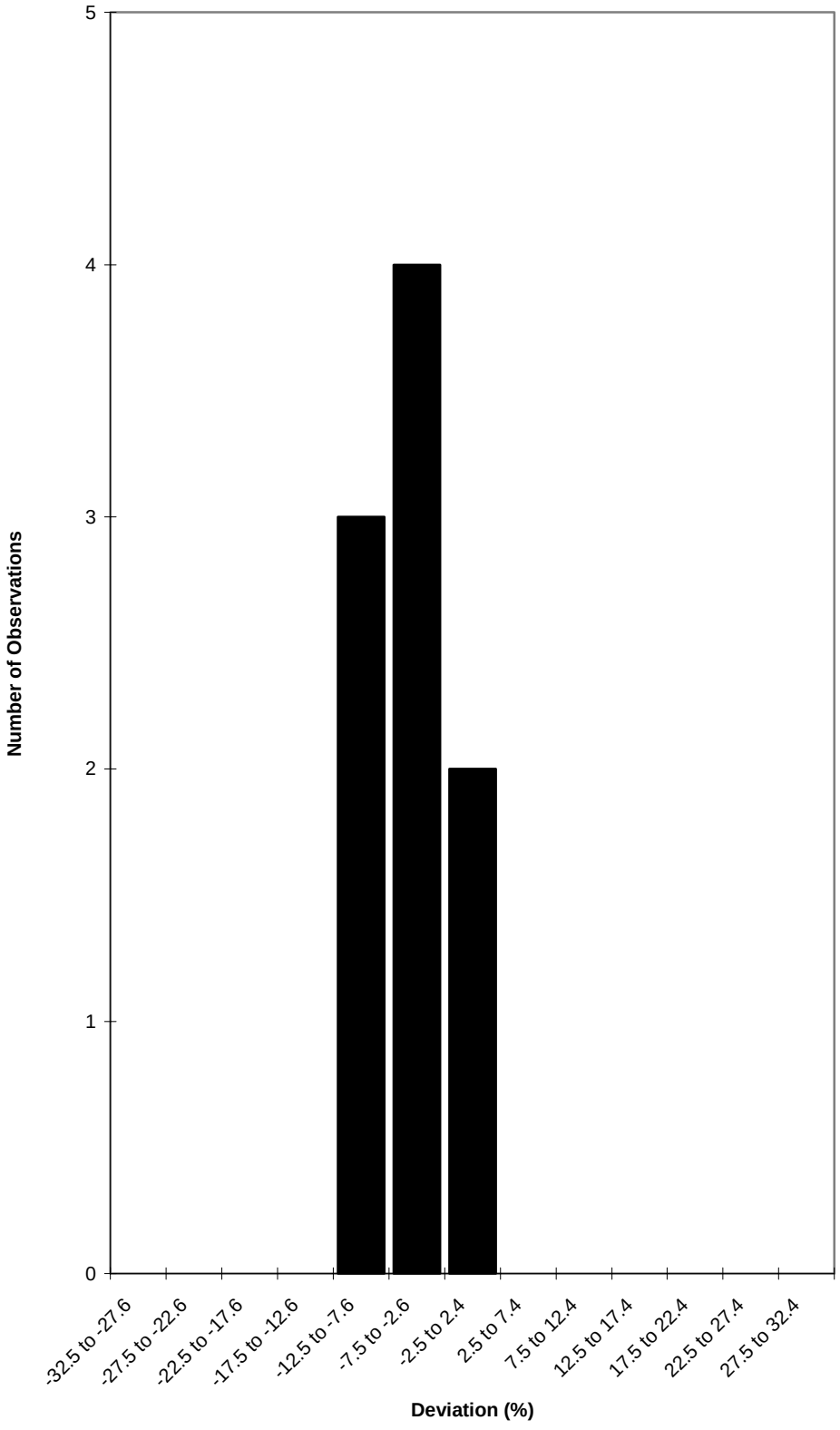


Figure 29 - Reported ^{239}Pu results (high level)

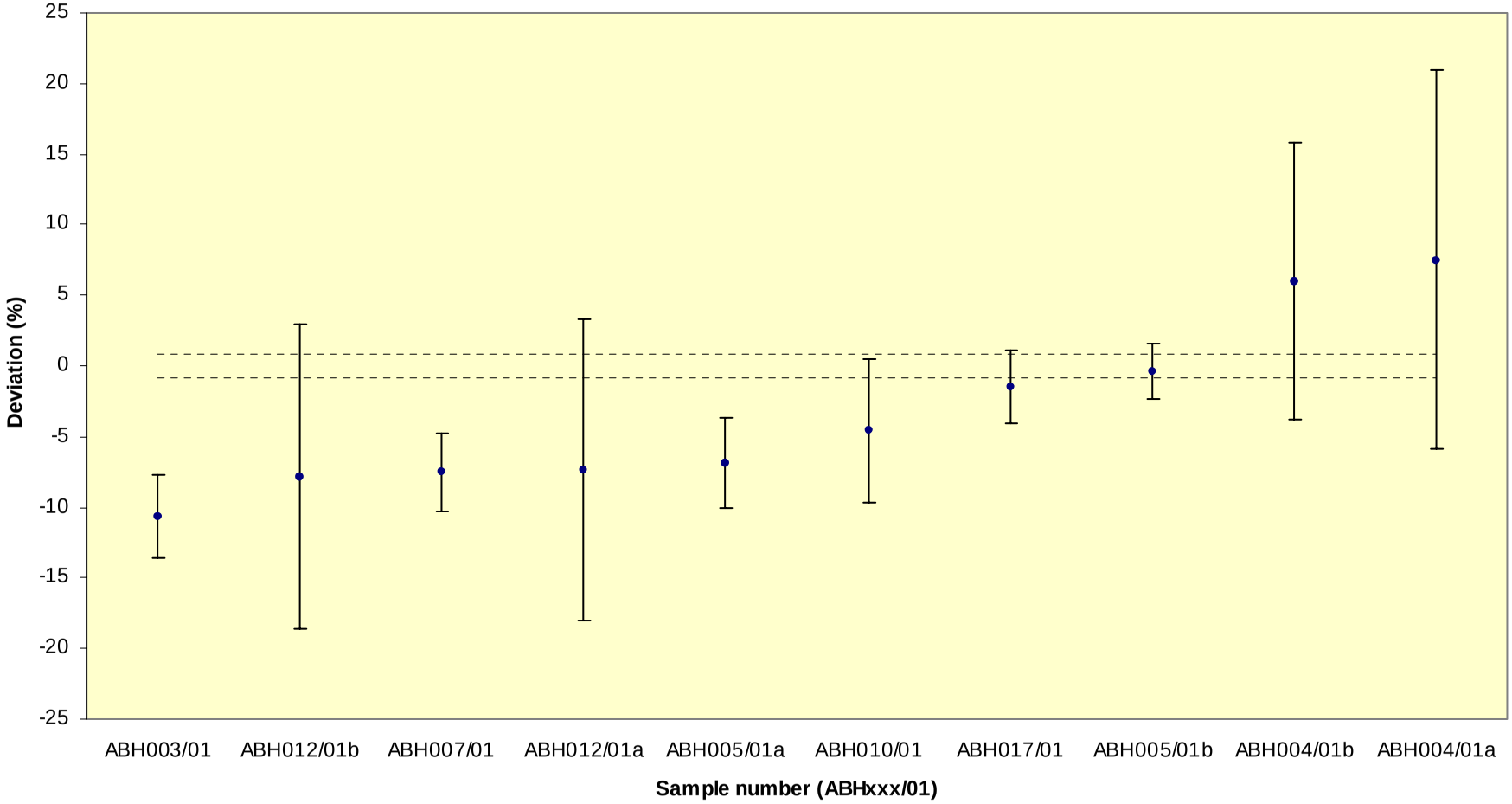


Figure 30 ^{239}Pu high level results

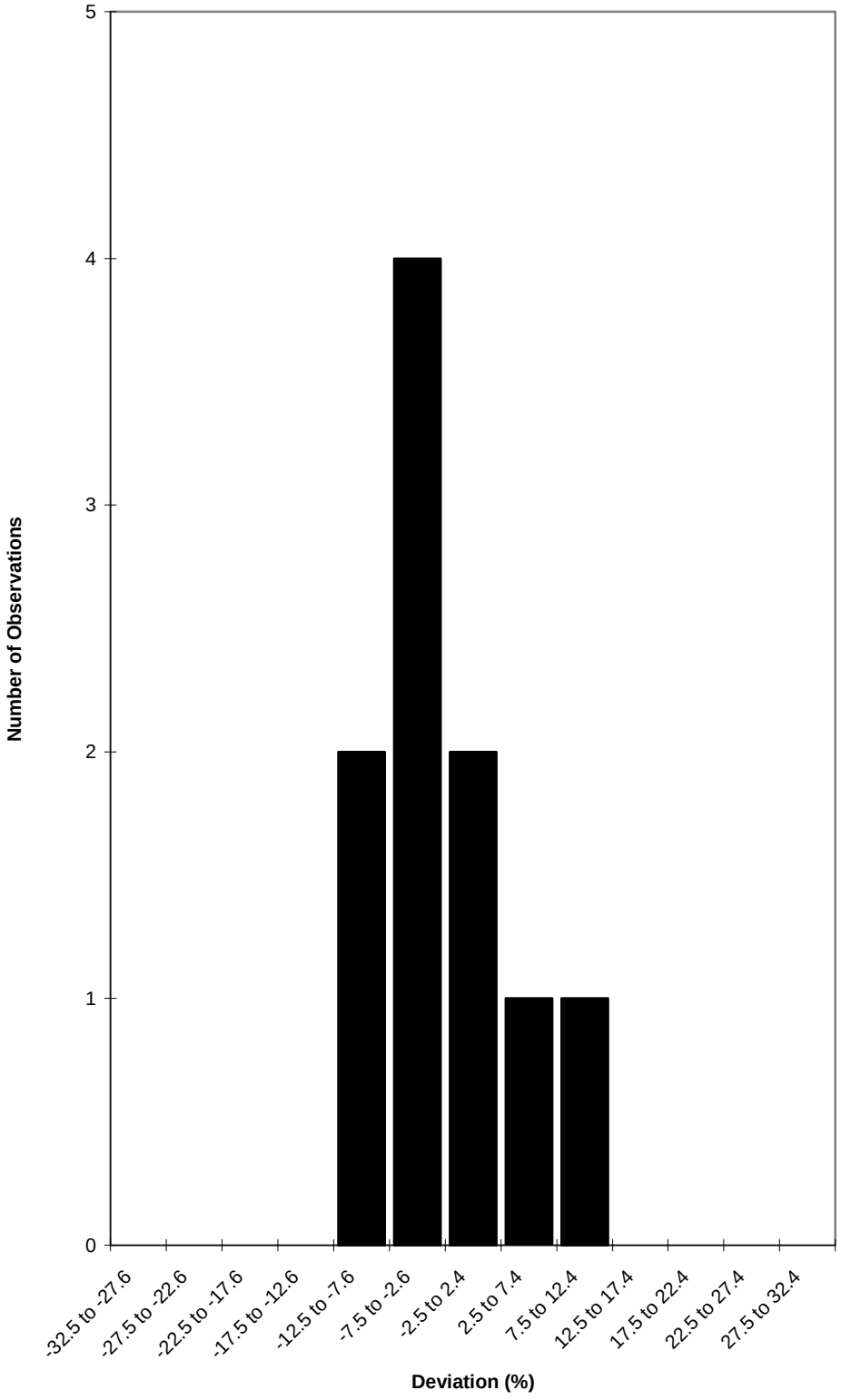


Figure 31 - Reported ^{241}Am results (high level)
(x = alpha spectrometry, o = gamma spectrometry, + = other)

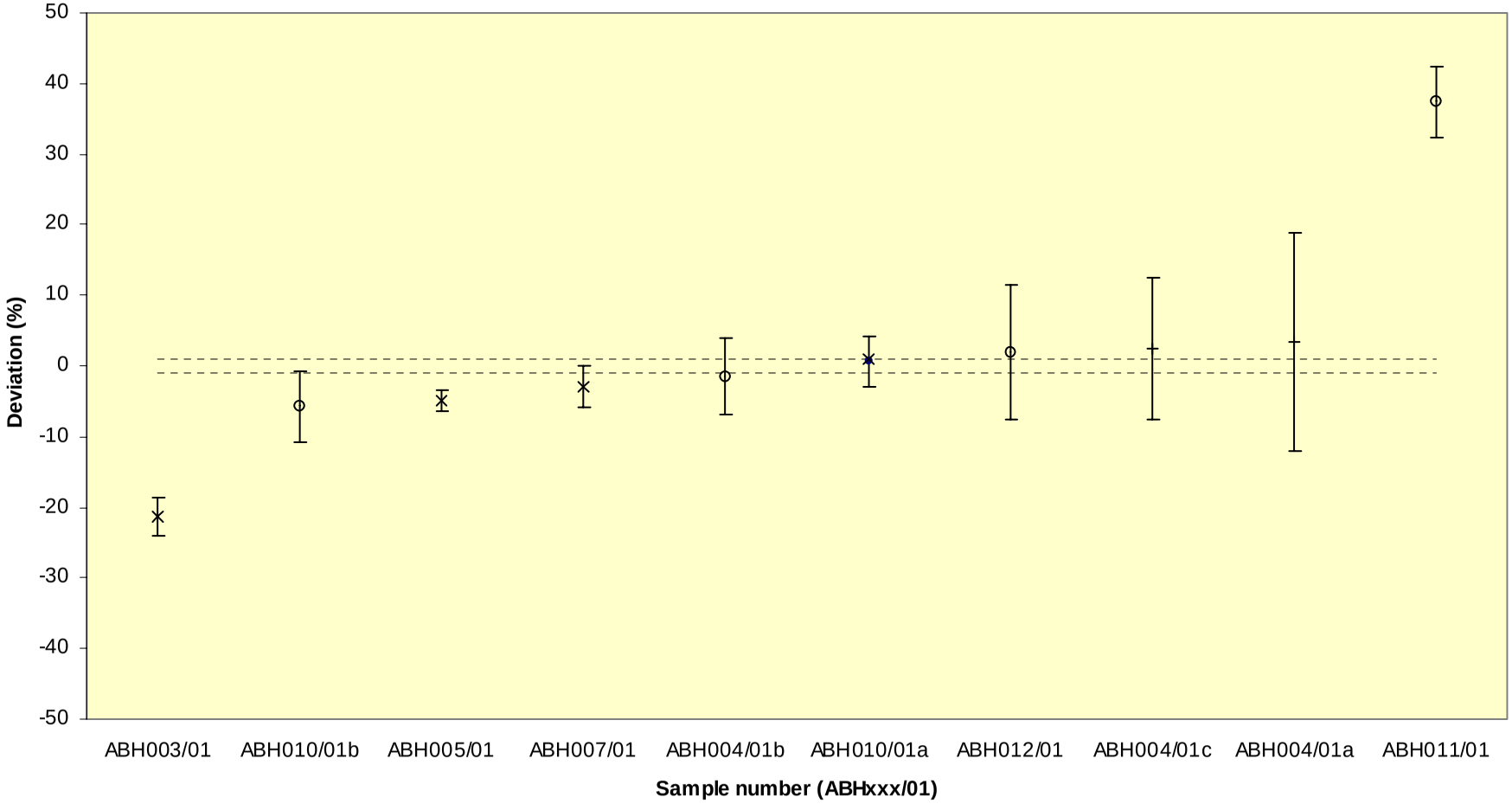


Figure 32 ^{241}Am high level results

(One outside limits of plot)

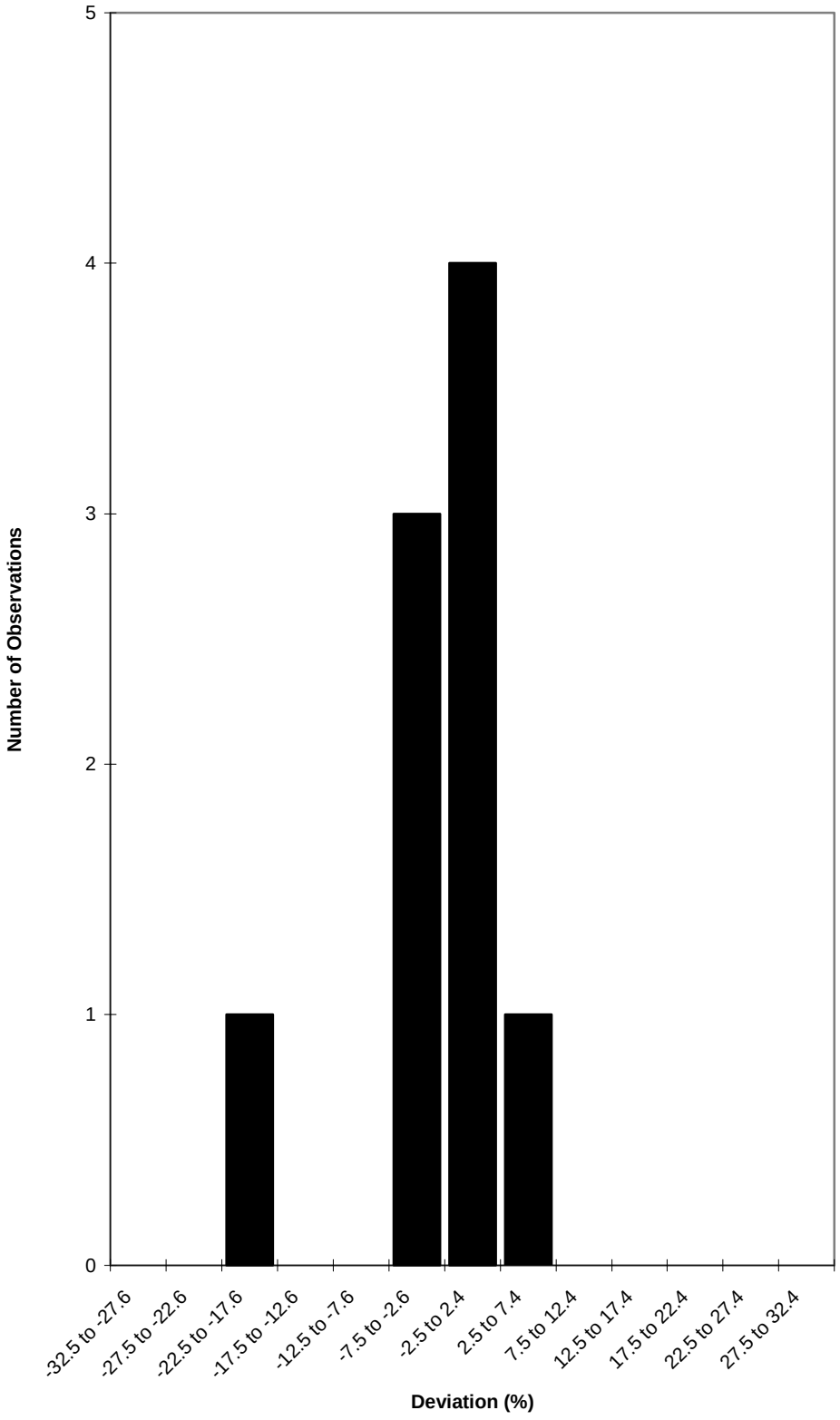


Figure 33 - Reported ^{22}Na results (low level)

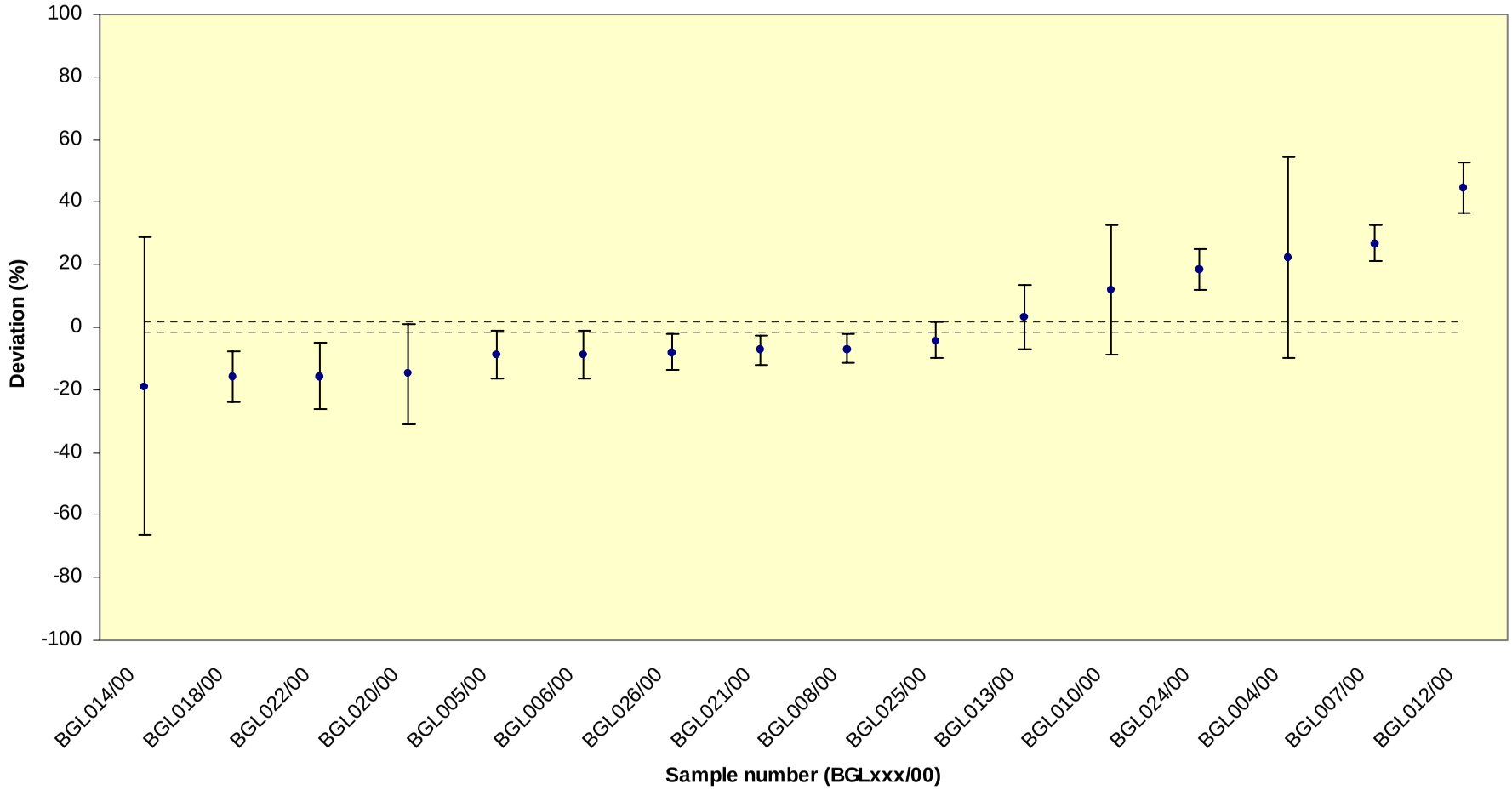


Figure 34 ^{22}Na low level results

(One outside limits of plot)

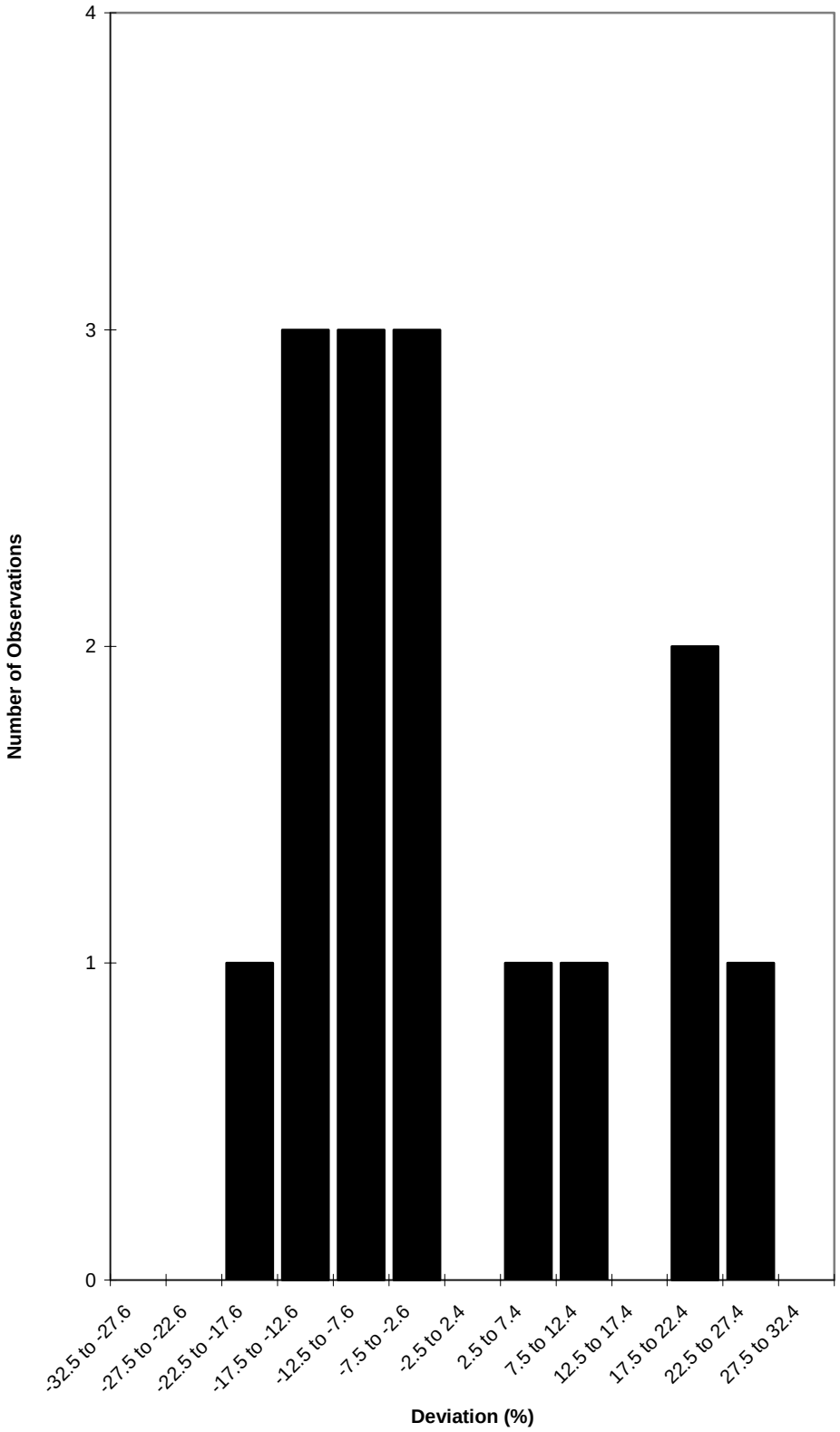


Figure 35 - Reported ^{60}Co results (low level)

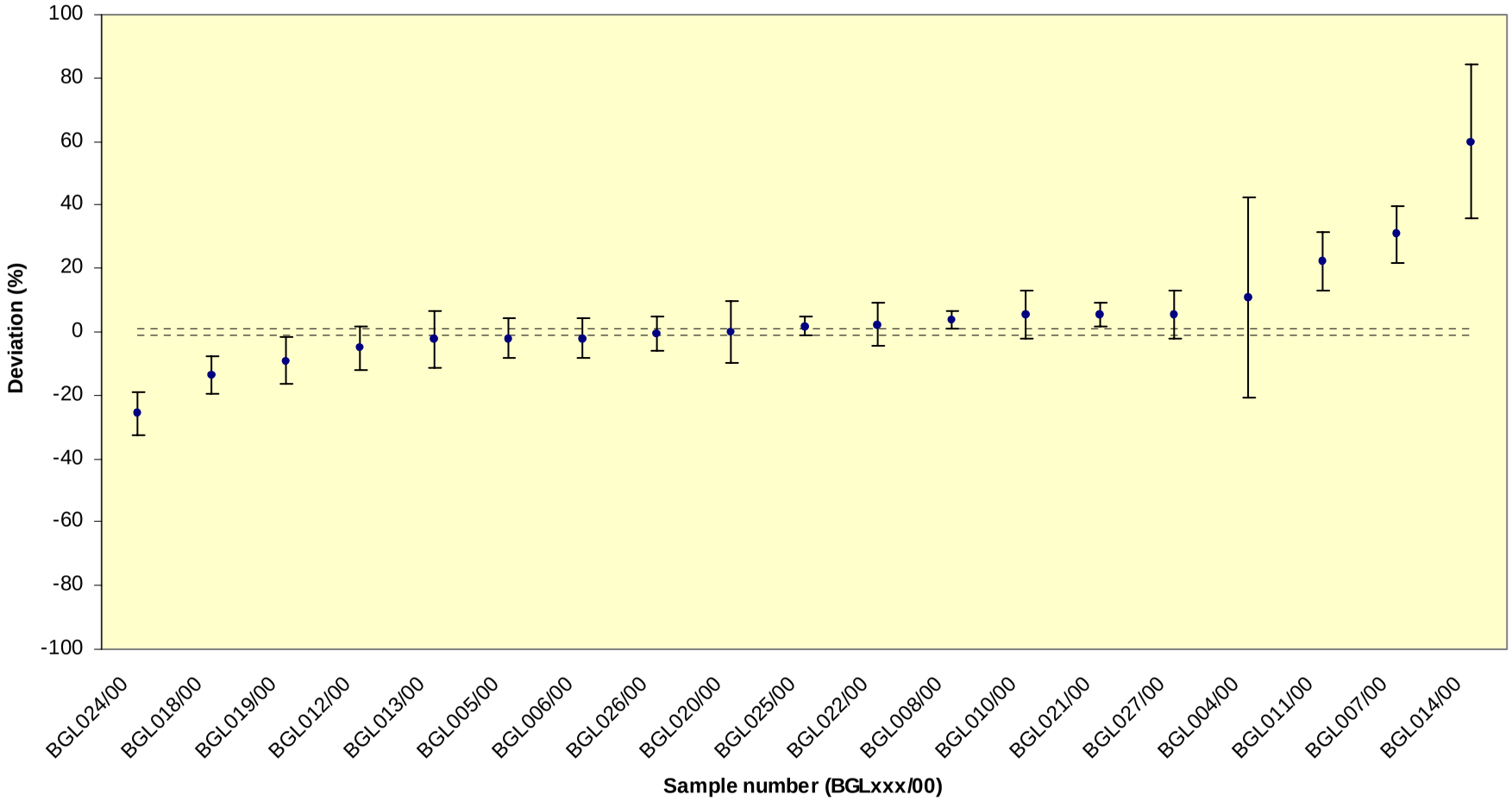


Figure 36 ^{60}Co low level results

(One outside limits of plot)

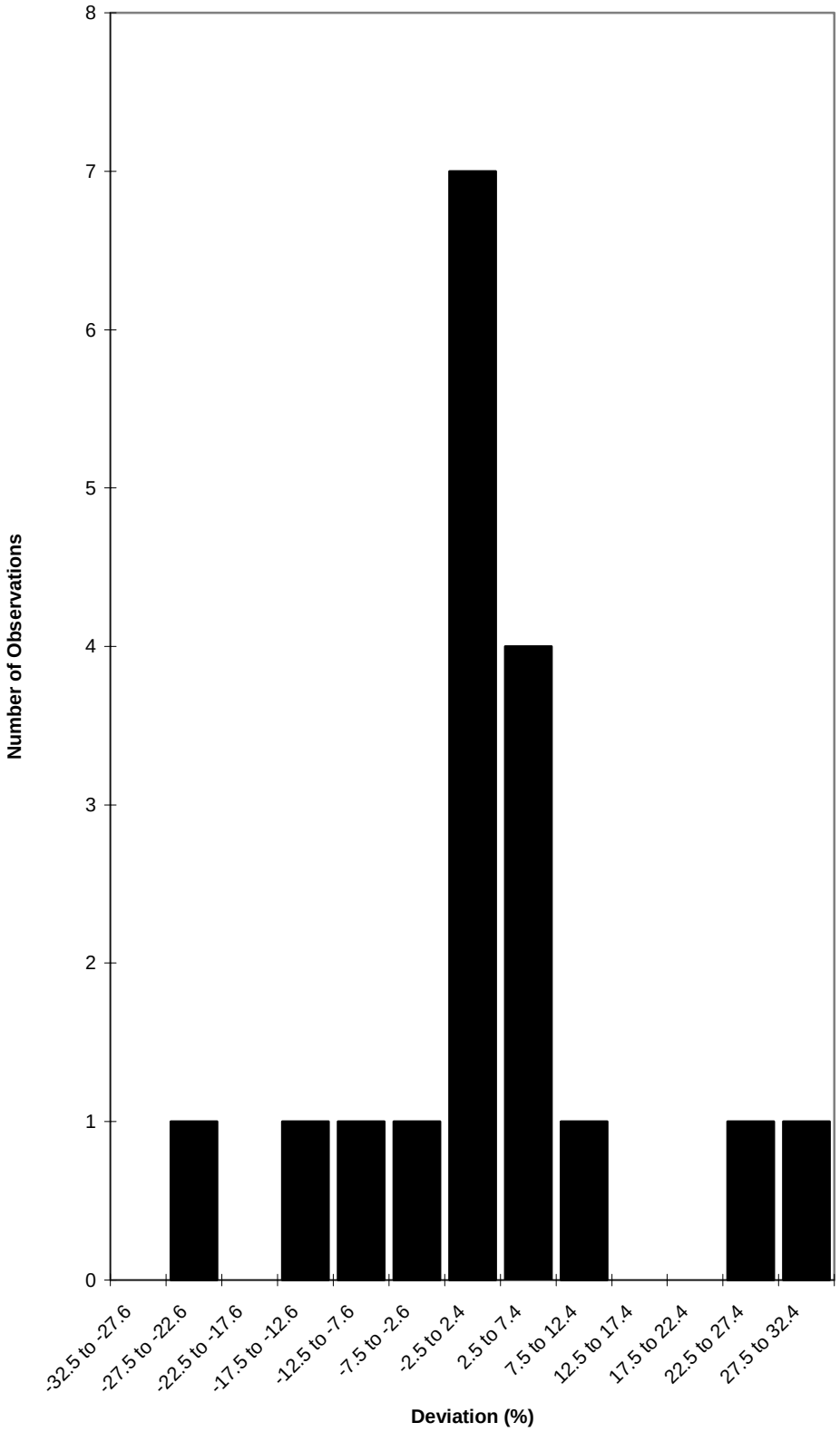


Figure 37 - Reported ^{65}Zn results (low level)
(One quoted maximum value)

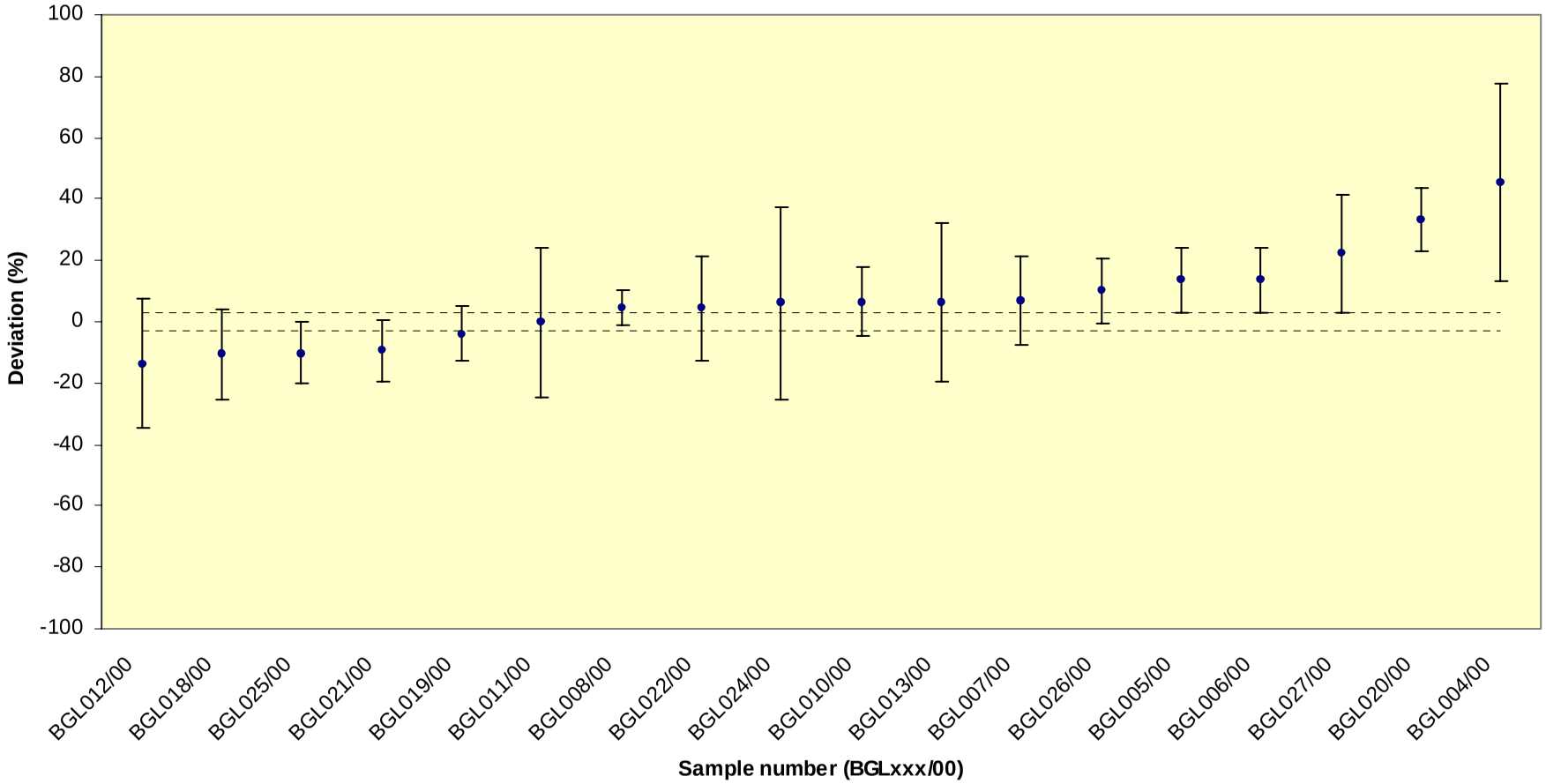


Figure 38 ^{65}Zn low level results

(Two outside limits of plot, one quoted maximum value)

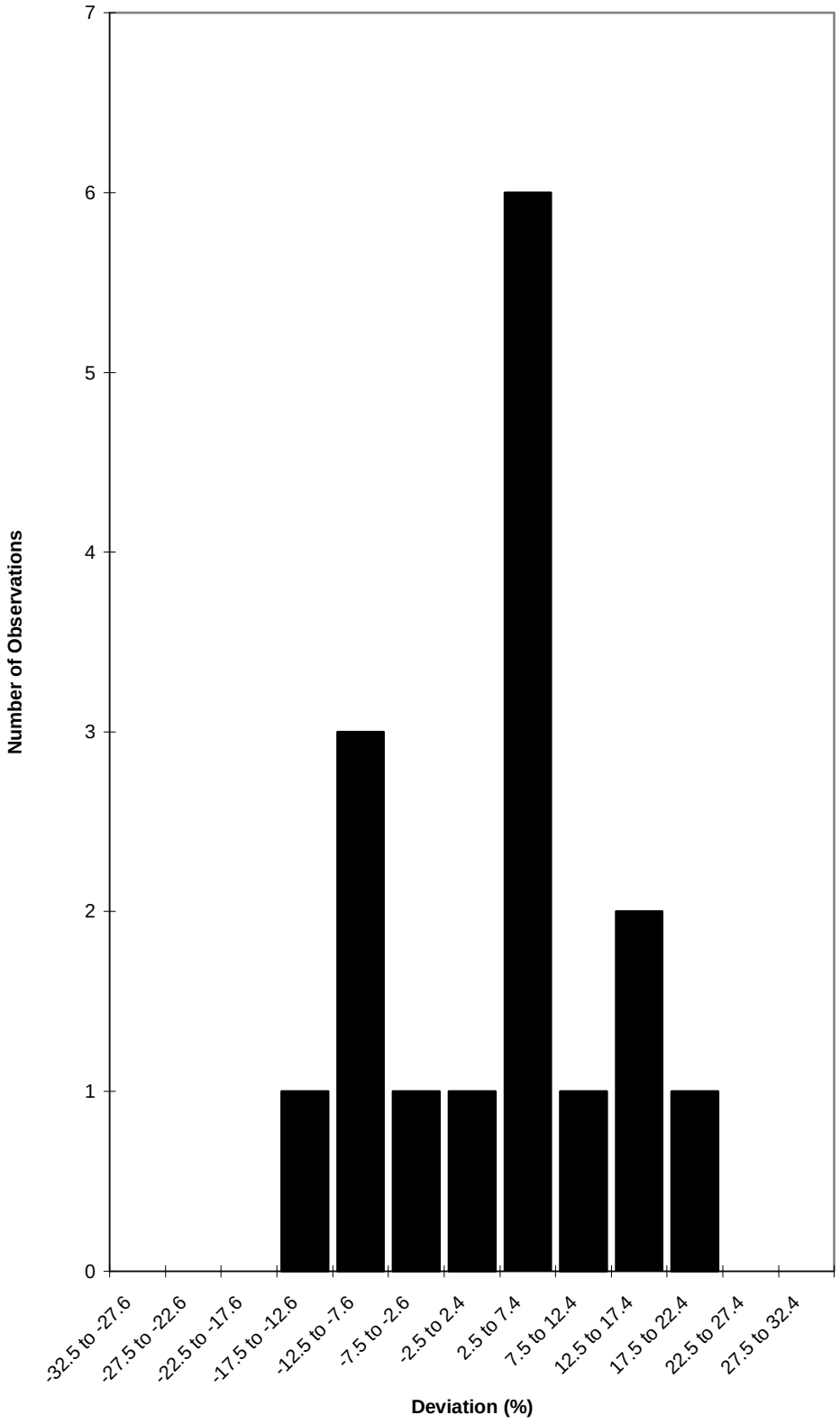


Figure 39 - Reported ^{124}Sb results (low level)
(One outside limits of plot, two quoted maximum values)

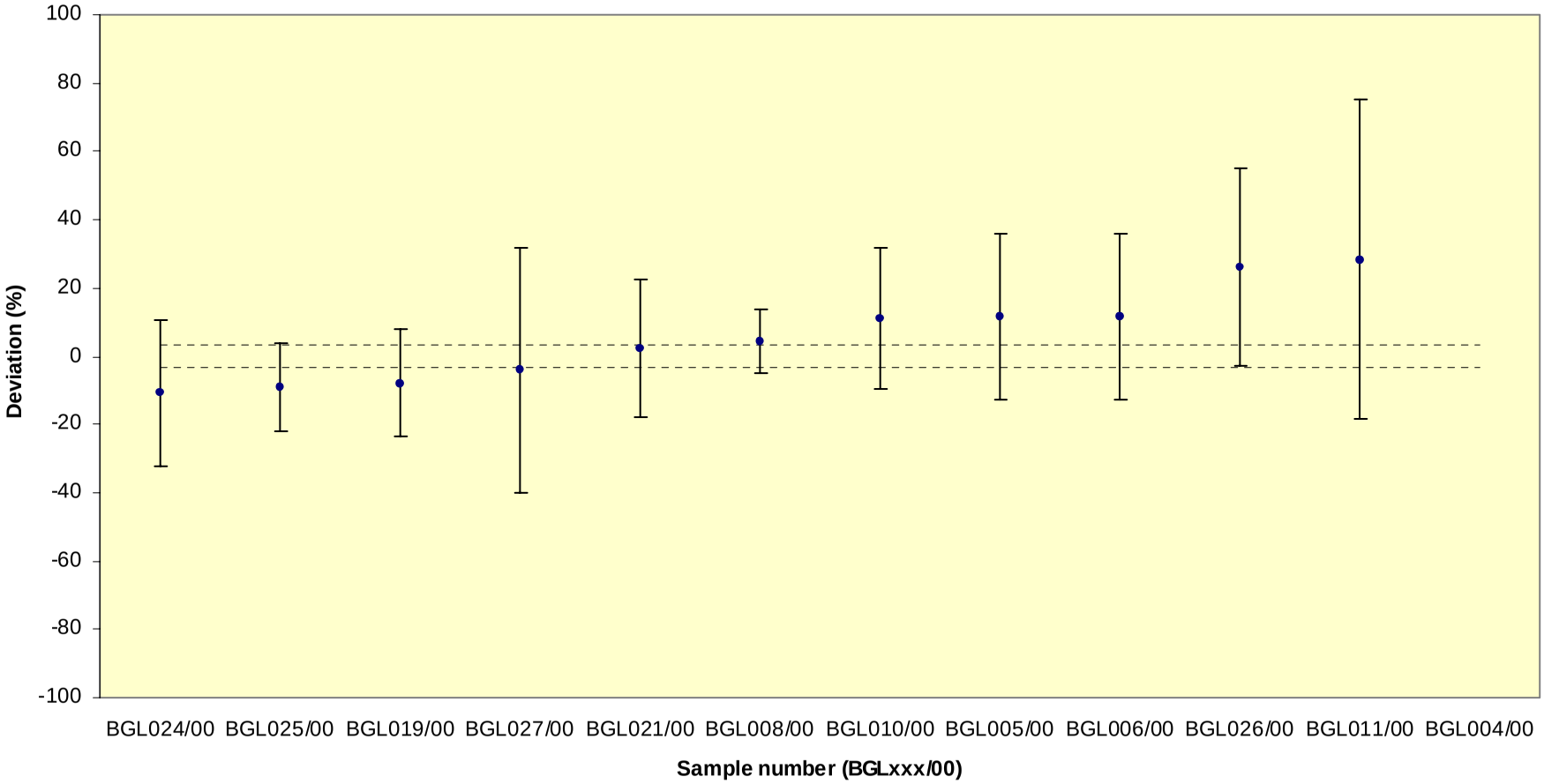


Figure 40 ^{124}Sb low level results

(One outside limits of plot, two quoted maximum values)

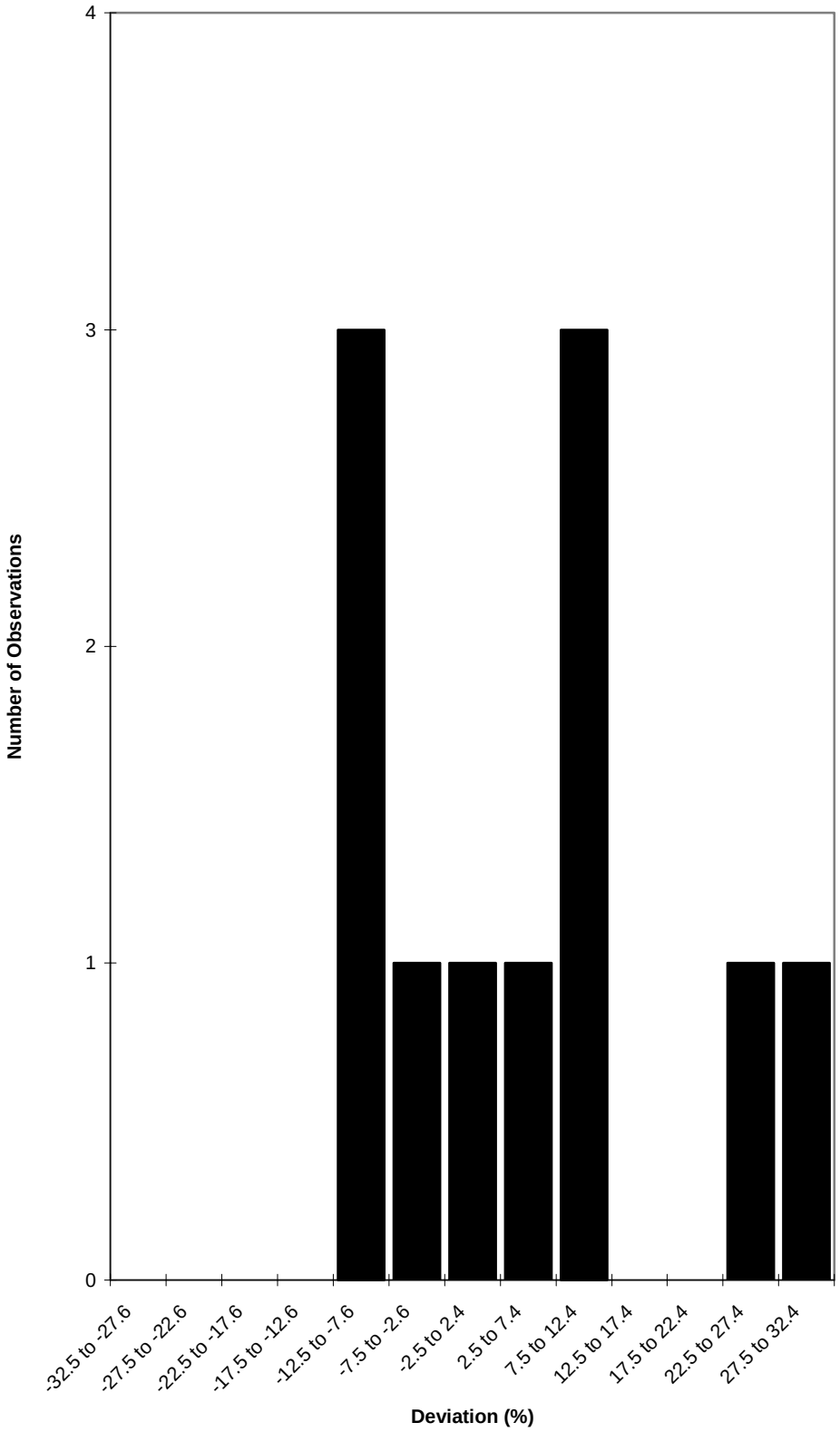


Figure 41 - Reported ^{125}Sb results (low level)
(One quoted maximum value)

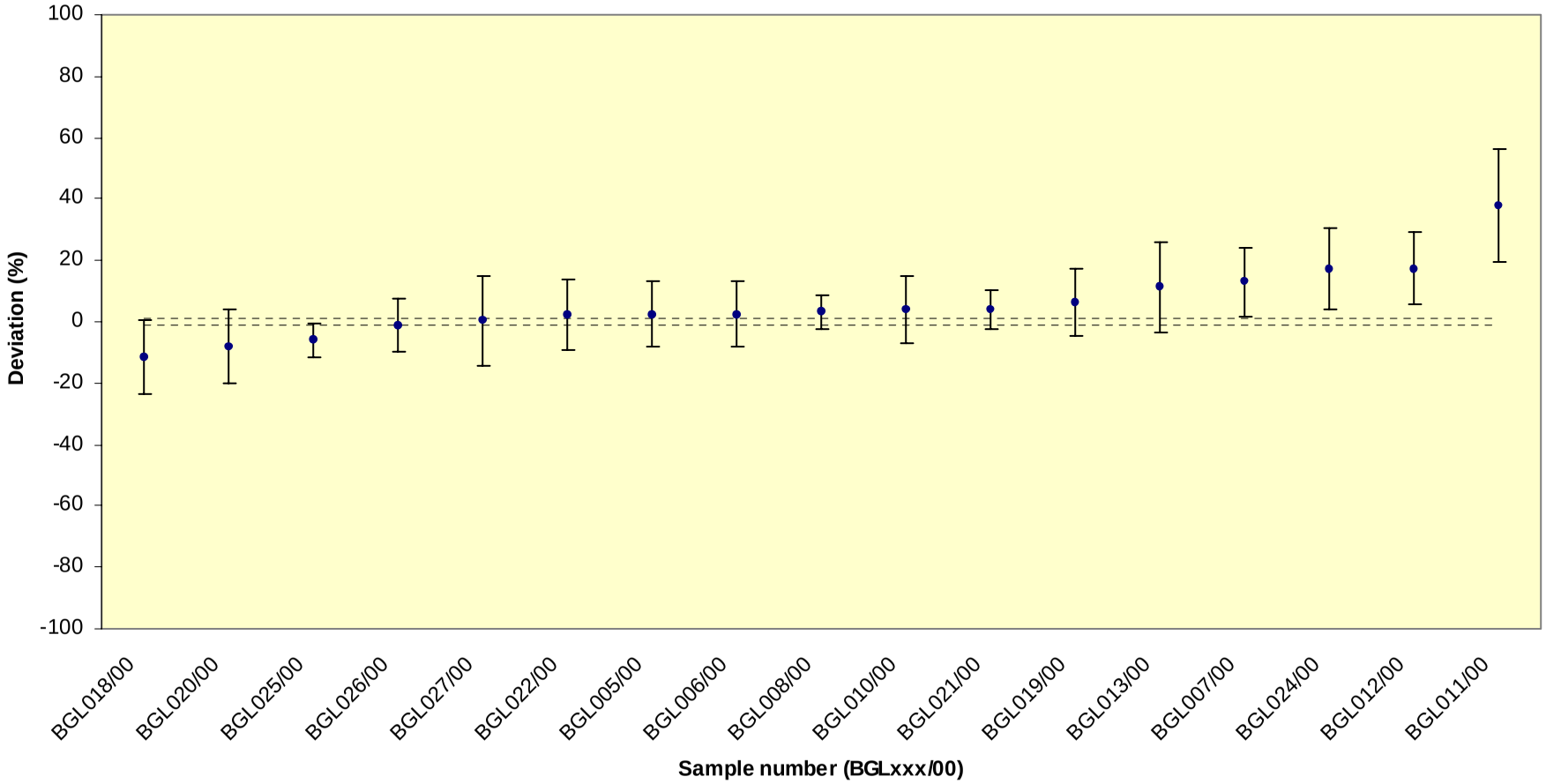


Figure 42 ^{125}Sb low level results

(One outside limits of plot, one quoted maximum value)

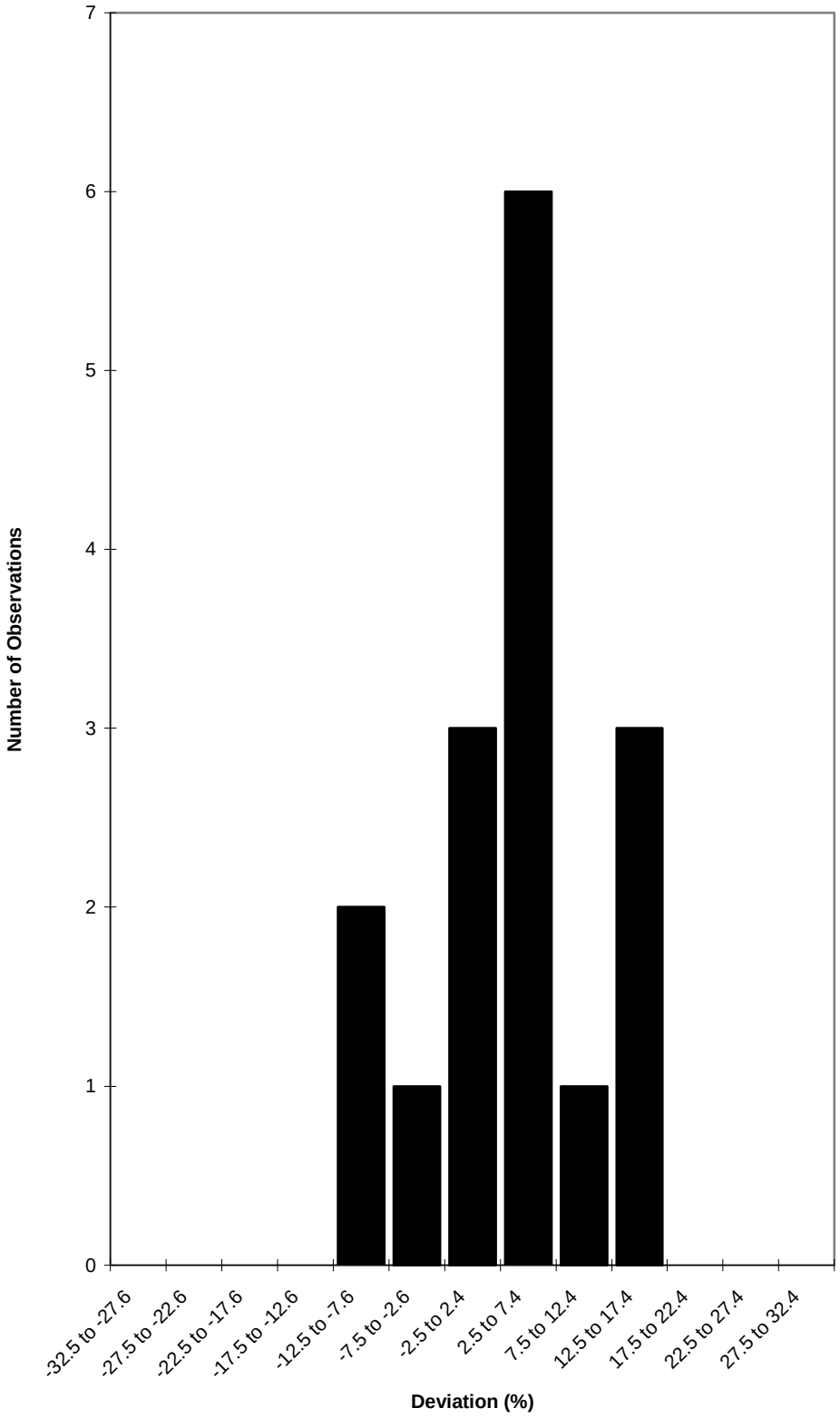


Figure 43 - Reported ^{134}Cs results (low level)
(One quoted maximum value)

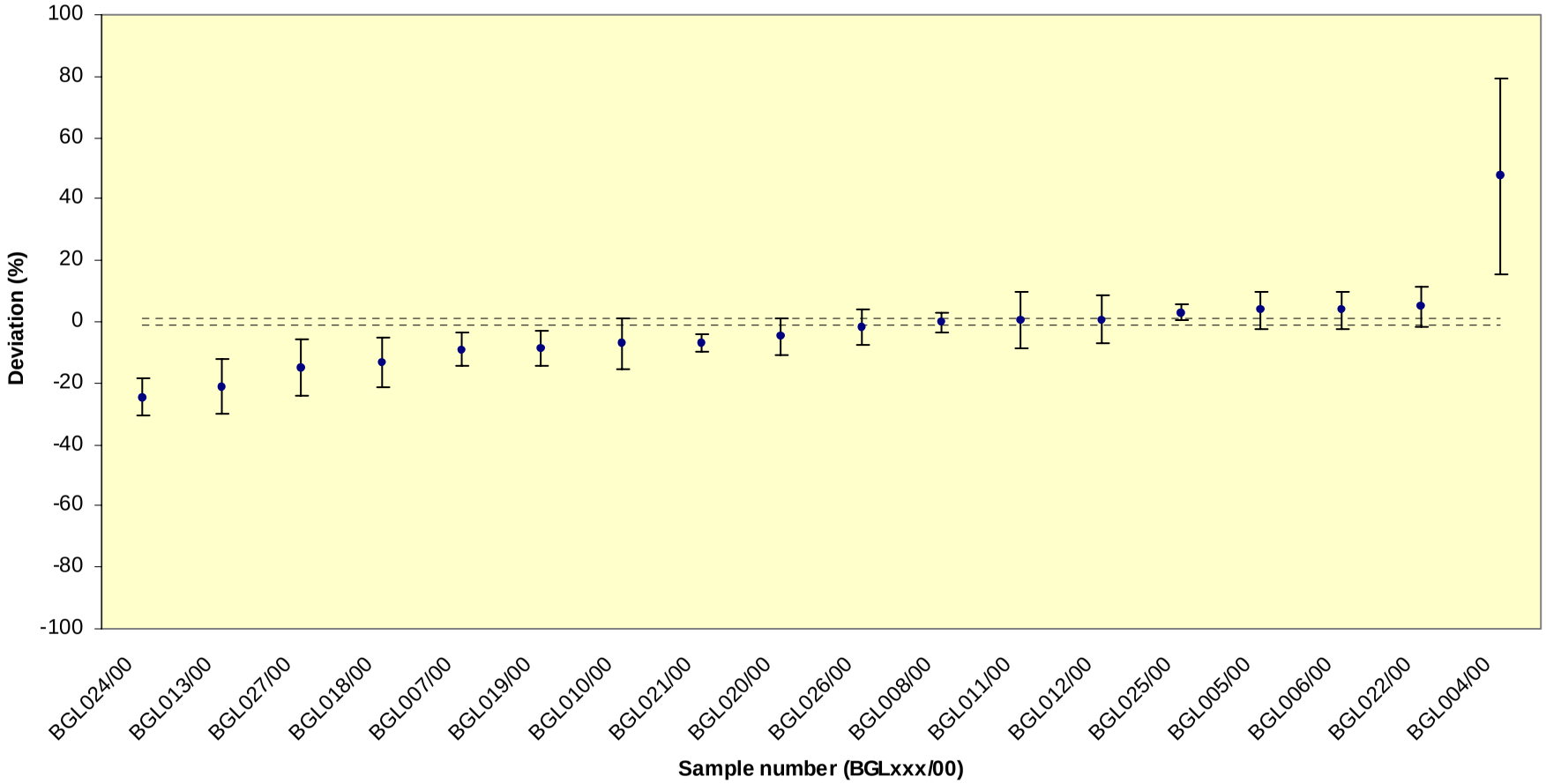


Figure 44 ^{134}Cs low level results

(One outside limits of plot, one quoted maximum value)

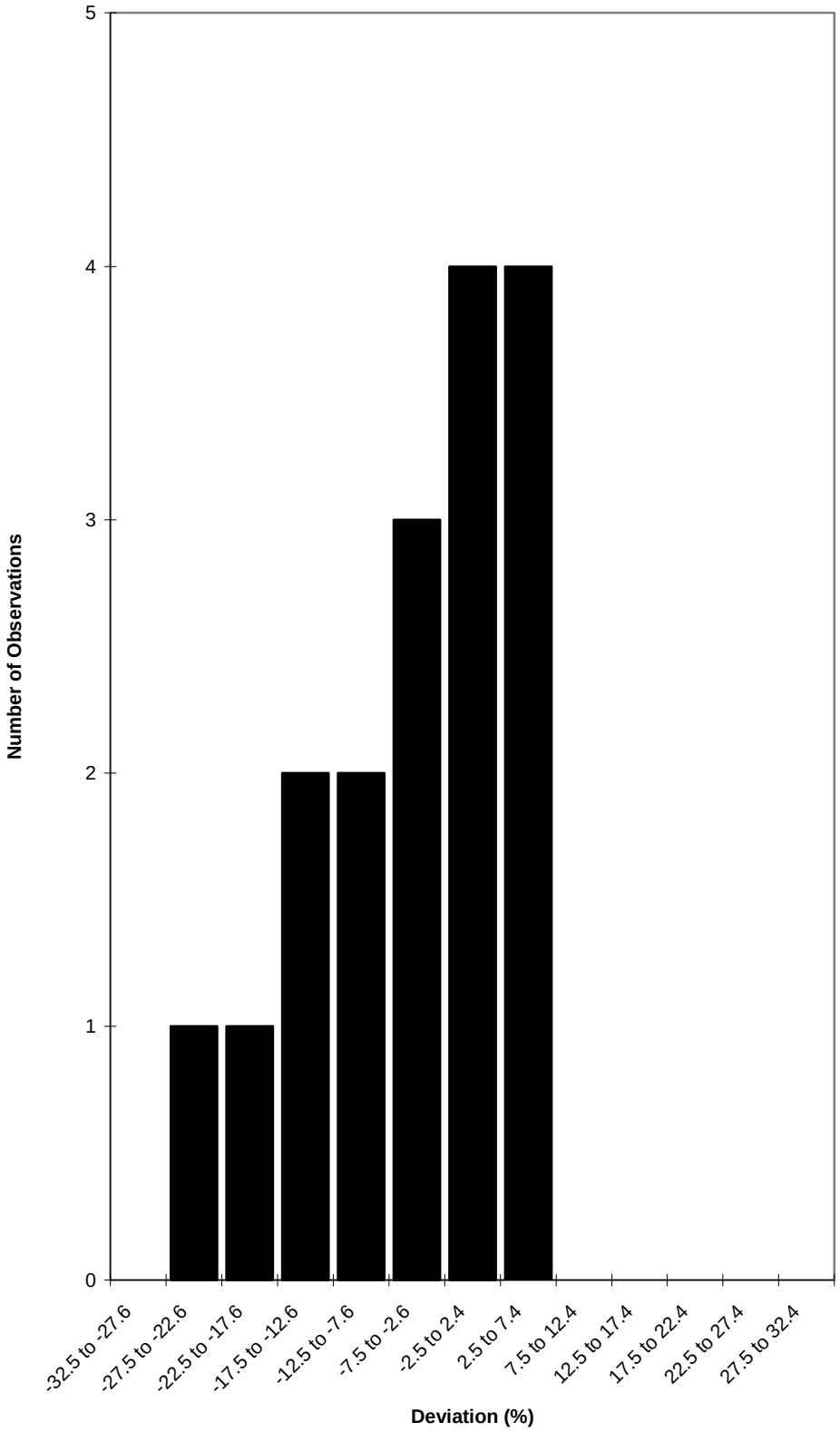


Figure 45 - Reported ^{137}Cs results (low level)
(One outside limits of plot, one quoted maximum value)

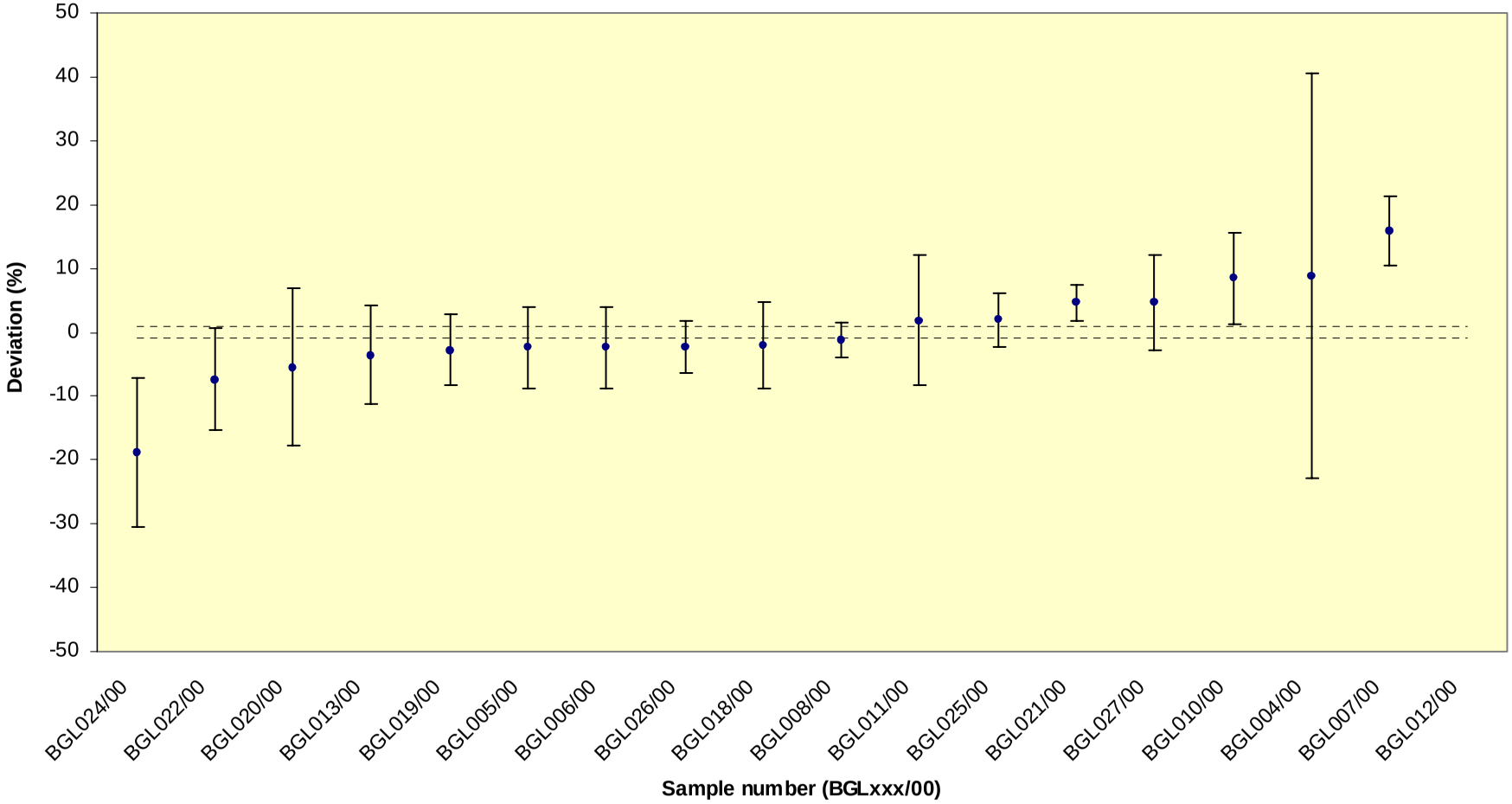


Figure 46 ^{137}Cs low level results

(One outside limits of plot, one quoted maximum value)

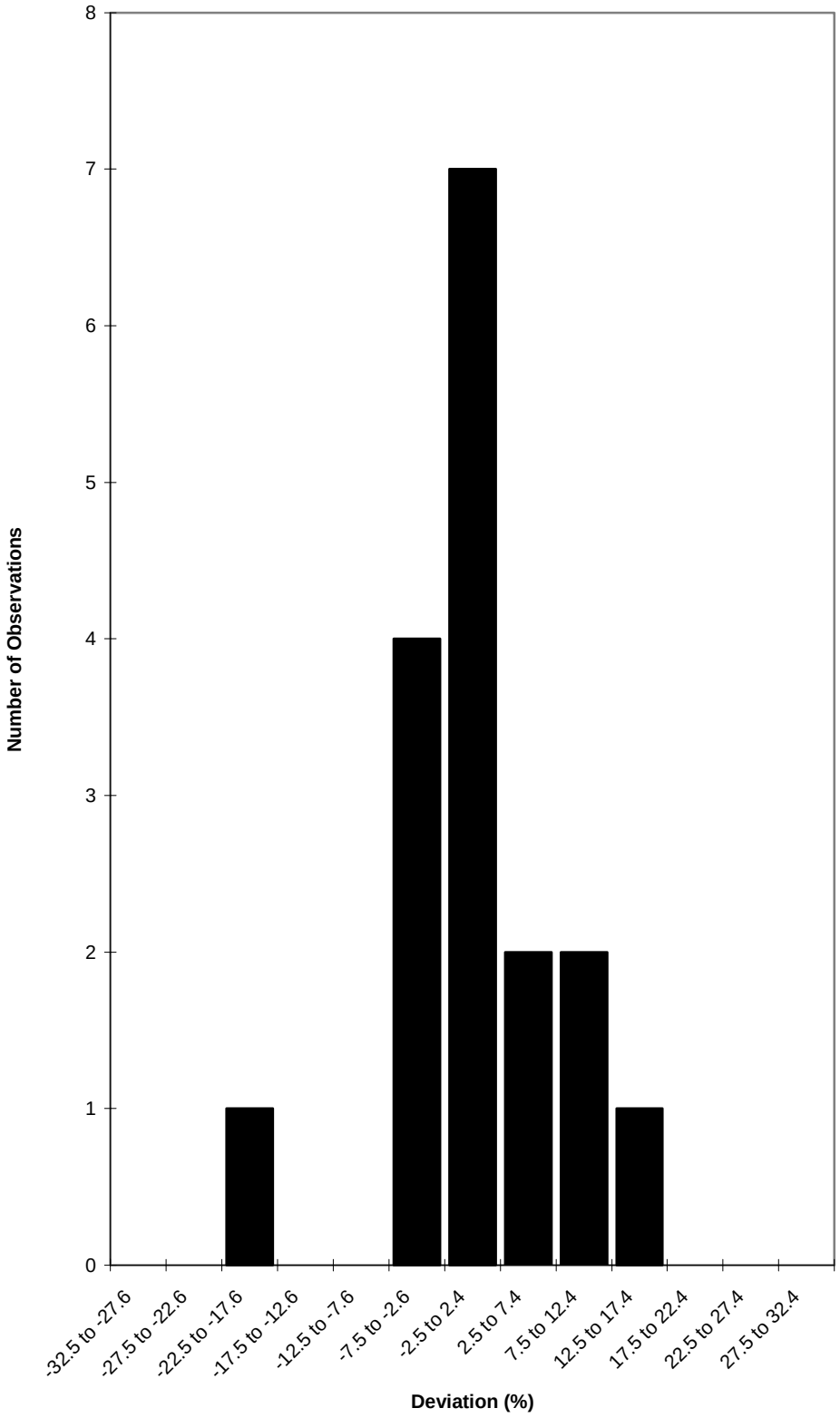


Figure 47 - Reported ^{154}Eu results (low level)
(One outside limits of plot)

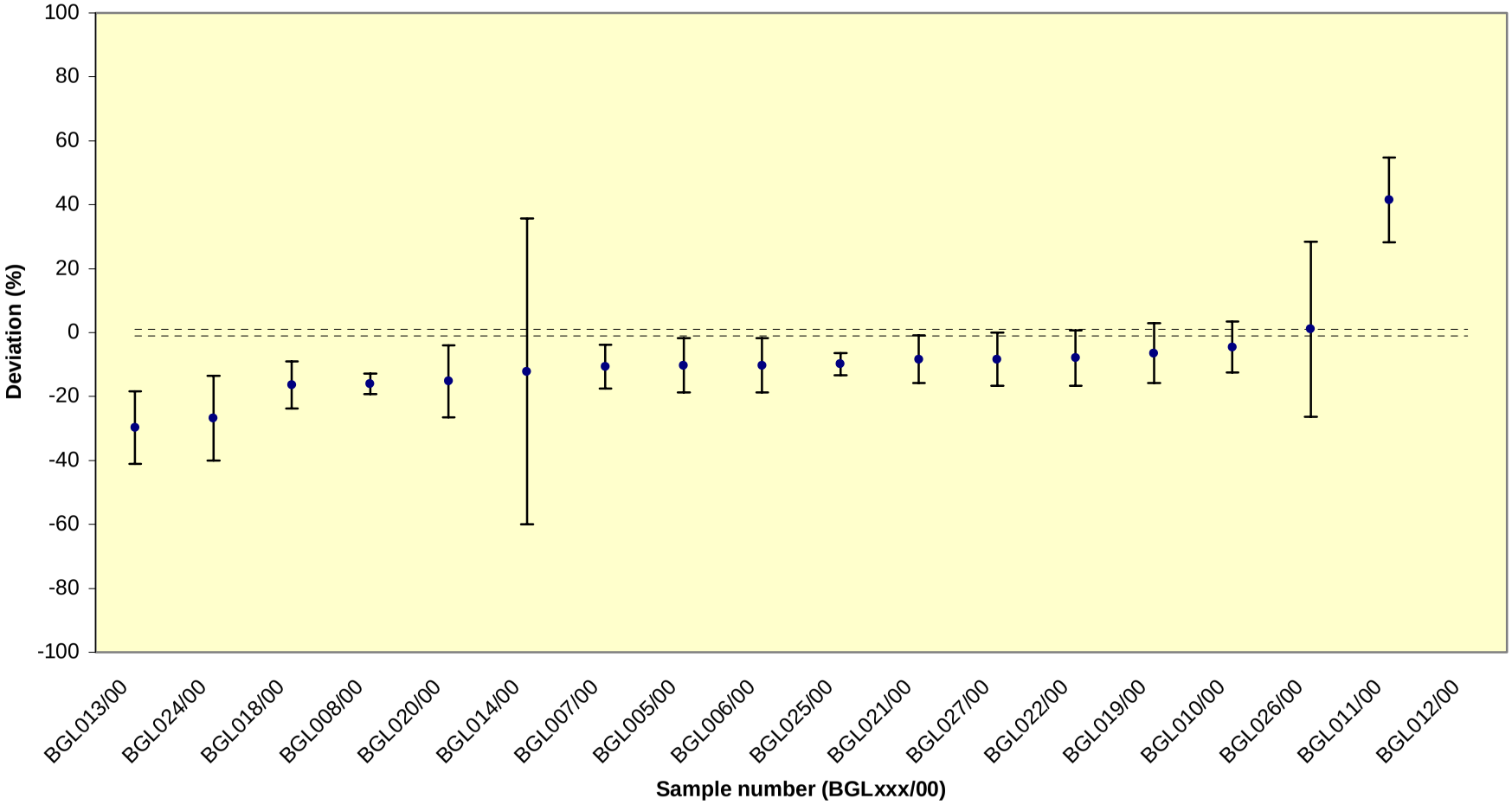


Figure 48 ^{154}Eu low level results

(Two outside limits of plot)

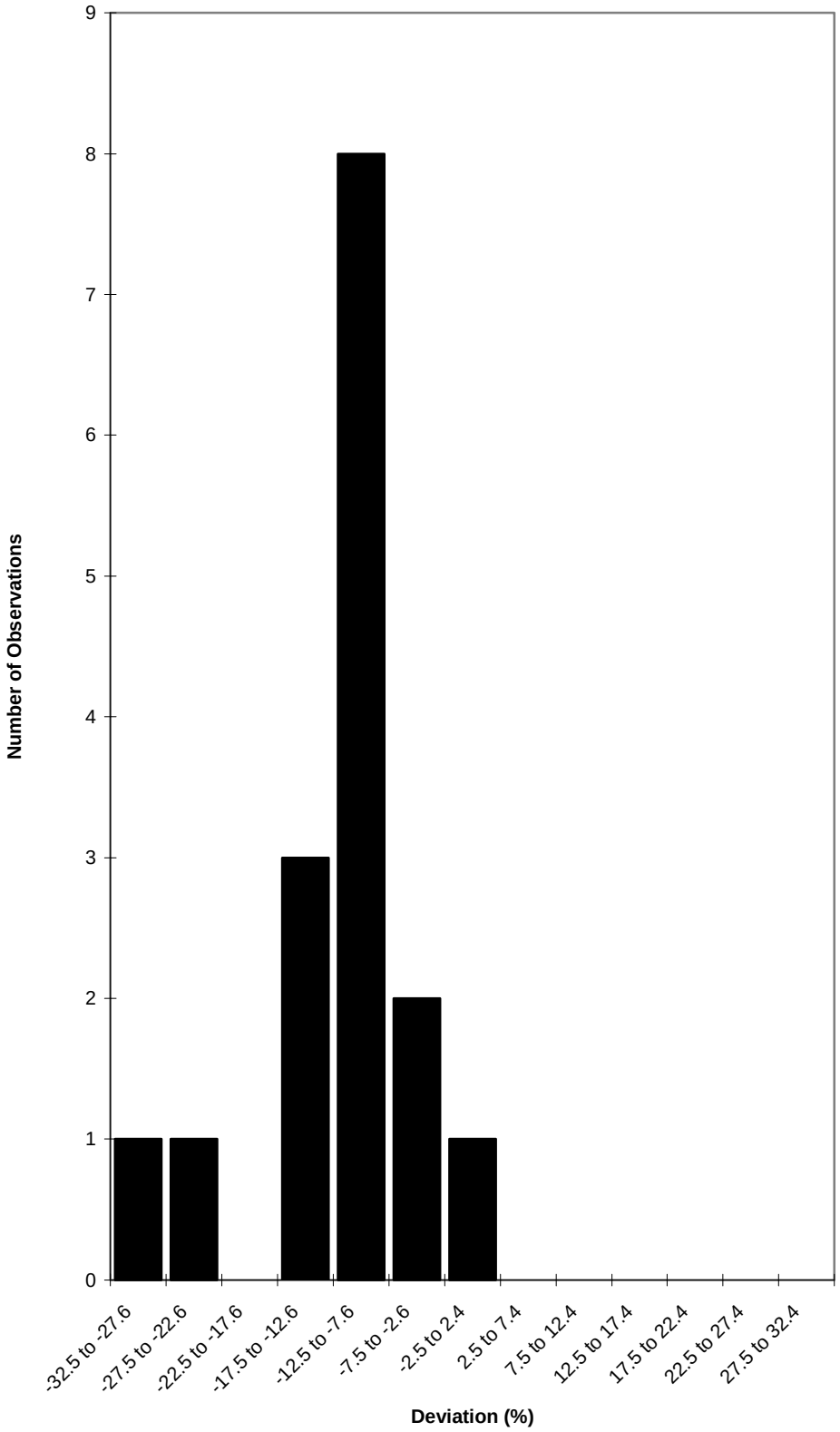


Figure 49 - Reported ^{155}Eu results (low level)

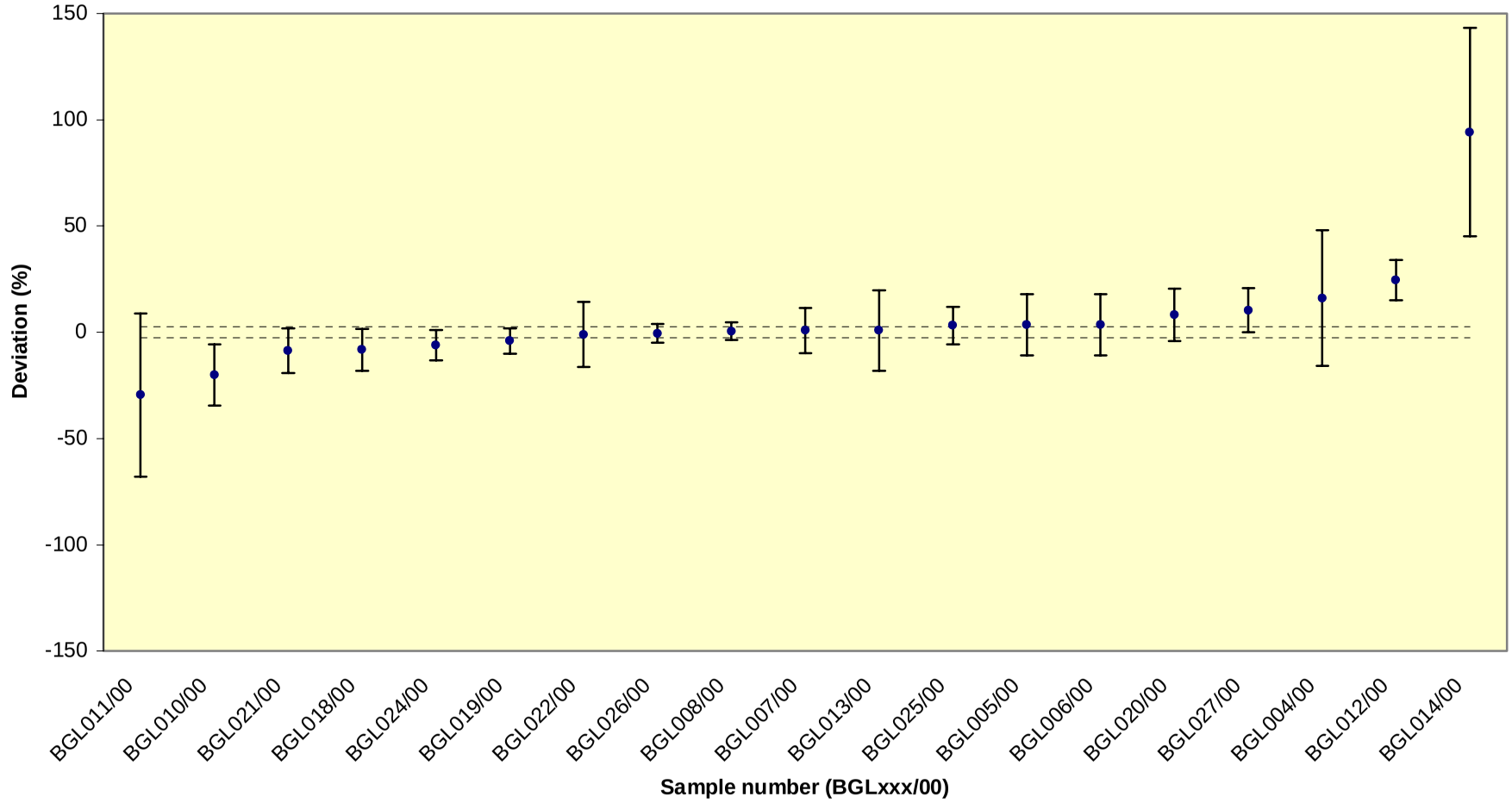


Figure 50 ^{155}Eu low level results

(One outside limits of plot)

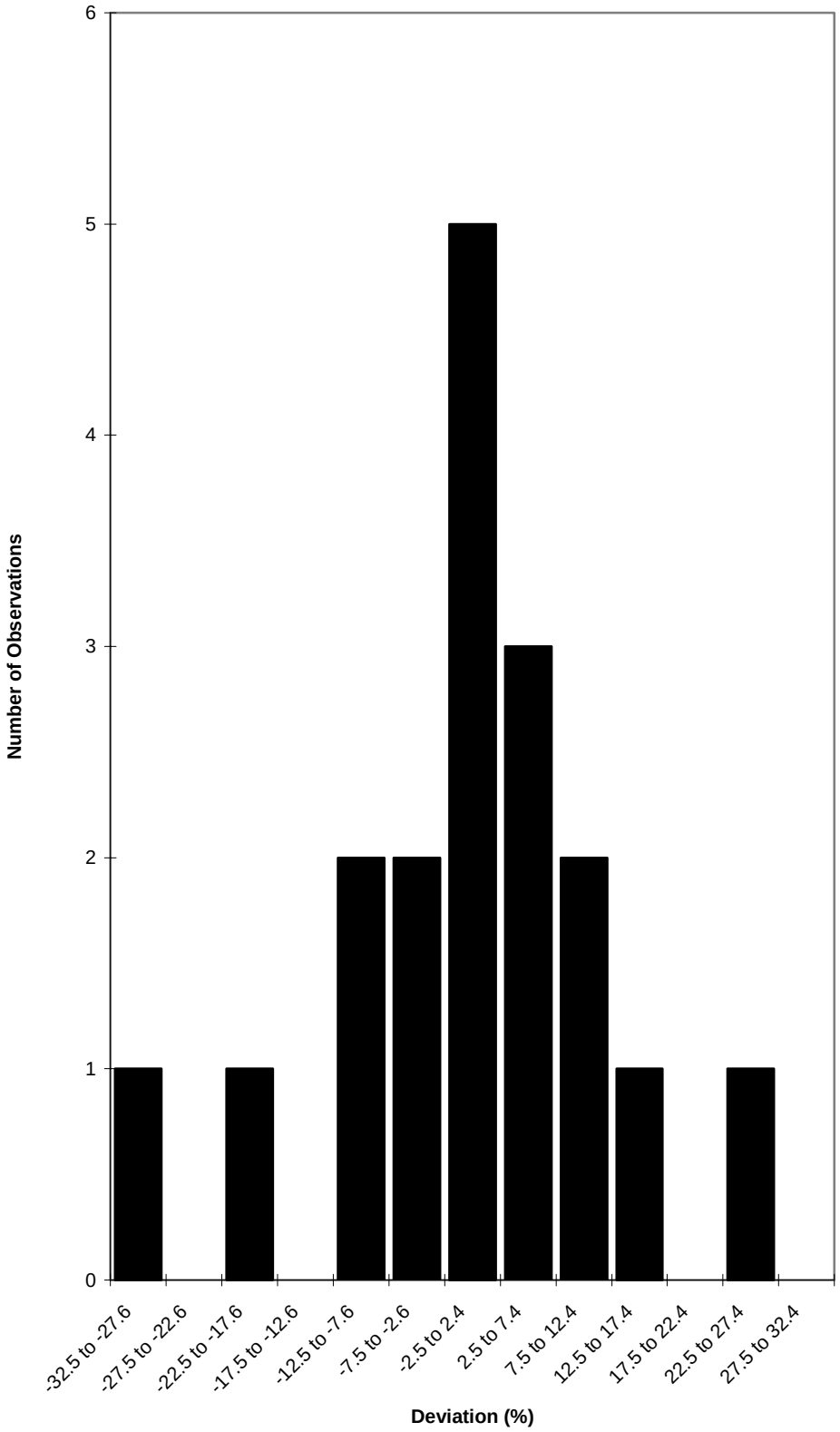


Figure 51 - Reported ^{207}Bi results (low level)

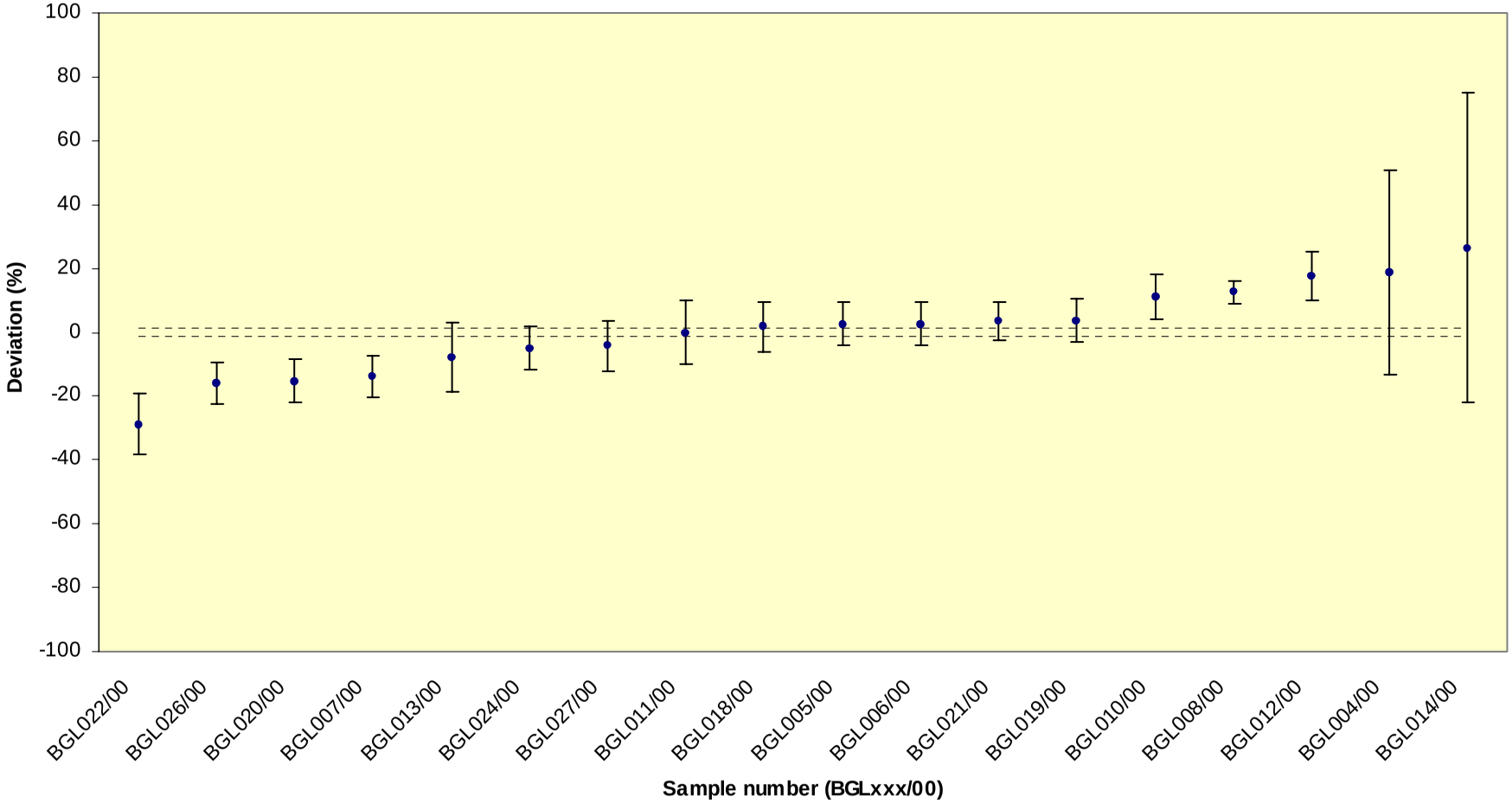


Figure 52 ^{207}Bi low level results

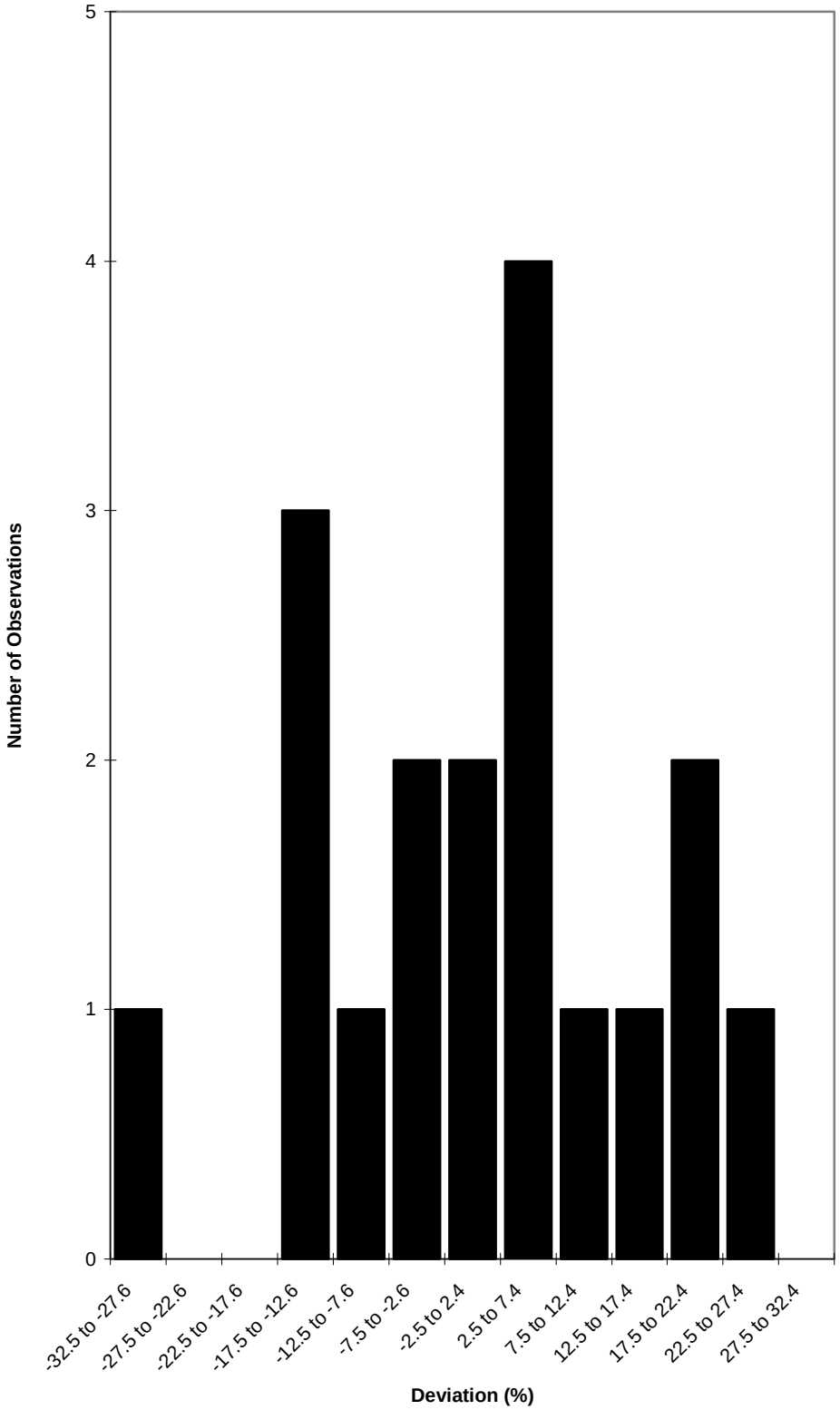


Figure 53 - Reported ^{22}Na results (high level)

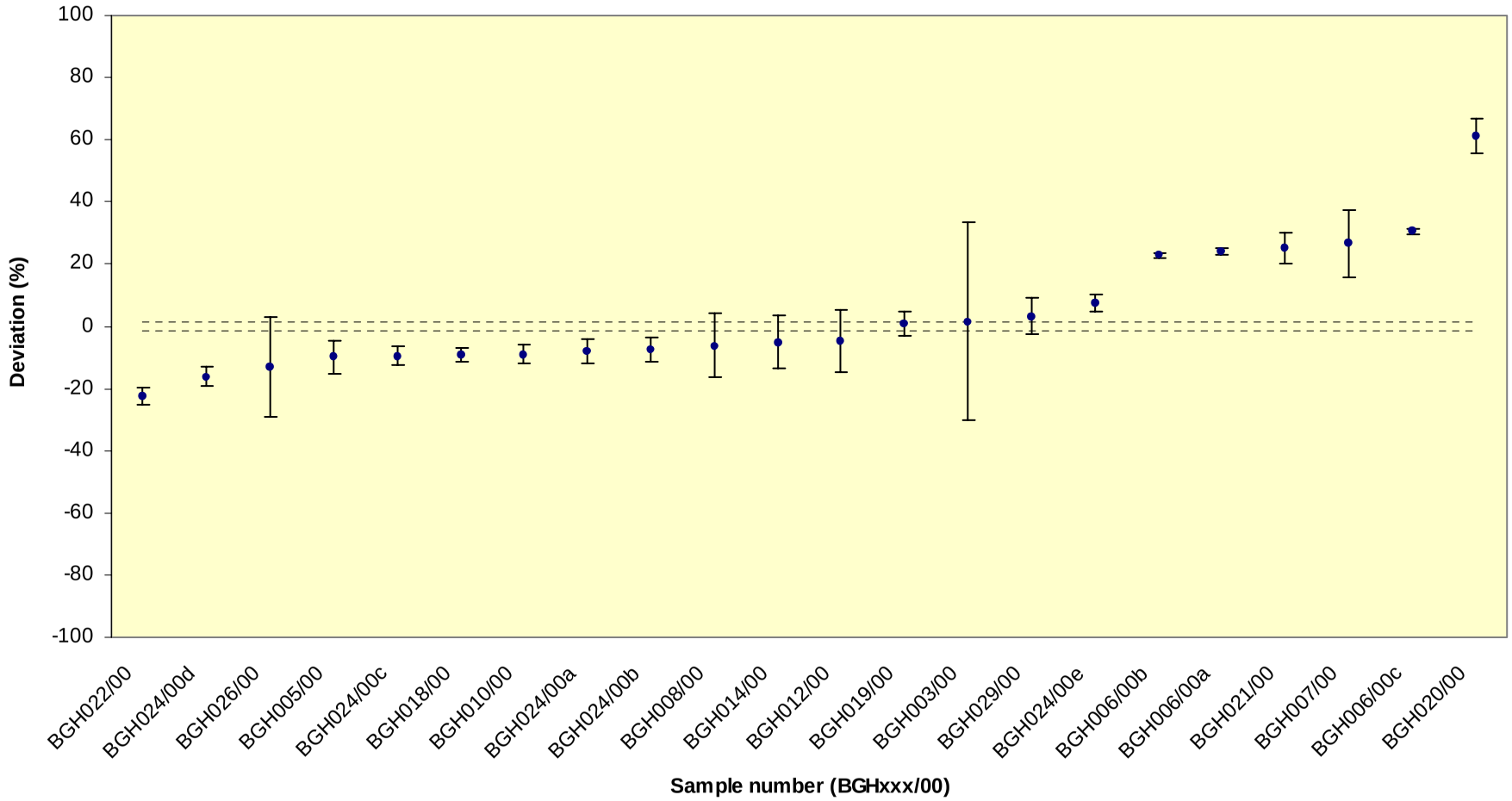


Figure 54 ^{22}Na high level results

(One outside limits of plot)

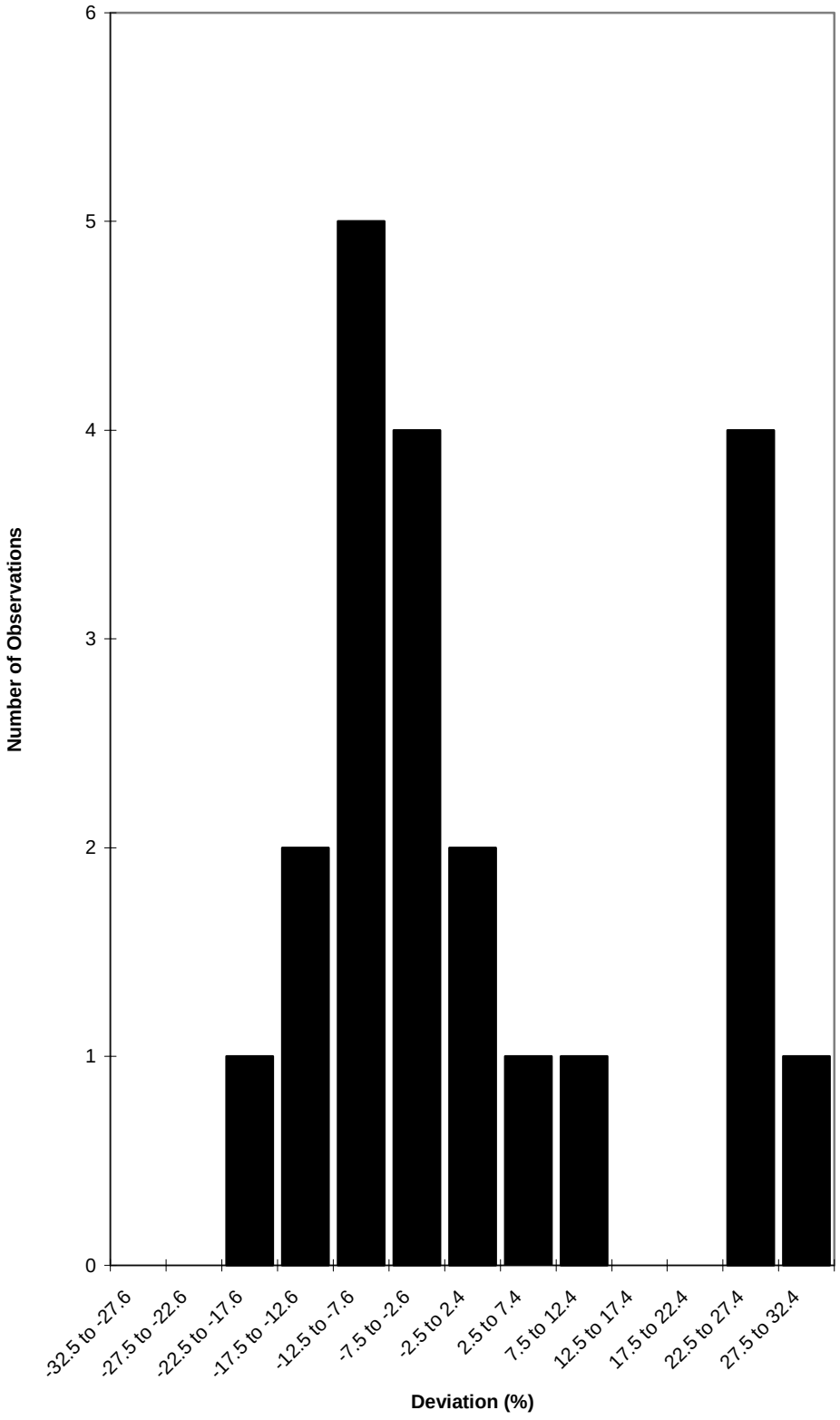


Figure 55 - Reported ^{60}Co results (high level)

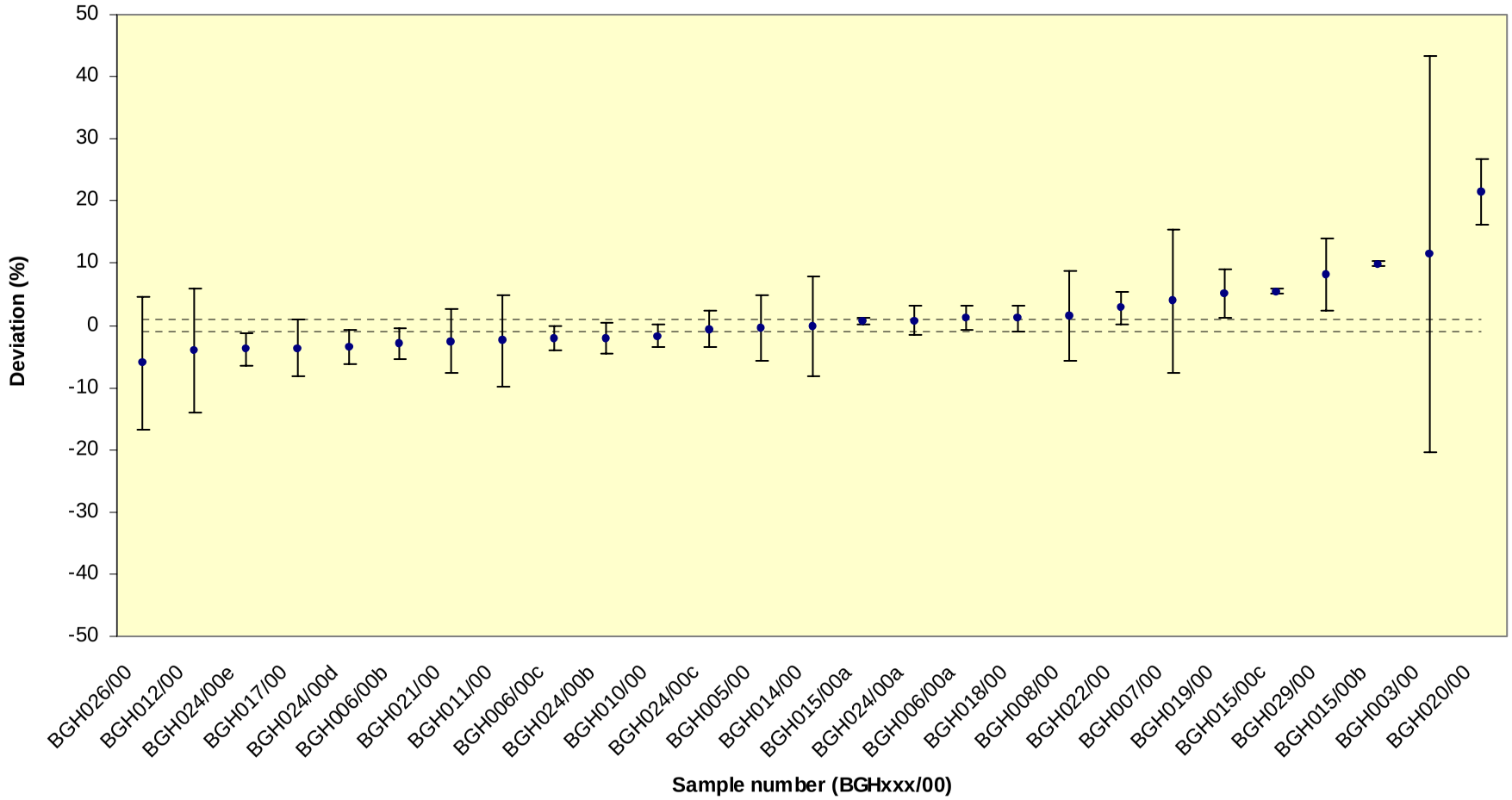


Figure 56 ^{60}Co high level results

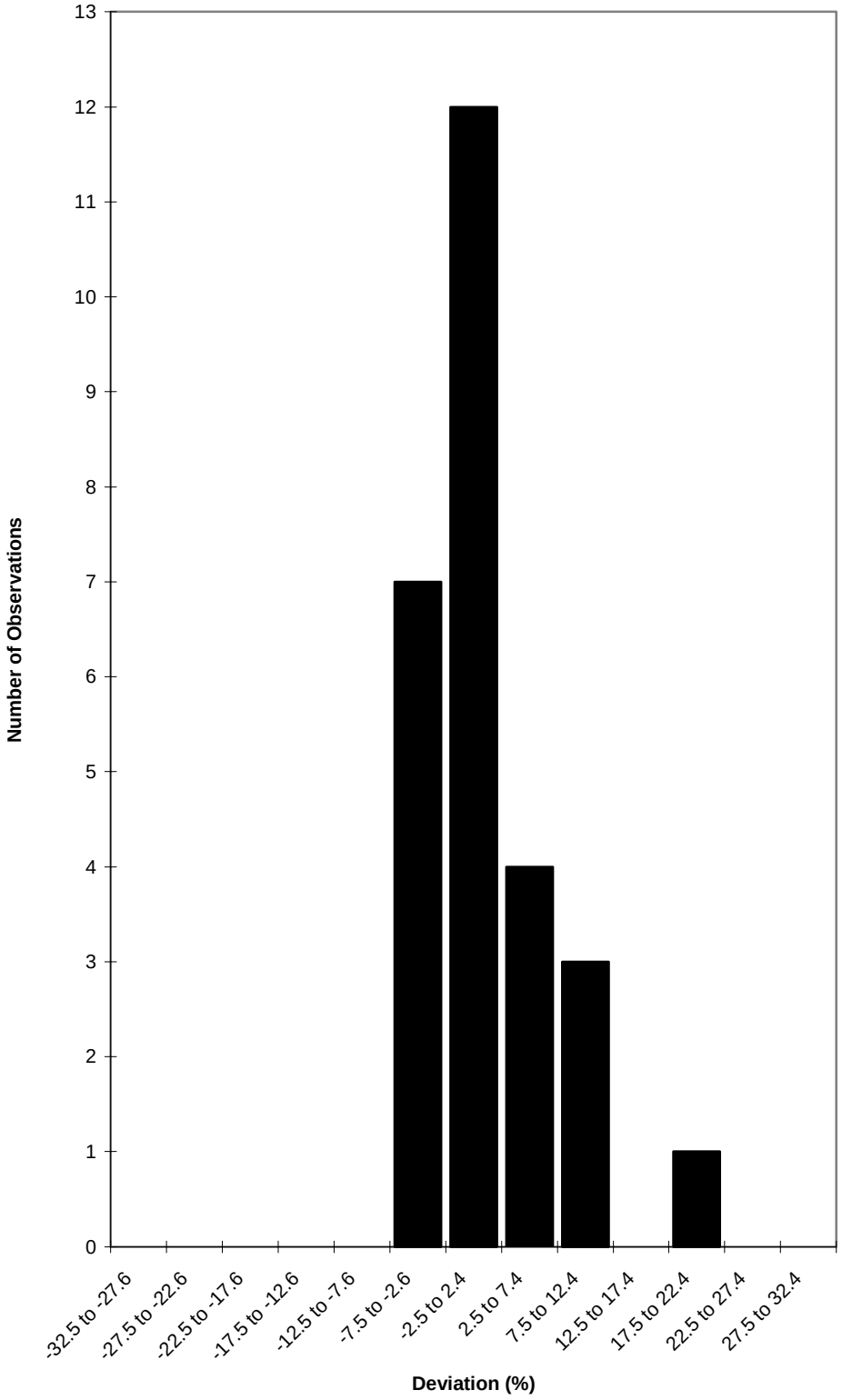


Figure 57 - Reported ^{65}Zn results (high level)

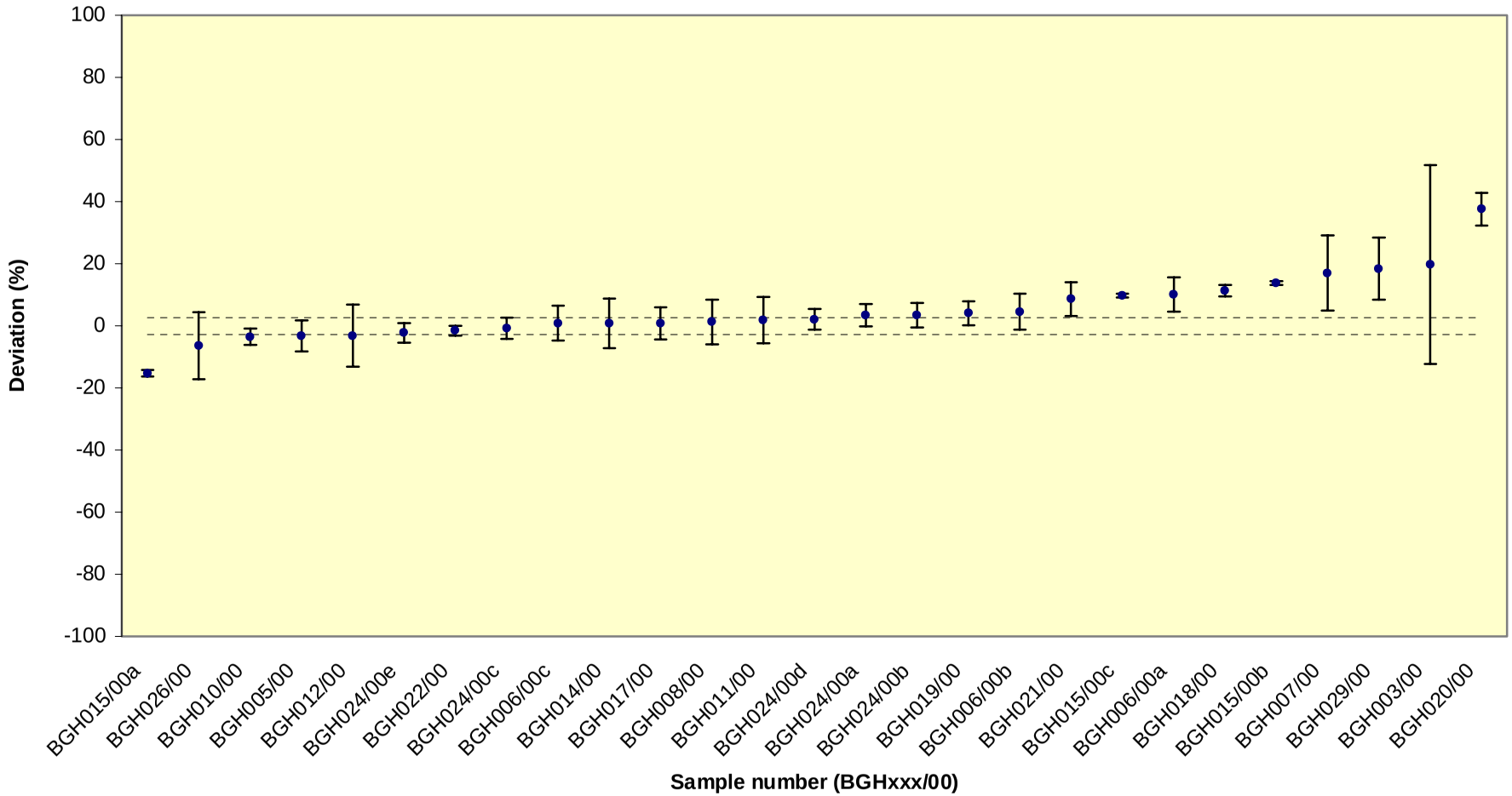


Figure 58 ^{65}Zn high level results

(One outside limits of plot)

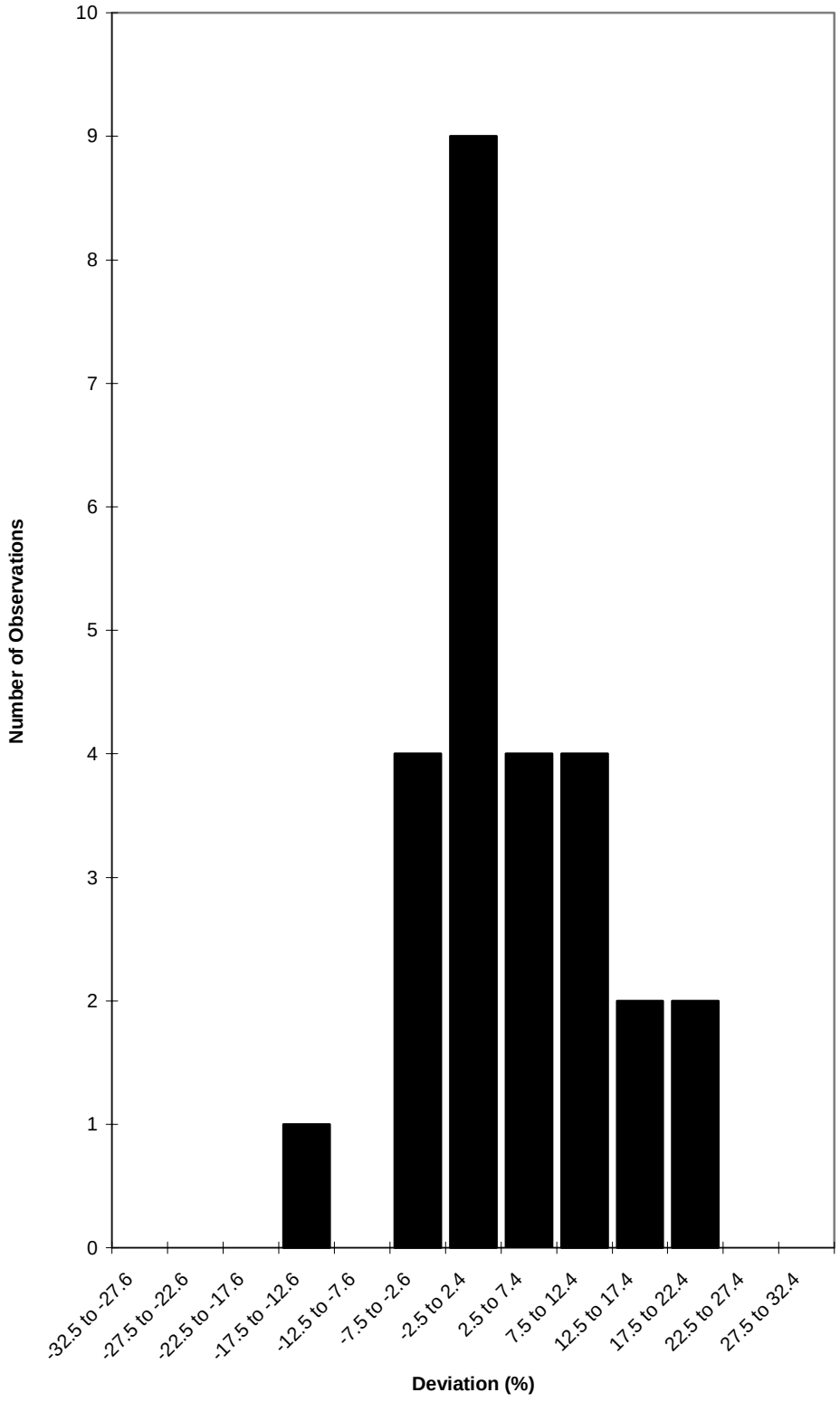


Figure 59 - Reported ^{124}Sb results (high level)

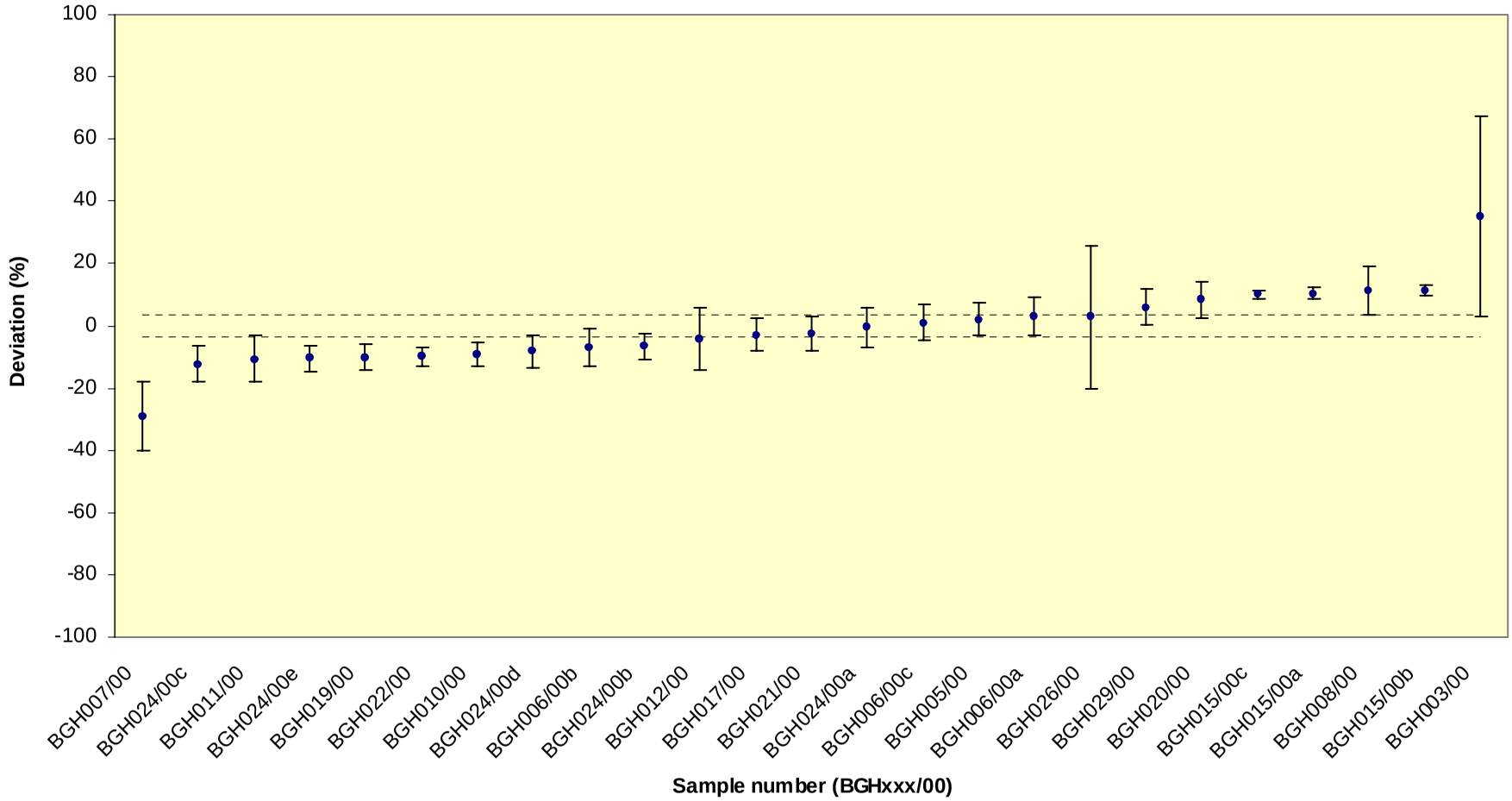


Figure 60 ^{124}Sb high level results

(One outside limits of plot)

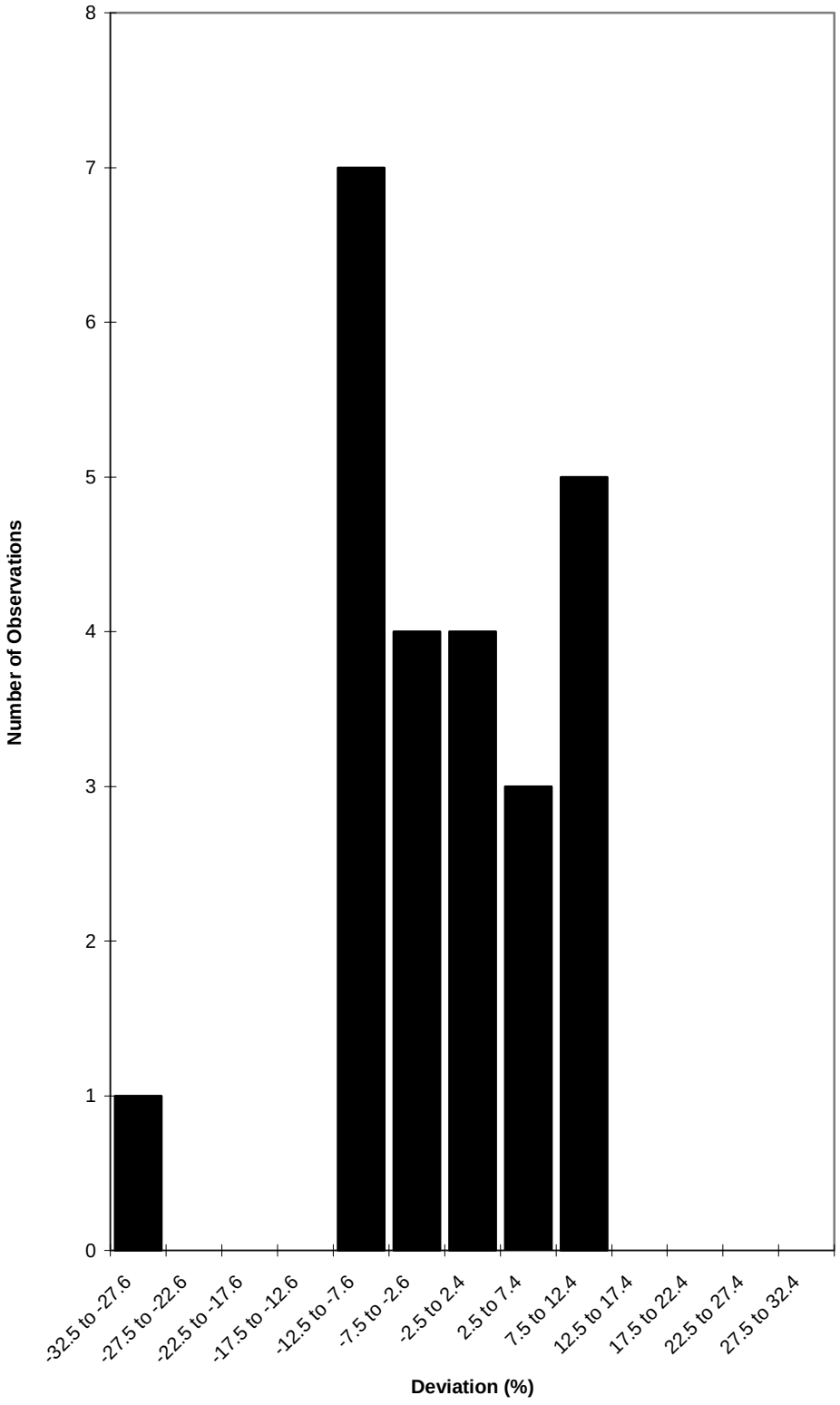


Figure 61 - Reported ^{125}Sb results (high level)

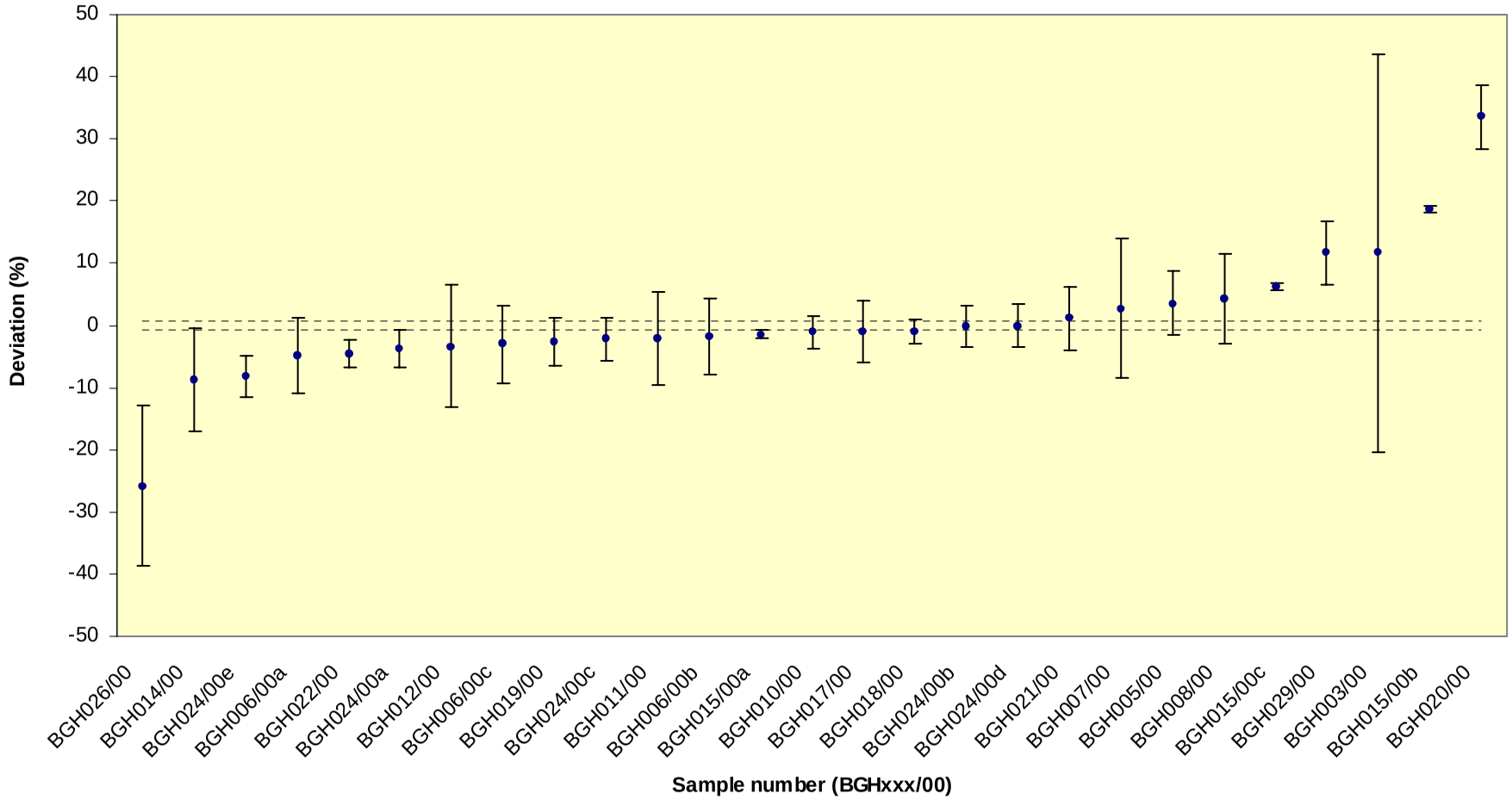


Figure 62 ^{125}Sb high level results

(One outside limits of plot)

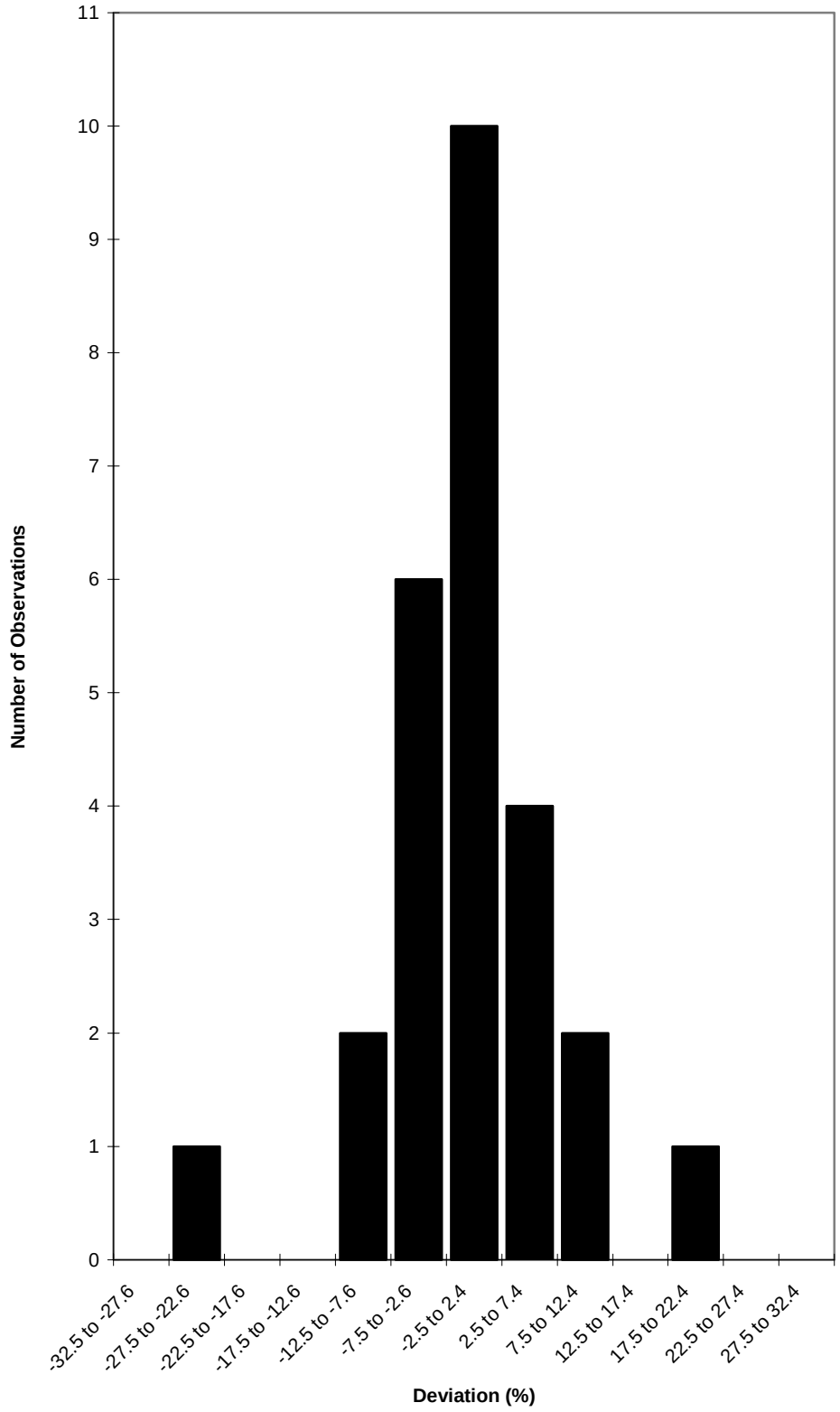


Figure 63 - Reported ^{134}Cs results (high level)

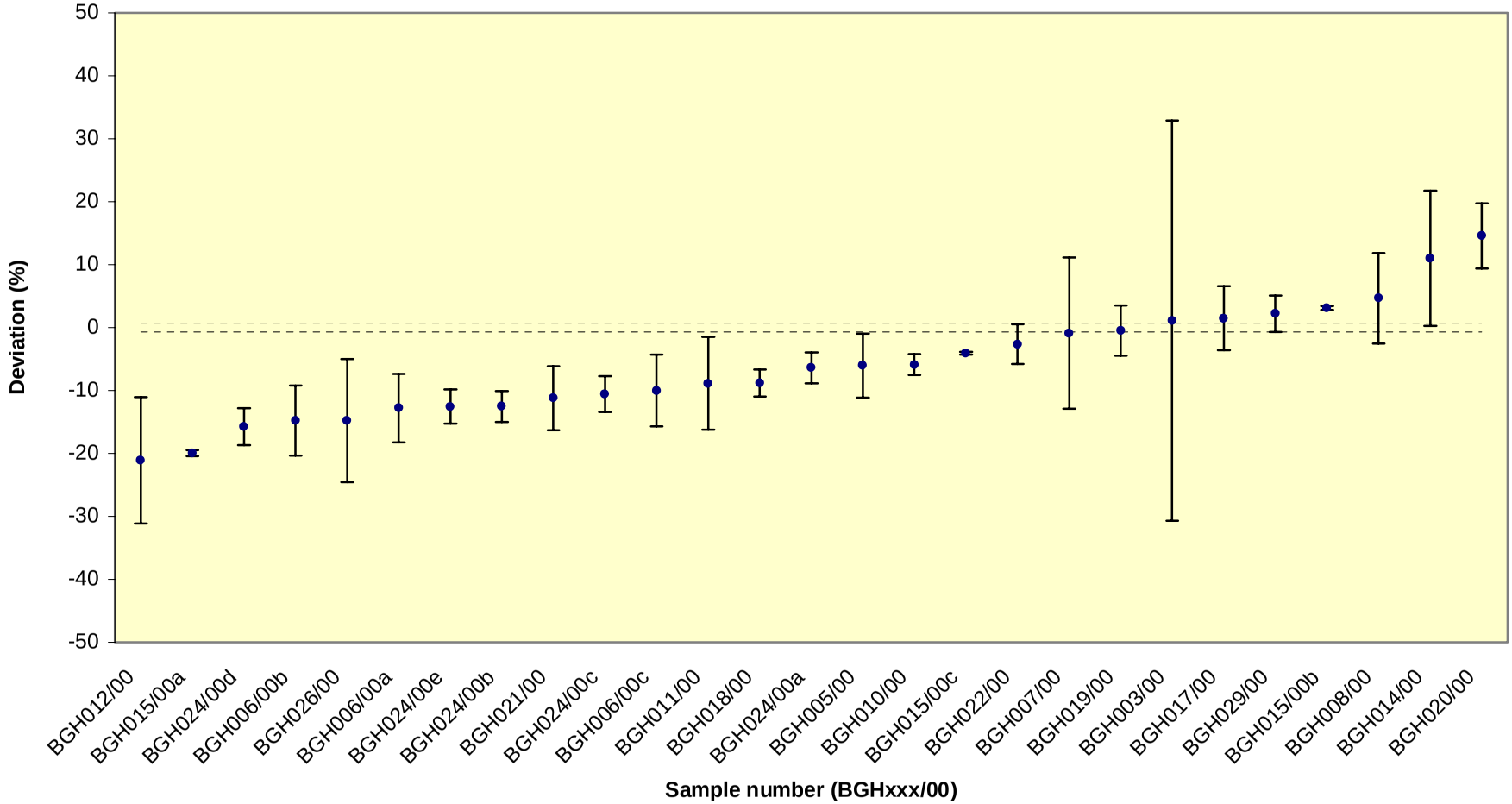


Figure 64 ^{134}Cs high level results

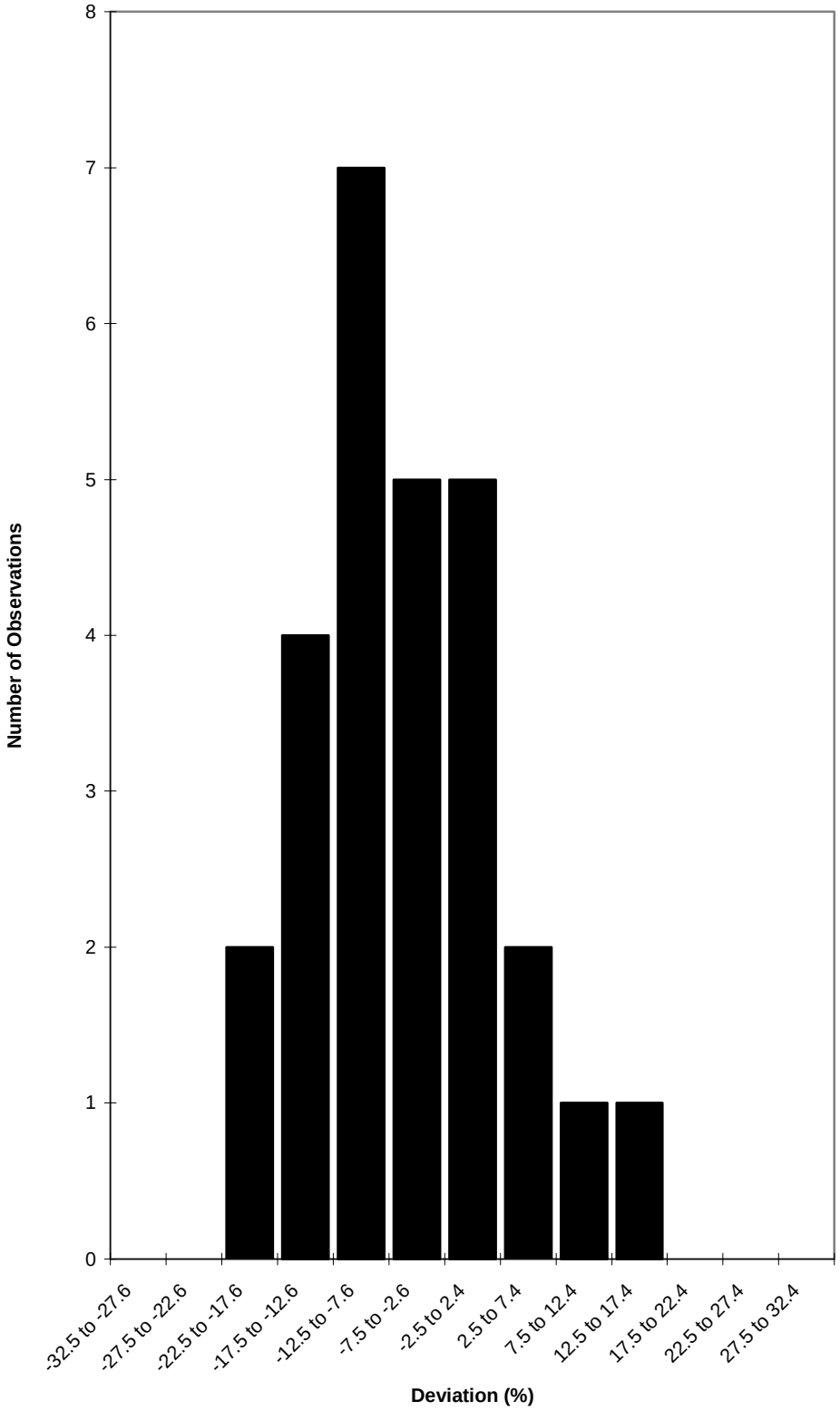


Figure 65 - Reported ^{137}Cs results (high level)

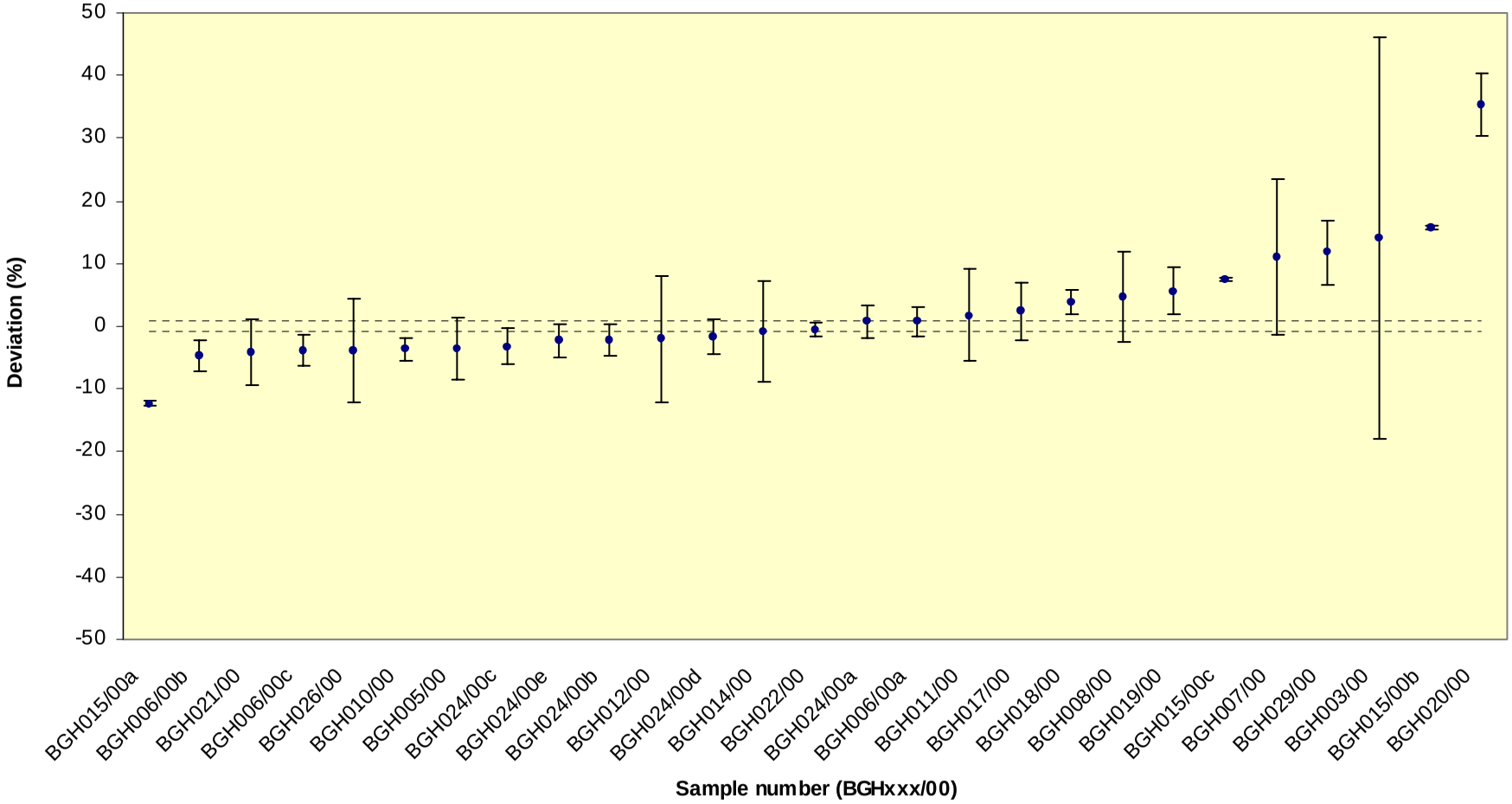


Figure 66 ^{137}Cs high level results

(One outside limits of plot)

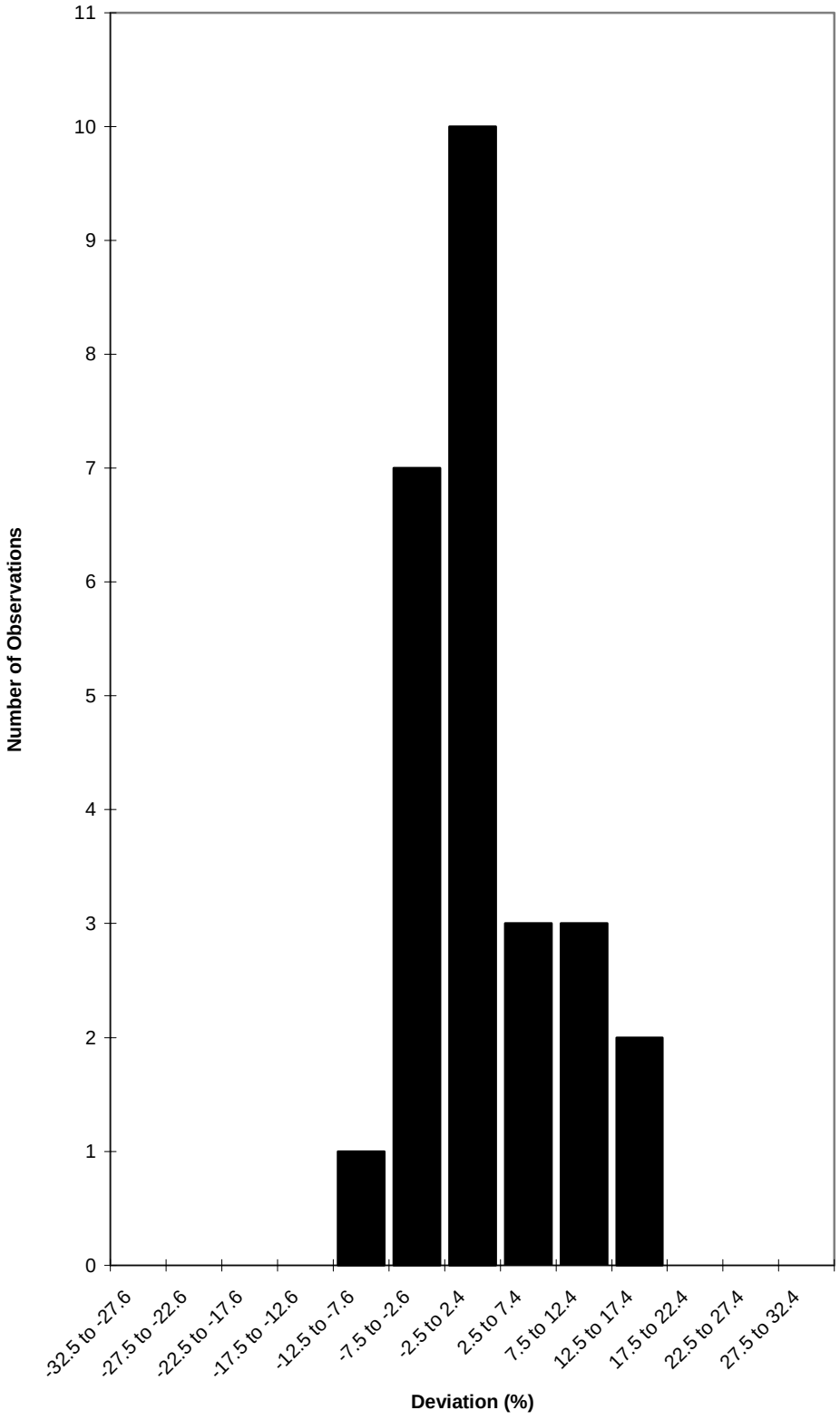


Figure 67 - Reported ^{154}Eu results (high level)
(One outside limits of plot)

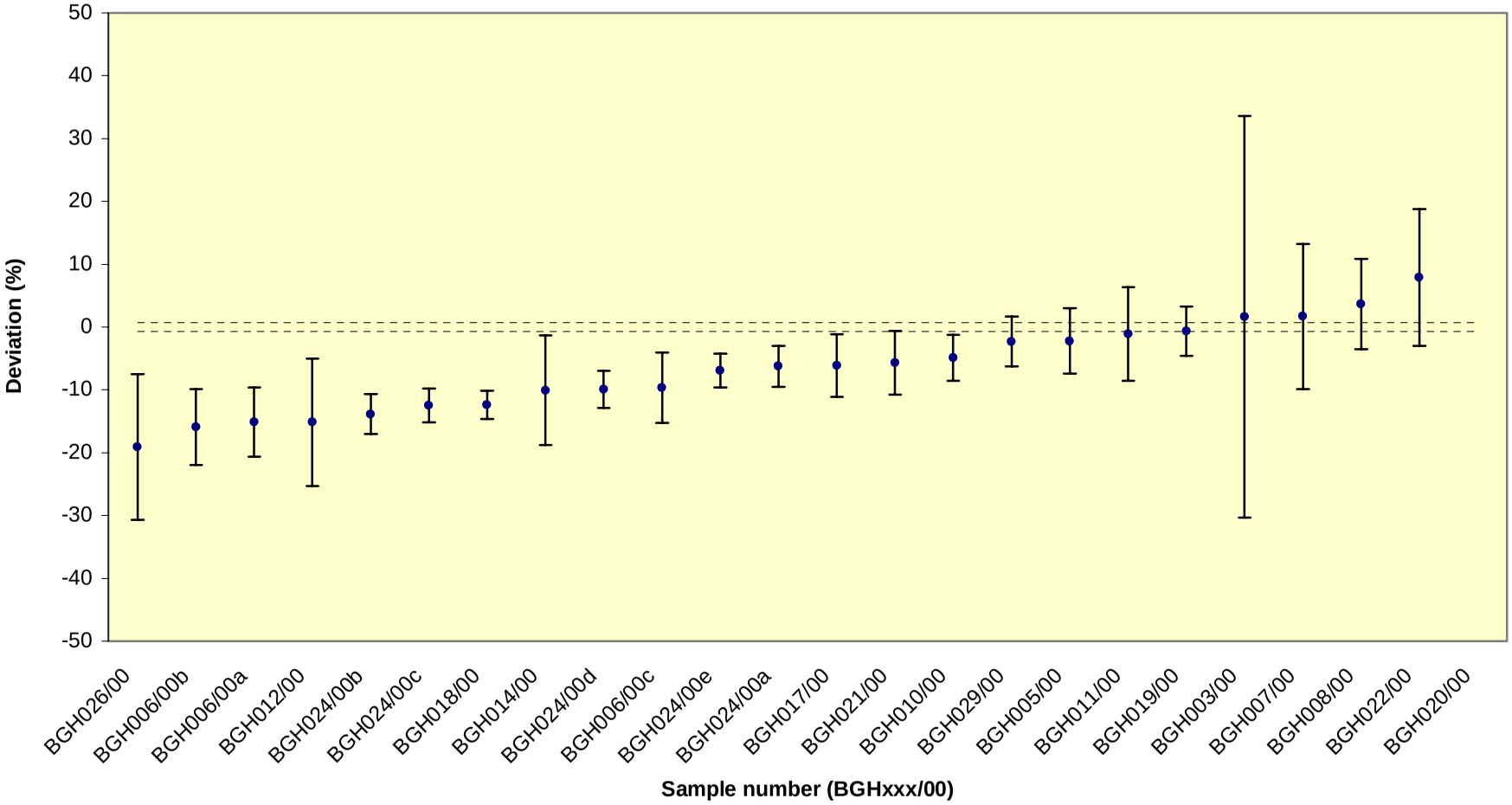


Figure 68 ^{154}Eu high level results

(One outside limits of plot)

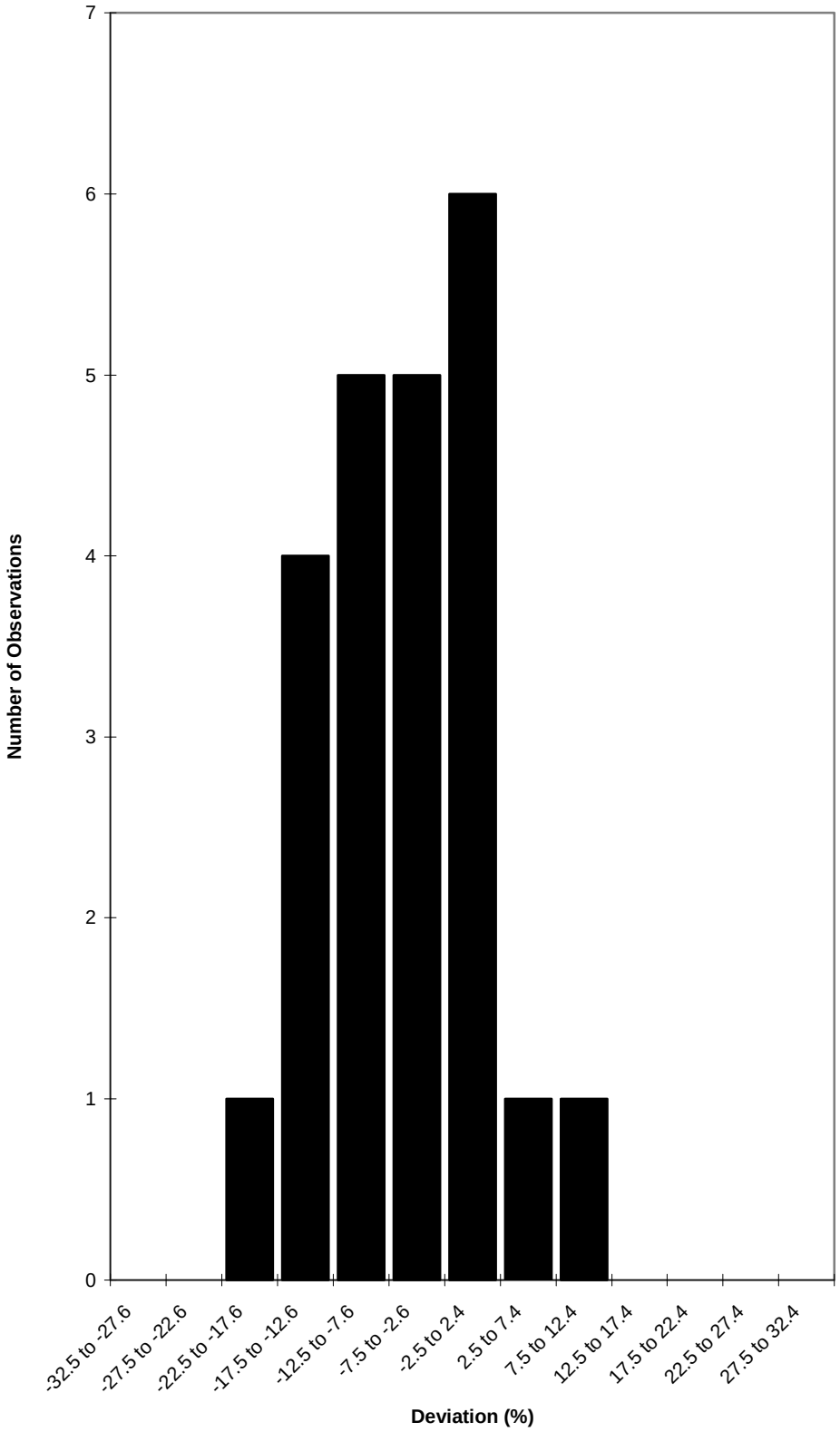


Figure 69 - Reported ^{155}Eu results (high level)

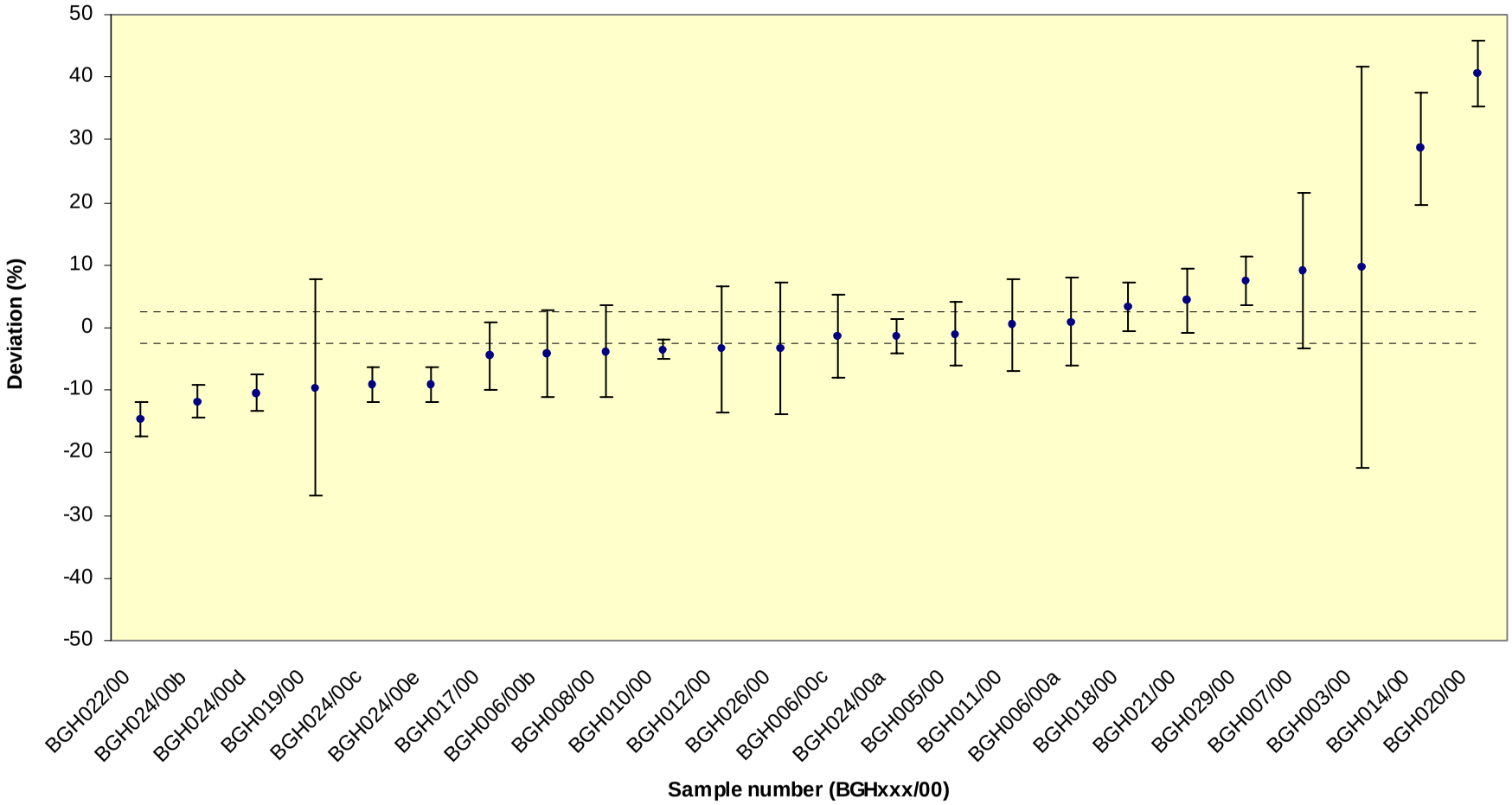


Figure 70 ^{155}Eu high level results

(One outside limits of plot)

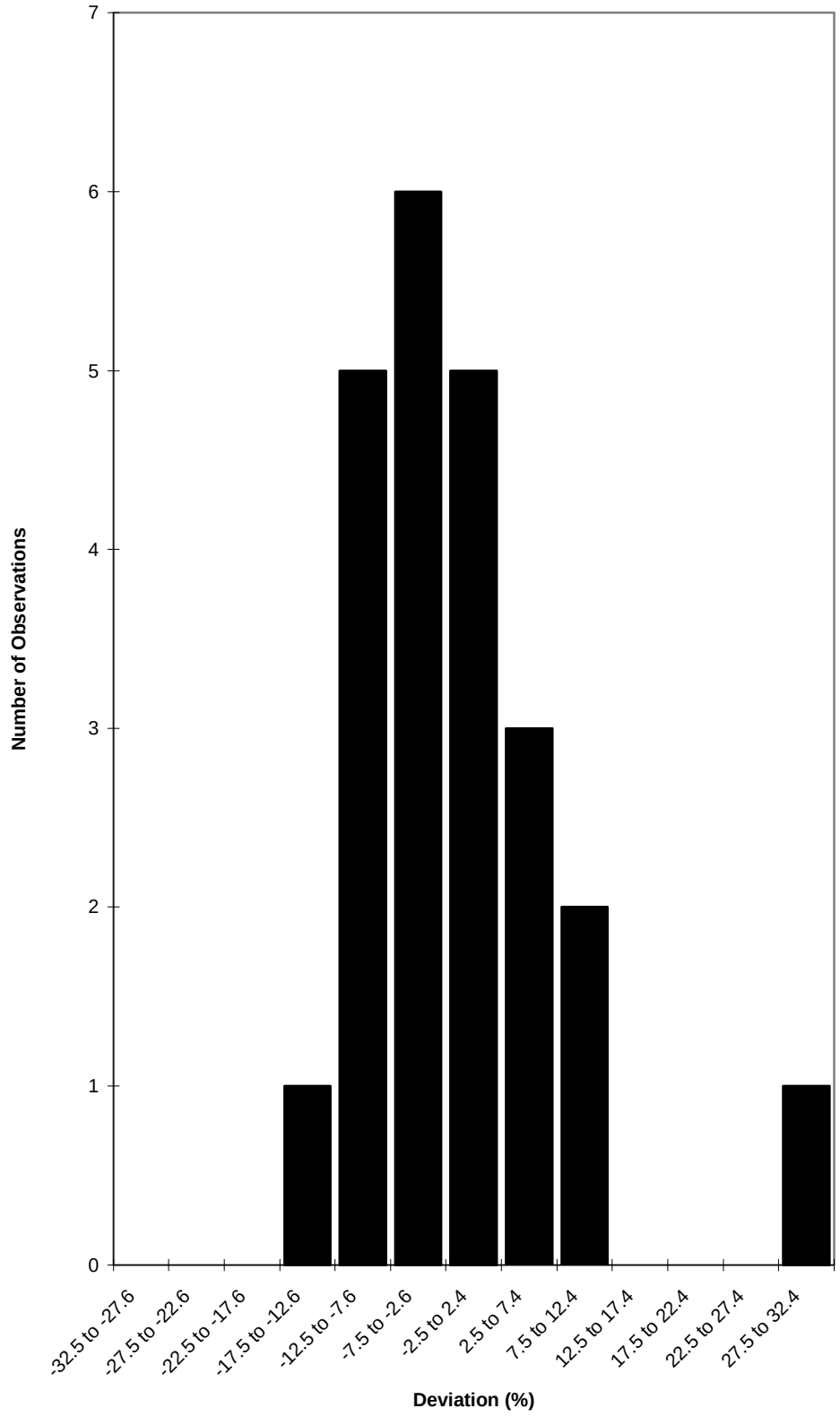


Figure 71 - Reported ^{207}Bi results (high level)

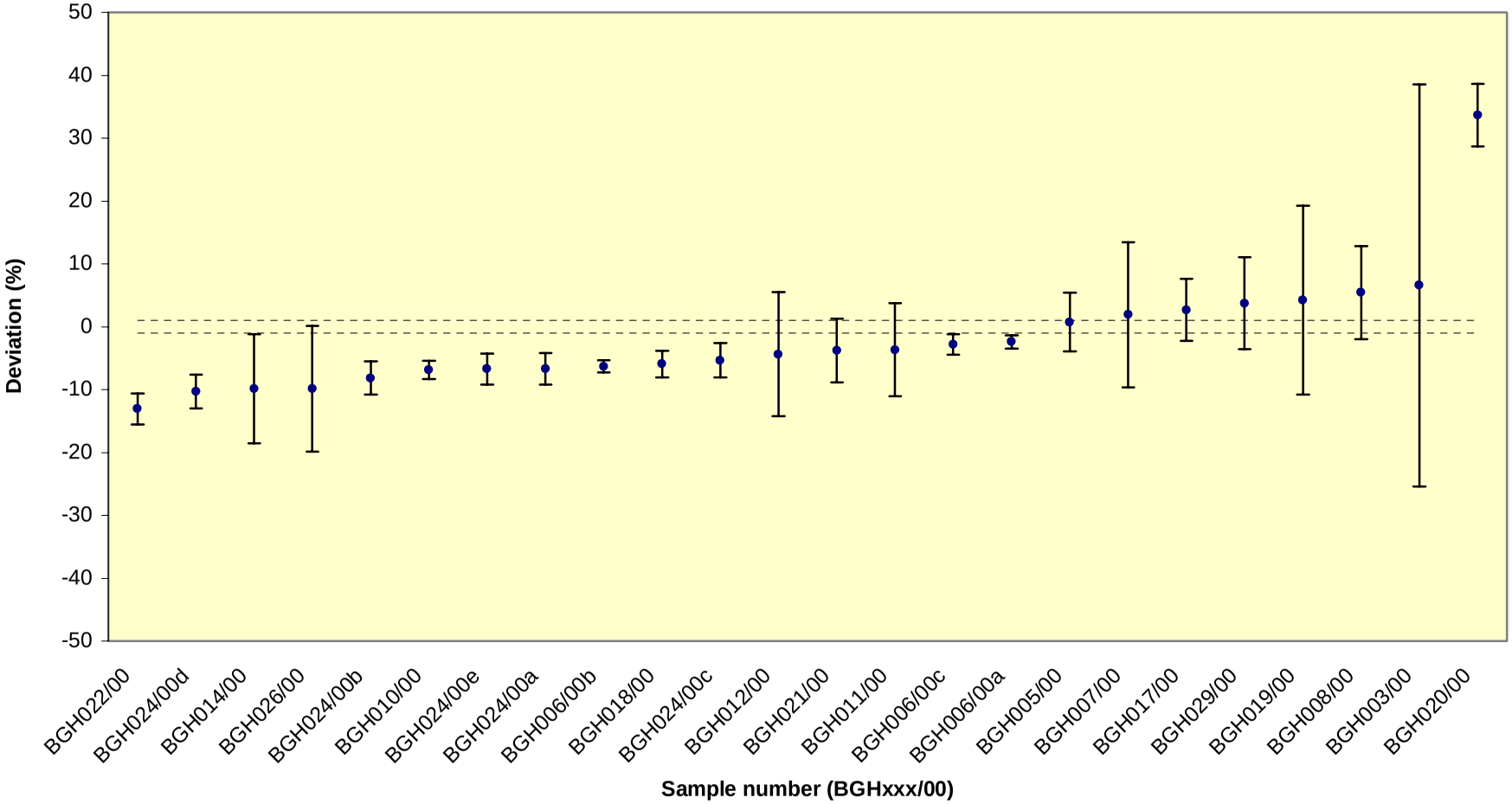
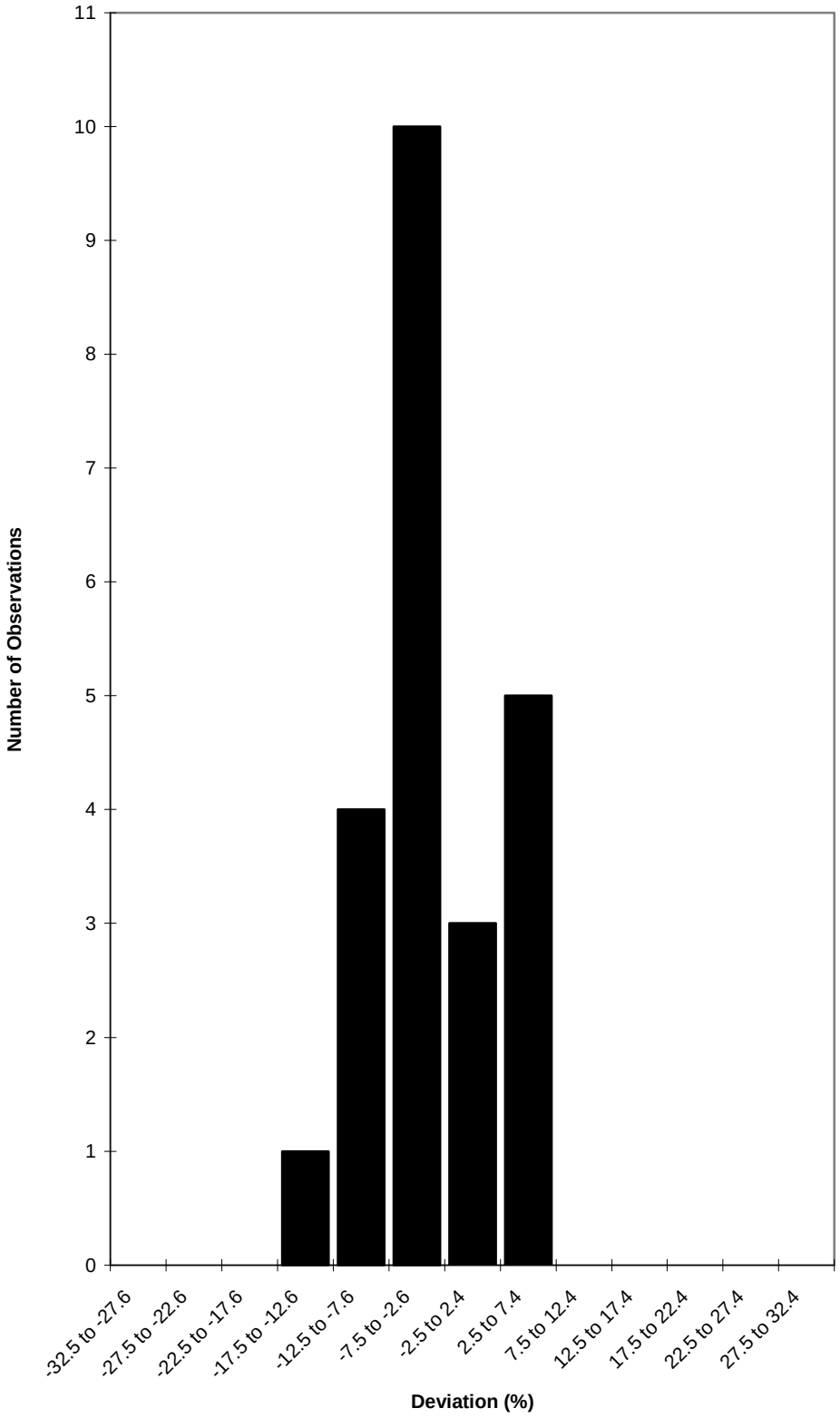


Figure 72 ^{207}Bi high level results

(One outside limits of plot)



APPENDIX 1

List of Participants

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