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ANL/NDM-118

Characteristics of the Samples in the FNG Fission Deposit Collection

by

J.W. Meadows

December 1990

ARGONNE NATIONAL LABORATORY,
ARGONNE, ILLINOIS 60439, U.S.A.

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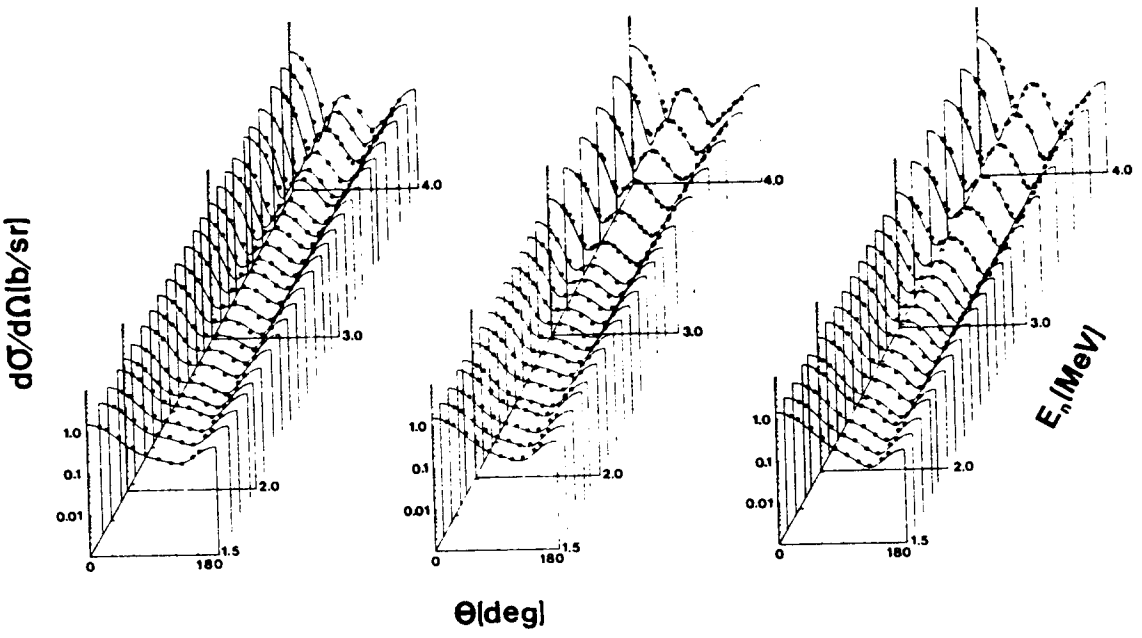

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CHARACTERISTICS OF THE SAMPLES IN THE FNG FISSION DEPOSIT COLLECTION.

J. W. Meadows

ABSTRACT

Information concerning the samples in the Fast Neutron Generator (FNG) Group's fission deposit collection has been assembled. This includes the physical dimensions, isotopic analyses, half–lives, alpha emission rates, specific activities and deposit weights.

I. INTRODUCTION

Over the past twenty years a number of thin deposits of thorium, uranium, neptunium, and plutonium isotopes suitable for use in fission detectors have been prepared by the Fast Neutron Generator (FNG) Group or obtained from other laboratories. The purpose of this memorandum is to gather the available information concerning these samples into one place and to enable anyone who may need such samples to use them with confidence. They were prepared for a number of purposes, but most were originally designed for use in fission cross section ratio measurements. Some are uniform deposits with well–determined masses that are suitable for use as neutron flux standards. The quality of others is doubtful. Altogether there are 108 samples. The preparation of the samples and their assay by low–geometry alpha counting is described in Secs. II. and III. The information for the individual deposits is given in tables in Section IV. This includes deposit dimensions, alpha emission rates, isotopic analyses and half–lives that were used to calculate specific activities and, finally, the deposit weights determined from this information. Section V. gives specific comments concerning individual samples and groups of samples and Sec. VI. discusses the sources of error.

II. SAMPLES

A. Deposit Preparation.

The oldest deposits in this collection are the ^{238}U and ^{235}U samples that were prepared by the evaporation of UF_4. The quality of these deposits was very good, but the method required relatively large amounts of material and was not very suitable when the amount available was small or when the specific activity was very high. For this reason, most of the samples were made by electrodeposition where the deposit efficiency was good, the unused material could be readily recovered, and the cleanup of the equipment was uncomplicated. Thorium and uranium samples were prepared by molecular plating from solutions of the nitrates in anhydrous acetone and isopropyl alcohol, respectively, following a procedure described by Parker et al.[1] Neptunium and plutonium samples were prepared following a method described by Ko.[2] The thickness of a single deposition was always $> 100\ \mu g/cm^2$. Thicker samples were made by depositing several layers. As a general practice, a rather large number of samples were made, and those that did not appear to be of uniform thickness and have good adherence to the backing were discarded.

B. Deposit Assay.

The assay of these samples is based on low–geometry alpha counting using the counter described in Sec. III. Specific activities are calculated using the half–lives in Table I and the isotopic analyses in Table II. The accuracy depends on the quality of this data. When this program was begun, the quality of the half–life data for the isotopes involved was poor. This situation has changed in the past decade, and an impressive body of data now exists for the longer–lived actinides (see Table I.). The methods of isotopic analyses have also improved but, even at the beginning of this program, they were capable of very good results providing the concentration was > 1%. Also, the analyses reported in Table II are based on several independent measurements. Some of those samples where the principal alpha emitter is also the principal isotope are an exception to the rule. Although these may be based on a single analysis, the high concentration yields a small error.

These samples may also include some shorter–lived isotopes of the element and the lower members of the various decay chains. Fortunately, those isotopes with short half–lives have correspondingly high alpha energies and can be eliminated by energy

discrimination. If a long–lived isotope is in the decay chain, it usually takes many years before its concentration becomes large enough for an appreciable correction. There are some intermediate cases, and each must be examined individually. For example, ^{233}U decays to ^{229}Th which has alpha decay energies near those of the parent isotope. The correction approaches 0.1% after only 11 years.

C. Deposit Quality.

A judgment of the deposit quality is given in Table II for many of the deposits. The quality scale is excellent, very good, good, fair, poor, and very poor. It may be noted that there are no deposits in this collection that are judged to be excellent; neither are there any that are judged to be very poor. Excellent deposits do exist. They are usually prepared by evaporation onto very smooth backings. The evaporated deposits in this collection are judged to be no better than very good because the backings are not as smooth as they should be. All the deposits judged to be very poor, and many that were only poor, have been discarded.

The judgment of quality is based primarily on the deposit's appearance, but it is also influenced by the alpha and fission spectra. Under low magnification (10X or 20X) the ideal deposit appears to be a smooth, uniform layer on a smooth backing with no sign of granularity or clumping. The spectrum of a single alpha line is symmetric, rising rapidly for three or more orders of magnitude, then falling at the same rate. For thick deposits, the line will be broad but still symmetric, and will have a flat top. Poor deposits will show a decided tail on the low energy side. For fission spectra, the region between the alphas and the fission fragments begins to fill in as the deposit thickens. It has been found empirically that the correction for fission events lost in the alpha region (extrapolation correction or C_x) is about the same as the correction for those fissions that are not counted because neither fragment escapes from the deposit.[9] For good deposits, the greatest part of this correction is

$$L = t/2R$$

where t is the deposit weight divided by the total area, and R is the range of the average fission fragment (see Table IV.). Because of clumping, the effective value of t may be much greater, with a corresponding increase in the effective value of L and also of C_x.

Figures 1 thru 6 illustrate alpha spectra for several of the deposits. The spectrum of the ^{235}U deposit 25S–5–3 is shown in Fig. 1. This is a very good deposit, prepared by NIST. Although it is fairly thick (181 μg U/cm^2), the alpha peaks are very clean and symmetric. Figures 2 and 3 show the spectra of two samples prepared by evaporation, U–235 SST–1 and U–235 SST–8. These are also rated very good, and their thickness is 132 and 200 μg U/cm^2, respectively. However, the quality of the backing is not as good as it should be, and the alpha spectra show a little more of a tail. The spectrum of U–238–213 is shown in Fig 4. Its thickness is only 118 μg U/cm^2, but its quality is poor. The ^{234}U alpha peak is broad and shows a decided low energy tail. Figure 5 shows the spectrum of U–238–60. This is a rather thick deposit (386 μg U/cm^2), with a quality rating of good. It is made from very pure ^{238}U, so its principal activity is ^{238}U. The alpha peak is broad due to the thickness of the deposit, but the spectrum is clean and shows only a small degree of tailing. Figure 6 shows the spectrum of Pu–239–267. The average thickness of this sample is only 26 μg Pu/cm^2, but it is rated as poor because of its appearance and the behavior of the fission spectrum. The alpha spectrum is fairly good although it does show some tailing. Figure 7 shows a typical alpha counter background.

Figure 7 illustrates the correlation of C_x with L. In order to maintain clarity only a few data points are shown, but a more extensive survey is given in Fig. 7 of Ref. 9. With the exception of the deposits judged to be of poor quality (points labeled 239–267 and 238–213), all the deposits referred to are rated as good or very good. All these points cluster around the line $C_x = L$ and the agreement can be considered fairly good. This is particularly true when it is remembered that C_x is a rather imprecise quantity whose size depends on just where the bias level was set. Furthermore, the information in Fig. 7 of Ref. 9 was taken from a number of measurements that were made for other purposes and where there was no attempt to maintain a consistent bias setting. The poor deposits lie far above the line, as expected.

III. THE LOW–GEOMETRY ALPHA COUNTER

All alpha counting was carried out in a low–geometry counter constructed at ANL. The interior of the counter is shown schematically in Fig. 8. Critical tolerances were ± 0.00025 cm. A silicon detector is positioned behind a 1.270 cm dia. aperture. The sample mounting depends on the particular sample, and Fig. 1 illustrates the mount for a 2.54 cm dia. deposit on a 6.985 cm dia. fission chamber electrode. There are 5 possible sample positions at increments of 5.0800 cm. At position 2, the distance from the top of the mounting block to the aperture plate is 9.6652 cm. This distance was re–measured whenever the counter was reassembled after it was taken apart for cleaning. The total uncertainty in the sample position from all causes, including the failure of the deposit backing to lie flat against the mounting block, is about 0.0025 cm.

Several small computer programs have been written to calculate the geometry factor under a variety of conditions. However, the following series approximation[5] is adequate for most cases, providing that the sample and aperture are perpendicular to a common axis, the sample and aperture radii are << the separation distance, and the sample distribution is uniform.

$$G = 0.5\,\{1 - [1/(1+\beta)^{1/2}] - (3/8)[\beta\gamma/(1+\beta)^{5/2}] + (5/16)[\beta\gamma^2/(1+\beta)^{7/2}]$$
$$- (35/64)[\beta^2\gamma/[(1+\beta)^{9/2}] - (35/128)/[\beta\gamma^3/(1+\beta)^{9/2}]$$
$$+ (315/256)[\beta^2\gamma^3/(1+\beta)^{11/2}] - (1155/1024)[\beta^3\gamma^3/(1+\beta)^{13/2}]\}$$

$\beta = (r_a/D)^2$
$\gamma = (r_s/D)^2$
r_a= aperture radius
r_s= sample radius
D = sample–aperture separation distance

A point of caution if a different aperture is installed: The aperture should come down to a knife edge. The thickness "a" of the edge (see Fig. 9) will affect the geometry factor. For that part of the sample with $r < r_a$, the distance D is actually D + a. For $r > r_a$, the sample–aperture distance is a combination of D and D + a. This effect can be significant, particularly at position 1. The edge thickness for the present aperture is quite small and the effect is negligible. However, some of the counting was done using an aperture with an edge thickness of 0.020 cm and that is enough to have a detectable effect on the geometry factor of a 2.54 cm dia. deposit. A computer program was written to calculate the geometry factor, including this effect. When this correction is made, the counts made at position 1, at the more distant positions and with other apertures agree within the statistical error.

IV. FISSION DEPOSIT CHARACTERISTICS

The physical characteristics of the deposits and the information on which the weight determination are based are given in Tables I thru V.

Table I lists the alpha and spontaneous fission half–lives of the sample isotopes. Table II gives the physical characteristics of the samples. This includes the material, diameter and thickness of the backing; the diameter and estimated chemical composition of the deposit; and a subjective estimate of the quality of the deposit. Table III gives the isotopic analyses and the specific activities. The average fission fragment range for the deposit material is also included in this table. The specific activities are calculated using the half–lives given in Table I and the isotopic analyses in Table II. The uncertainties in the half–lives are small, as are the uncertainties in most of the isotopic analyses, so most of the specific activities have small errors.

Table IV gives the alpha emission rate and its error, based on the most recent low-geometry alpha count. The specific activities are repeated in Table IV for convenience, and the number of sample atoms and sample weights are calculated. It should be remembered that these samples were made for a variety of purposes, and for some of these purposes an accurate mass determination based on an alpha count was not important. For some samples there is no isotopic analysis or, if there is one, it is not sufficiently accurate to give a good specific activity. A few of the samples have never been alpha counted. A few of the sample weights are based on comparative fission rates or on direct weighing. These are identified in the table. Table V gives a list of the correlated and partially correlated errors in the sample weights, based on alpha counting. This information is given regardless of how the weight information in Table IV was obtained, and you may notice that the total error is occasionally large. All the errors have been simplified to some extent. For example, the error due to the nonuniformity of the sample and to deviations from the nominal diameter depends on the reciprocal of the sample–detector distance. In estimating the errors, it was assumed that all the samples in a particular group were always counted at the same position — low activity samples at position 1; medium activity samples at position 2; high activity samples at position 3. The last column of Table V shows the total nonrandom error for a given group of samples. This is the minimum error in the sample weight, based on alpha–counting. In most cases the error is only a few tenths of a percent but, in a few cases where the isotopic analyses is uncertain or where the weights are based on direct weighing, the error is as large as 5 or 10%.

V. COMMENTS

Th–230

Th–230–49 thru Th–230–59 (5 samples)

These samples are made from material that is > 99% ^{230}Th. At the time when these samples were made, the half–life of ^{230}Th was very uncertain, so a measurement of the specific activity of this material using low–geometry alpha counting and mass determination by isotopic dilution established the half–life as 75380 ± 300 years.[3] Table V shows that the mass of these samples can be determined by alpha–counting to an accuracy of < 0.5%.

Th–232

There are several groups of these deposits. The mass of one group can be measured accurately by alpha–counting. The others cannot.

Th–232–8 thru Th–232–21 (5 samples)

These are made from natural thorium spiked with ^{230}Th to a concentration of about 0.4%. There is no isotopic analysis. If one of the samples was sacrificed for isotopic analysis, the rest could be used as thorium standards.

Th–232–30 thru Th–232–34 (3 samples)

These were part of a group of samples used in the measurement of the Th–232/U–235 fission cross section ratio and of the ^{230}Th half–life. The Th–230 content is well established (0.3830 ± 0.0012%).

Th–232–57 thru Th–232–63 (4 samples)

These natural thorium samples were made for a special purpose. The low specific activity and the presence of other members of the decay chain in nonequilibrium amounts made both low–geometry and 2π alpha counting impractical. Approximate weights were determined by direct weighing, but the uncertainty is large.

Th–232–60 thru Th–232–61 (2 samples)

These samples were made from natural thorium containing about 0.25% ^{235}U. The ^{235}U was added so the energy response of a fission detector could be calibrated using ^{235}U thermal fission.

U–233

U–233–1002 thru U–233–12 (6 samples)

These samples have two different sizes and backings, but they were all made from the same material (see Table III). The small amount of ^{232}U does not contribute to the effective alpha–emission rate. Most of the alphas emitted by ^{232}U and its daughters have energies well above the ^{233}U alphas and can be rejected by energy discrimination. However, the first daughter of ^{233}U, ^{229}Th, is just beginning to be significant in these samples. The correction is about 0.15%.

U–234

U–234–1 thru U–234–48 (8 samples)

These samples are made from three different batches of material. One was spiked with 9.9% ^{235}U. Almost all the alpha activity is due to ^{234}U, and Table V gives a minimum error in the mass determination of 0.2%.

U–235

There are several groups of ^{235}U deposits. The one containing sample nos. 5–2 thru R5 is made from material whose isotopic composition is particularly well determined.

U–235 SST–1 thru U–235 SST–8 (3 samples)

These deposits were prepared by vacuum evaporation of UF_4, so their uniformity should be very good. The backing material is steel, and some corrosion can be seen. These samples were made in the late 1960's, and their alpha activities have been measured at frequent intervals. In spite of corrosion spots appearing in the deposit area, no change has been observed in the alpha–emission rate. The isotopic analysis in Table II is based on an average of four measurements. The individual results are

Isotopic Analysis in Mole %

Isotope	(1)	(2)	(3)	(4)	Average
^{234}U	0.8548	0.8560	0.8561	0.8429	0.8524
^{235}U	93.2559	93.2267	93.2498	93.4037	93.2480
^{236}U	0.3317	0.3326	0.3321	0.3174	0.3284
^{238}U	5.5576	5.5847	5.5620	5.4360	5.5351

The errors reported with the isotopic analyses were internal precisions and were quite small. However, the scatter in the above table indicates an error of > 0.4% in the ^{234}U content which is the critical number for the alpha emission rate. Sample mass comparisons reported in Ref. 6 placed the mass of SST–5 at 417.3 ± 0.7 μg. This can be compared with the 416.3 ± 2.0 μg reported in Tables IV and V.

U–235 5–2 thru R5 (9 samples)

The material used for these deposits has been around since 1971 (e.g., W. P. Poenitz and R. J. Armani[7]), and three of the deposits included in this list were used in the 1984 ^{235}U and ^{239}Pu sample mass comparison (see Ref. 6). A very accurate redetermination of the isotopic composition was reported by Poenitz et al.,[8] and these are the values given in Table III. The alpha activity of samples of this material was measured by low–geometry counting and their mass was obtained by isotopic dilution. The resulting specific activity was 2.437 ± .0045 α/s/μg. The value listed in Table III is 2.436 ± .010 α/s/μg, in very good agreement. The error is larger, as my estimate of the alpha–counting errors is somewhat more conservative.

The chemical form of sample number 5–2 is uncertain. It is believed to be some hydrated oxide and $UO_4 \cdot H_2O$ is assumed. This is just a guess based on the appearance of the deposit. Deposits 5–3 thru 6–7 are on platinum and were heated to over 800 °C to convert the deposit to U_3O_8. Deposits N–U5–2, N–U5–3, and R5 should be similar to 5–2.

25S–5–3 (1 sample)

This is a standard ^{235}U deposit from NBS (now NIST) which was used in the 1984 ^{235}U sample mass intercomparison (see Ref. 6).

U–235–6 thru U–235–14 (3 samples)

These samples were prepared about 1975. They contain about 5% ^{233}U, so the isotopic composition and the resulting mass determinations should be fairly accurate (see Table V). U–235–14 has been used frequently in fission cross section ratio measurement with consistent results.

U–235–1 thru U–235–3 (3 samples)

These are fairly pure samples (99.56% U–235) that were used with the U–238 8–1 thru 8–3 samples in ratio measurements. An actual mass determination was never necessary and these samples have never been counted. In any case, the ^{234}U content is not known well enough to give an accurate estimate of the specific activity.

U–235–J thru U–235–T (4 samples)

These thick, large–diameter deposits were prepared from 93% U–235 and have been converted to U_3O_8. The ^{234}U content is not well–enough known to get an accurate weight by alpha counting. The weights reported in Table IV were obtained by direct weighing and the accuracy is no better than 5 to 10%.

U–236

U–236–1 thru U–236–47 (11 samples)

These deposits were prepared about 1975, and the comments for the ^{234}U deposits apply here also. There is no analyses for U–236–34.

U–238

U–238–59 thru U–238–60 (2 samples)

These two very thick deposits were prepared by the electrodeposition of very pure ^{238}U. They were then heated to a fairly low temperature so the chemical form is that of a hydrated oxide. The composition $UO_4 \cdot H_2O$ is assumed. According to Table III, the material contains < 6 ppm other isotopes. The alpha spectrum shows a group at the ^{234}U alpha energies that is consistent with about 6 ppm ^{234}U. Most of the ^{234}U alphas (if any) would be in the same region. However, they would not be detectable at the 6 ppm level due to the longer half–life.

Table V shows that the specific activity of these samples can be estimated with reasonable accuracy. However, they are not very suitable for highly accurate work because

(1) The low specific activity requires that they be counted at position 1 in the low–geometry alpha counter where the errors in the geometry factor are greatest (about 0.6%). A very long count at position 2 in the low–geometry counter might bring the error down to 0.3–0.4%.

(2) These are very thick samples, so corrections to the fission counts for loss in the deposit and for extrapolation to zero bias are large.

U–238–211 thru U–238–217 (6 samples)

These deposits have been spiked with about 1% ^{234}U and about 2% ^{235}U. Two measurements of the isotopic abundances were made in 1971. The agreement between the two suggests that the error in the ^{234}U content is no better than 0.4%. The error in the weight, as determined by alpha counting, can be no better than about 0.5%. This is good enough for these samples to serve as a secondary standard. The deposits were prepared about 1984.

U–238–4 thru U–238–9 (6 samples)

These samples have been spiked with 3 to 10% ^{233}U. There are two analyses for the 3% and 5% spikes that are in good agreement, but only one for the 10% spike. In all cases the concentration of ^{233}U is high enough so that the U–233/U–238 ratio should be quite accurate. For the most part, these are thin, nongranular deposits. Unfortunately, the uniformity of some is not of the best. They can be counted at position 3 and greater, so the effect of any nonuniformity on the weight determination will not be large. In measurements where the neutron fluence is uniform across the deposit they can provide accurate results. The samples were deposited about 1975.

U–238–26 (1 sample)

This sample was prepared from depleted uranium by vacuum evaporation of UF_4. The concentration of ^{234}U is not particularly accurate and it provides about 2.6% of the total alpha decay. Furthermore, the total alpha activity is too low for convenient counting. The weight quoted in Table IV is based on comparative fission rates. The accuracy is probably no better than 2%.

U–238–K thru U–238–O (4 samples)

These thick, large–diameter, natural uranium deposits have been converted to U_3O_8. The weights given in Table IV are based on direct weighing and are probably no better than 5–10%. The specific activities given in Table III are based on the isotopic composition of natural uranium given in the General Electric Nuclide Chart. The deposits were prepared about 1980.

U–238 8–1 thru U–238 8–3 (3 samples)

These deposits were prepared about 1971. They contain 10% ^{233}U and were used in the measurements of the U–238/U–235 fission cross section ratio. Since the ratio of the masses was determined by the ratio of the thermal fission rates, it was never necessary to obtain an actual sample weight. For this reason, these samples have never been counted. The specific activity is adequate but the ^{234}U content, which contributes about 95% of the total alpha activity, has an error of nearly 5%.

Np–237

Np–237–56 thru Np–237–80 (12 samples)

These deposits range from about 12.8 $\mu g/cm^2$ to 350 $\mu g/cm^2$. They were made in 1981 from fairly clean material, and their quality ranges from poor to good. There is a trace of ^{240}Pu but it contributes < 1% of the total activity and is well separated from the ^{237}Np alphas. In terms of atom %, the ^{240}Pu content is < 0.01%. The limiting factor in the accuracy for ^{237}Np is the half–life (see Table I). There is only a single measurement of good precision, and its uncertainty is about 0.5%.

Pu–239

Pu–239–12 thru Pu–239–14 (3 samples)

This material contains about 1% ^{240}Pu which contributes about 3.6% of the alpha activity. The ^{241}Pu does not contribute significantly, first, because it decays almost entirely by beta emission; second, because the analysis in Table III dates from about 1971

so most of the ^{241}Pu will now be ^{241}Am with alpha energies well above that of the ^{239}Pu alphas. With care it should be possible to determine the weights of these samples to about 0.2%.

Pu–239–146 thru Pu–239–267 (2 samples)

These two deposits were made from very pure ^{239}Pu, but the quality of the deposits is not all that good. On the basis of the size of the extrapolation correction to their fission spectra, I would characterize them as poor. That correction is nearly three times as large as it should be. The weight determinations by alpha counting should be quite accurate (about 0.2%), but the uncertainties in the fission corrections may limit the overall accuracy (see Ref. 9).

49I–1–3 (1 sample)

This is a standard deposit from NIST (formerly NBS). It was used in the 1984 ^{235}U and ^{239}Pu sample mass intercomparison.[6]

Pu–242

Pu–242–49 (1 sample)

This is the only remaining ^{242}Pu deposit and it contains 9.1% ^{239}Pu. The small amount of ^{241}Pu does not affect the alpha decay rate in any significant way (see Pu–239–12). The ^{238}Pu alphas can be rejected by energy discrimination.

VI. SOURCES OF ERROR

The principal sources of error other than counting statistics are summarized in Table V. The following discussion gives the reasons behind the numbers.

A. Counting Statistics

This is a completely uncorrelated error. Table IV gives the alpha emission rates for most samples based on the most recent set of counts and the statistical error for those counts. **New emission rates should be measured before any of these samples are used for any serious purpose.**

B. Error in the Half–Lives

The decay rate for most samples is dominated by a single isotope, and only the error in that half–life (Table I0) need be considered. Two isotopes are necessary in only a few cases. This error is fully correlated for those samples where the same isotope dominates the alpha emission.

C. Error in the Isotopic Analysis

This source of error becomes important when the concentration of the isotope that dominates the alpha emission is low. Typical uncertainties in the minor isotopes is about 0.004 so if the concentration is around 5% the error becomes negligible. The material used to make the ^{235}U samples 5–2 thru R5 is a special case. The uncertainty here is estimated to $< 0.002\%$.

D. Error in the alpha count due to sample characteristics

These errors are fully correlated for all measurements made with a particular sample. They are otherwise uncorrelated.

1. Sample Uniformity

Many samples that appear to be uniform may actually have a thickness that depends on the radius. This will affect the geometry factor, The effect depends on the radius and is inversely dependent on the sample–detector distance.

2. Sample radius

The geometry factor depends inversely on the sample radius. It is assumed that the uncertainty in the radius is ± 0.051 cm. For a 2.54 cm diameter sample this translates into a 0.43% uncertainty at position 1. At position 3 it is negligible.

3. Sample–Detector distance

There may be some uncertainty in this distance due to bowing or other distortion of the sample backing. It is assumed that this is ± 0.2% at position 1 and is smaller at other positions.

E. Errors in the Alpha Counter Dimensions

These have nothing to do with the samples and are fully correlated for all measurements.

1. Aperture radius

This is assumed to be ± 0.0005 cm which translates into a 0.1% uncertainty in the alpha count.

2. Shelf position

It is assumed that this uncertainty introduces an error of 0.1% at position 1. Since it is inversely proportional to the square of the sample aperture distance, it will be negligible at the other positions.

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Table I. The Alpha and Spontaneous Fission Half–Lives.[a]

Isotope	α Half–life years	SF Half–life years
^{229}Th[b]	$(7.340\pm.160)\times10^{3}$	
^{230}Th[c]	$(7.538\pm.030)\times10^{4}$	
^{232}Th	$(1.405\pm.006)\times10^{10}$	
^{233}U	$(1.592\pm.002)\times10^{5}$	$(1.220\pm.280)\times10^{17}$
^{234}U	$(2.457\pm.003)\times10^{5}$	$(2.040\pm1.02)\times10^{16}$
^{235}U	$(7.038\pm.007)\times10^{8}$	$(3.500\pm.900)\times10^{17}$
^{236}U	$(2.343\pm.004)\times10^{7}$	$(2.000\pm1.00)\times10^{16}$
^{238}U	$(4.468\pm.004)\times10^{9}$	$(8.200\pm.090)\times10^{15}$
^{237}Np	$(2.140\pm.010)\times10^{6}$	$> 10^{18}$
^{239}Pu	$(2.411\pm.003)\times10^{4}$	$(5.500\pm.500)\times10^{15}$
^{240}Pu	$(6.563\pm.007)\times10^{3}$	$(1.310\pm.050)\times10^{11}$
^{241}Pu (α)	$(6.000\pm.050)\times10^{5}$	
(β)	$(1.440\pm.010)\times10^{1}$	
^{241}Am	$(4.326\pm.006)\times10^{2}$	$(1.060\pm.030)\times10^{14}$
^{242}Pu	$(3.735\pm.011)\times10^{5}$	$(6.842\pm.075)\times10^{10}$

[a]Reference 4
[b]Reference 10
[c]Reference 3

Table II. Description of samples.

Sample No.	Mat.	Backing Dia. (cm)	Backing Thick (cm)	Deposit Dia. (cm)	Deposit Comp.	Deposit Area (cm^2)	Frag. Range (cm^2)	Quality
Th–230–49	Pt	5.08	0.0127	2.54	$ThO_2 \cdot H_2O$	5.067	5.1	G
Th–230–50	"	"	"	2.54	"	"	"	P
Th–230–52	"	"	"	2.54	"	"	"	F
Th–230–54	"	"	"	2.54	"	"	"	F
Th–230–59	"	"	"	2.54	"	"	"	F
Th–232–8	"	"	"	—	"	—	5.1	F
Th–232–11	"	"	"	2.54	"	5.067	"	G
Th–232–12	"	"	"	2.54	"	"	"	F
Th–232–16	"	"	"	2.54	"	"	"	F
Th–232–21	"	"	"	—	"	—	"	G
Th–232–30	"	"	"	2.54	"	5.067	"	G
Th–232–31	"	"	"	2.54	"	"	"	G
Th–232–34	"	"	"	2.54	"	"	"	F
Th–232–57	"	"	"	—	"	—	"	F
Th–232–58	"	"	"	—	"	—	"	F
Th–232–62	"	"	"	—	"	—	"	F
Th–232–63	"	"	"	—	"	—	"	G
Th–232–60	"	"	"	—	"	—	"	G
Th–232–61	"	"	"	—	"	—	"	F
U–233–1002	Mo	6.985	0.0127	2.510	$UO_4 \cdot H_2O$	4.948	4.1	F
U–233–1202	"	"	"	2.520	"	4.988	"	—
U–233–1402	"	"	"	2.480	"	4.830	"	F
U–233–10	Pt	2.38	"	1.270	"	1.267	"	G
U–233–11	"	"	"	"	"	"	"	G
U–233–12	"	"	"	"	"	"	"	G
U–234–1	St	6.985	0.0254	—	$UO_4 \cdot H_2O$	—	4.1	—
U–234–3	"	"	"	2.54	"	5.067	"	P
U–234–4	"	"	"	2.510	"	4.948	"	G
U–234–5	"	"	"	2.461	"	4.757	"	—
U–234–6	"	"	"	—	"	—	"	—
U–234–31	Mo	"	0.0127	2.500	"	4.909	"	F
U–234–32	"	"	"	2.500	"	4.909	"	G
U–234–48	"	"	"	—	"	—	"	—
U–235 SST–1	St	6.985	0.0254	2.54	UF_4	5.067	4.7	VG
U–235 SST–5	"	"	"	"	"	"	"	G
U–235 SST–8	"	"	"	"	"	"	"	VG
U–235 5–2	"	"	"	2.480	UO_4H_2O	4.830	4.1	G
U–235 5–3	Pt	5.08	0.0127	2.54	U_3O_8	5.067	6.0	P
U–235 5–4	"	"	"	"	"	"	"	F
U–235 5–6	"	"	"	"	"	"	"	F

Table II. (continued)

Sample No.	Mat.	Backing Dia. (cm)	Backing Thick (cm)	Deposit Dia. (cm)	Deposit Comp.	Deposit Area (cm^2)	Frag. Range (cm^2)	Quality
U–235 6–5	Pt	5.08	0.0127	2.52	U_3O_8	4.988	6.0	G
U–235 6–6	"	"	"	2.54	"	5.067	"	G
U–235 6–7	"	"	"	2.52	"	4.988	"	G
N–U5–2	St	1.905	0.254	1.27	"	1.267	"	G
N–U5–3	"	"	"	"	"	"	"	F
R5	"	4.445	0.127	2.22	"	3.761	"	G
25S–5–3	Pt	1.905	0.0127	1.27	UO_2	1.267	6.6	G
U–235–6	Mo	6.985	"	2.58	$UO_4 \cdot H_2O$	5.228	4.1	F
U–235–10	"	"	"	2.768	"	6.018	"	G
U–235–14	"	"	"	2.758	"	5.974	"	F
U–235–1	St	"	0.0254	2.54	"	5.067	"	G
U–235–2	"	"	"	"	"	"	"	P
U–235–3	"	"	"	"	"	"	"	G
U–235–J	Pt	"	0.0127	5.08	U_3O_8	20.27	6.0	—
U–235–P	"	"	"	"	"	"	"	—
U–235–S	"	"	"	"	"	"	"	—
U–235–T	"	"	"	"	"	"	"	—
U–236–1	St	6.985	0.0254	—	$UO_4 \cdot H_2O$	—	4.1	—
U–236–2	"	"	"	2.580	"	5.228	"	—
U–236–3	"	"	"	2.580	"	"	"	—
U–236–4	"	"	"	2.510	"	4.948	"	—
U–236–5	"	"	"	2.540	"	5.067	"	—
U–236–6	"	"	"	2.620	"	5.391	"	—
U–236–34	Mo	"	0.0127	2.540	"	5.067	"	—
U–236–35	"	"	"	"	"	"	"	—
U–236–36	"	"	"	2.520	"	4.988	"	—
U–236–46	"	"	"	—	"	—	"	—
U–236–46	"	"	"	—	"	—	"	—
U–238–59	St	6.985	0.0254	2.540	"	5.067	4.1	F
U–238–60	"	"	"	"	"	"	"	G
U–238–210	Pt	5.08	0.0127	2.54	U_3O_8	"	6.0	G
U–238–211	"	"	"	"	"	"	"	P
U–238–212	"	"	"	"	"	"	"	—
U–238–213	"	"	"	"	"	"	"	P
U–238–214	"	"	"	"	"	"	"	—
U–238–217	"	"	"	"	"	"	"	—
U–238–4	Mo	6.985	0.0127	—	$UO_4 \cdot H_2O$	—	4.1	—
U–238–11	"	"		—	"	—	"	—
U–238–13	"	"		2.833	"	6.326	"	—

Table II. (continued)

Sample No.	Mat.	Backing Dia. (cm)	Backing Thick (cm)	Deposit Dia. (cm)	Deposit Comp.	Deposit Area (cm^2)	Frag. Range (cm^2)	Quality
U–238–15	Mo	6.985	0.0127	—	$UO_4 \cdot H_2O$	—	4.1	G
U–238–8	"	"		—	"	—	"	—
U–238–9	"	"		2.522	"	4.996	"	G
U–238–26	St	"	0.0254	2.54	UF_4	5.067	4.7	G
U–238–K	Pt	"	0.0127	5.08	U_3O_8	20.27	6.0	—
U–238–L	"	"	"	"	"	"	"	—
U–238–M	"	"	"	"	"	"	"	—
U–238–O	"	"	"	"	"	"	"	—
U–238 8–1	St	"	0.0254	—	$UO_4 \cdot H_2O$	—	4.1	—
U–238 8–2	"	"	"	—	"	—	"	—
U–238 8–3	"	"	"	—	"	—	"	—
Np–237–56	Pt	5.08	0.0127	—	NpO_2	—	5.6	F
Np–237–70	"	"	"	—	"	—	"	G
Np–237–71	"	"	"	—	"	—	"	P
Np–237–72	"	"	"	—	"	—	"	P
Np–237–73	"	"	"	—	"	—	"	P
Np–237–74	"	"	"	—	"	—	"	P
Np–237–75	"	"	"	—	"	—	"	F
Np–237–76	"	"	"	2.54	"	5.067	"	G
Np–237–77	"	"	"	—	"	—	"	F
Np–237–78	"	"	"	—	"	—	"	F
Np–237–79	"	"	"	2.54	"	5.067	"	G
Np–237–89	"	"	"	—	"	—	"	P
Pu–239–12	St	6.985	0.0254	—	PuO_2	—	6.7	F
Pu–239–13	"	"	"	2.520	"	4.988	"	P
Pu–239–14	"	"	"	—	"	—	"	F
Pu–239–146	"	"	"	2.500	"	4.909	"	F
Pu–239–267	"	"	"	"	"	4.906	"	P
49I–1–3	Pt	1.905	0.0127	1.270	"	1.267	"	G
Pu–242–49	Mo	6.985	0.0127	2.500	"	4.909	6.7	F

Table III–A. Thorium Isotopic Analysis in Mole %.

Sample No.	230	232	Av. Atomic Wt.
Th–239–49	99.600(0.60)	0.400	230.043
Th–230–50	"	"	"
Th–230–52	"	"	"
Th–230–54	"	"	"
Th–230–59	"	"	"
Th–232–8			
Th–232–11	Natural thorium spiked with		
Th–232–12	~ 0.4% Th–230. No isotopic		
Th–232–16	analysis on this batch.		
Th–232=21			
Th–232–30	0.383	99.617	232.030
Th–232–31	"	"	"
Th–232–34	"	"	"
Th–232–57	0.0	100.0 Natural thorium	
Th–232–58	"	"	
Th–232–62	"	"	
Th–232–63	"	"	
Th–232–60	Natural thorium + ~1/4% U–235		
Th–232–61		"	

Table III–B. Isotopic Analysis in Mole %.

Sample No.	232 ppm	233	234	235	236	238	Av. Atomic Wt.
U–233–1002	0.8	99.540	0.184	0.062	0.013	0.203	233.058
U–233–1202	"	"	"	"	"	"	"
U–233–1402	"	"	"	"	"	"	"
U–233–10	"	"	"	"	"	"	"
U–233–11	"	"	"	"	"	"	"
U–233–12							
U–234–1	—	—	99.900	0.064	0.036	<0.007	234.045
U–234=3	—	—	"	"	"	"	"
U–234–4	—	—	"	"	"	"	"
U–234–5	—	—	"	"	"	"	"
U–234–6	—	—	"	"	"	"	"
U–234–31	—	—	89.950	9.920	0.053	0.075	234.137
U–234–32	—	—	"	"	"	"	"
U–234–48	—	0.005	99.07	0.08	0.055	0.789	234.072
U–235 SST–1	—	—	0.852	93.283	0.328	5.535	235.200
U–235 SST–5	—	—	"	"	"	"	"
U–235 SST–8	—	—	"	"	"	"	"
U–235 5–2	—	—	1.0247	98.4897	0.4374	0.0983	235.041
U–235 5–3	—	—	"	"	"	"	"
U–235 5–4	—	—	"	"	"	"	"
U–235 6–5	—	—	"	"	"	"	"
U–235 6–6	—	—	"	"	"	"	"
U–235 6–7	—	—	"	"	"	"	"
N–U5–2	—	—	1.025	98.440	0.437	0.098	235.041
N–U5–3	—	—	"	"	"	"	"
R5	—	—					
U–235–1	—	—	0.028	99.856	0.062	0.056	235.051
U–235–2	—	—	"	"	"	"	"
U–235=3	—	—					
25S–5–3	—	—	0.0610	99.748	0.0652	0.1261	235.048
U–235–6	—	5.127	0.050	94.420	0.307	0.094	234.942
U–235–10	—	"	"	"	"	"	"
U–235–14	—						

Table III–B. (continued)

Sample No.	232 ppm	233	234	235	236	238	Av. Atomic Wt.
U–235–J U–235–P U–235–S U–235–T	These are deposits of ~ 93% U–235 and ~5% U–238. However, exact analysis is not known.						
U–236–1	—	—	—	0.402	99.593	0.011	236.056
U–236–2	—	—	—	"	"	"	"
U–236–3	—	—	—	"	"	"	"
U–236–4	—	—	—	"	"	"	"
U–236–5	—	—	—	"	"	"	"
U–236–6	—	—	—	"	"	"	"
U–236–34	No analysis						
U–236–35	—	—	0.015	13.64	86.19	0.16	235.604
U–236–36	—	—	0.004	11.00	88.84	0.16	235.948
U–236–46	—	—	"	"	"	"	"
U–236–47	—	—	"	"	"	"	"
U–238–59	—	←	< 6 ppm			100.0	238.051
U–238–60	—		"			"	"
U–238–210	—	—	1.0100	2.364	0.135	96.491	237.936
U–238–211	—	—	"	"	"	"	"
U–238–212	—	—	"	"	"	"	"
U–238–213	—	—	"	"	"	"	"
U–238–214	—	—	"	"	"	"	"
U–238–217	—	—	"	"	"	"	"
U–238–4	—	3.153	—	0.01464	—	96.832	237.892
U–238–11	—	"	—	"	—	"	"
U–238–13	—	"	—	"	—	"	"
U–238–15	—	"	—	"	—	"	"
U–238–8	—	6.091	—	0.0125	—	93.897	237.746
U–238–9	—	10.050	0.022	0.015	—	89.914	237.547
U–238–26	—	—	—	0.415	—	99.585	238.038

Table III–B. (continued)

Sample No.	232 ppm	233	234	235	236	238	Av. Atomic Wt.
U–238–K	—	—	0.0055	0.72	—	99.2745	238.029
U–238–L	Natural uranium. Handbook values given. There is no independent analysis.						
U–238–M							
U–238–O							
U–238–8–1	—	—	0.114	10.842	0.050	88.993	237.716
U–238 8–2	—	—	"	"	"	"	"
U–238 8–3	—	—	"	"	"	"	"

Table III–C. Isotopic analysis for the neptunium and plutonium samples

Sample No.	237	238	239	240	241	242	Av. Atomic Wt.
Np–237–56	100.0	—	—	—	—	—	237.048
Np–237–71	"	—	—	—	—	—	"
Np–237–72	"	—	—	—	—	—	"
Np–237–73	"	—	—	—	—	—	"
Np–237–74	"	—	—	—	—	—	"
Np–237–75	"	—	—	—	—	—	"
Np–237–76	"	—	—	—	—	—	"
Np–237–77	"	—	—	—	—	—	"
Np–237–78	"	—	—	—	—	—	"
Np–237–79	"	—	—	—	—	—	"
Np–237–80	"	—	—	—	—	—	"
Pu–239–12	—	—	98.944	1.012	0.049	—	239.077
Pu–239–13	—	—	"	"	"	—	"
Pu–239–14	—	—	"	"	"	—	"
Pu–239–146	—	—	99.952	0.048	—	—	239.056
Pu–239–267	—	—	"	"	—	—	"
49I–1–3	—	—	99.105	0.879	0.010	0.006	239.064
Pu–242–49	—	0.007	9.128	0.097	0.099	90.669	241.054

Table IV. Fission Sample Activities and Weights

Sample No.	Alpha Activity α/s	Alpha Activity Random Error %	Specific Activity d/s/atom[a]	Specific Activity d/s/μg	Atoms Element[a]	Element (μg)	Wt. μg/cm² Element
Th–230–49	147852	0.22	2.8998(–13)	758.0	0.5099(18)	195.1	38.5
Th–230–50	182992	0.19	"	"	0.6310(18)	241.4	47.6
Th–230–52	34054	0.37	"	"	0.1174(18)	44.9	8.86
Th–230–54	583446	0.06	"	"	2.012(18)	769.7	151.9
Th–230–59	282892	0.10	"	"	0.9756(18)	373.2	73.6
Th–232–8	1334.7	0.33	—	—	—	—	—
Th–232–11	5894.2	0.14	—	—	—	—	—
Th–232–12	1972.9	0.28	—	—	—	—	—
Th–232–16	2314.3	0.24	—	—	—	—	—
Th–232–21	23524.	0.20	—	—	—	—	—
Th–232–30	4063.1	0.17	1.1176(–15)	2.901	3.636(18)	1401	276.5
Th–232–31	4080.6	0.16	"	"	3.651(18)	1407	277.7
Th–232–34	8489.2	0.11	"	"	7.596(18)	2926	577.4
Th–232–57	—	—	—	—	—	—	—
Th–232–58	—	—	—	—	—	—	—
Th–232–62	—	—	—	—	—	—	—
Th–232–63	—	—	—	—	—	—	—
Th–232–60	—	—	—	—	—	—	—
Th–232–61	—	—	—	—	—	—	—
U–233–1002	77538	0.10	1.3750(–13)	355.3	0.5639(18)	218.2	44.1
U–233–1202	90836	0.10	"	"	0.6606(18)	255.7	51.3
U–233–1402	106138	0.10	"	"	0.7719(18)	298.7	61.8
U–233–10	—	—	—	—	—	—	—
U–233–11	—	—	—	—	—	—	—
U–233–12	—	—	—	—	—	—	—
U–234–1	—	—	8.9309(–14)	229.8	—	—	—
U–234–3	68457	0.13	"	"	0.7665(18)	297.9	58.8
U–234–4	82220	0.12	"	"	0.9204(18)	357.7	72.3
U–234–5	96356	0.07	"	"	1.079(18)	407.1	85.6
U–234–6	—	—	"	"	—	—	—
U–234–31	39093	0.12	8.0418(–14)	206.9	0.4861(18)	189.0	38.5
U–234–32	75057	0.05	"	"	0.9333(18)	362.8	73.9
U–234–48	—	—	8.8592(–14)	228.0	—	—	—
U–235 SST–1	1358.4	—	7.9414(–16)	2.034	1.710(18)	657.8	131.8
U–235 SST–5	846.8	0.20	"	"	1.066(18)	416.3	82.2
U–235 SST–8	2062.3	0.15	"	"	2.597(18)	1014.	200.1

Table IV. (continued)

Sample No.	Alpha Activity α/s	Random Error %	Specific Activity d/s/atom[a]	d/s/μg	Atoms Element[a]	Element (μg)	Wt. μg/cm² Element
U–235 5–2	2029.3	0.10	9.5090(–16)	2.436	2.134(18)	833.0	172.4
U–235 5–3	789.86	0.13	"	"	0.8306(18)	324.2	64.0
U–235 5–4	886.6	0.12	"	"	0.9324(18)	364.0	71.8
U–235 6–5	3446.8	0.10	"	"	3.625(18)	1415.	283.7
U–235 6–6	3034.3	0.11	"	"	3.191(18)	1246.	245.7
U–235 6–7	2901.5	0.11	"	"	3.051(18)	1191.	238.8
N–U5–2	—	—	"	"	—	—	—
N–U5–3	127.2	(0.3)	"	"	0.1338(18)	52.2	41.2
R5	194.1	(0.3)	"	"	0.2041(18)	79.6	20.6
25S–5–3	50.82	(0.3)	8.6250(–17)	0.2210	0.5892(18)	230.0	181.5
U–235–6	5283.6	0.10	7.1921(–15)	18.44	0.7346(18)	286.5	54.8
U–235–10	4918.3	0.14	"	"	0.6838(18)	266.7	44.3
U–235–14	6601.6	0.07	"	"	0.9179(18)	358.0	59.9
U–235–1	—	—	—	—	—	—	—
U–235–2	—	—	—	—	—	—	—
U–235–3	—	—	—	—	(1.005(18))[b]	—	—
U–235–J	—	—	—	—	—	(10400)[c]	(513)
U–235–P	—	—	—	—	—	(9700)[c]	(478)
U–235–S	—	—	—	—	—	(10200)[c]	(498)
U–235–T	—	—	—	—	—	(11700)[c]	(577)
U–236–1	—	—	9.3418(–16)	2.384	—	—	—
U–236–2	679.4	0.45	"	"	0.7273(18)	285.0	54.5
U–236–3	1503.8	0.48	"	"	1.610(18)	630.8	120.7
U–236–4	919.9	0.28	"	"	0.9847(18)	385.9	78.0
U–236–5	1418.0	0.23	"	"	1.518(18)	594.8	117.4
U–236–6	1591.1	0.25	"	"	1.703(18)	667.4	123.8
U–236–34	1061.2	0.35	"	"	1.136(18)	445.1	87.8
U–236–35	617.06	0.25	8.2602(–16)	2.112	0.7470(18)	292.2	57.7
U–236–36	1312.7	0.20	8.3664(–16)	2.136	1.569(18)	614.6	123.2
U–236–46	—	—	"	—	—	—	—
U–236–47	—	—	"	—	—	—	—
U–238–59	33.58	0.40	4.9169(–18)	0.01244	6.831(18)	2699.	532.6
U–238–60	24.33	0.32	"	"	4.949(18)	1956.	386.0
U–238–210	2718.2	0.13	9.1001(–16)	2.304	2.987(18)	1180.	232.9
U–238–211	3914.8	0.12	"	"	4.302(18)	1699	335.3
U–238–212	3971.2	0.09	"	"	4.364(18)	1724.	34.0
U–238–213	1376.2	0.09	"	"	1.512(18)	597.3	117.9
U–238–214	537.2	0.20	"	"	0.5903(18)	233.2	46.0
U–238–217	1011.9	0.20	"	"	1.112(18)	439.2	86.7

Table IV. (continued)

Sample No.	Alpha Activity α/s	Alpha Activity Random Error %	Specific Activity d/s/atom[a]	Specific Activity d/s/μg	Atoms Element[a]	Element (μg)	Wt. μg/cm² Element
U–238–4	—	—	4.3550(–15)	11.03	—	—	—
U–238–11	—	—	"	"	—	—	—
U–238–13	—	—	"	"	—	—	—
U–238–15	3965.9	0.11	"	"	0.9106(18)	359.6	56.8
U–238–8	—	—	"	"	—	—	—
U–238–9	13508	0.14	1.3889(–14)	35.22	0.9726(18)	383.5	76.8
U–238–26	—	—	"	—	(2.404(18))[b]	(950)	(187)
U–238–K	—	—	1.0022(–17)	0.02536	—	(12000)[c]	(592)
U–238–L	—	—	"	"	—	(11100)[c]	(548)
U–238–M	—	—	"	"	—	(7400)[c]	(365)
U–238–O	—	—	"	"	—	(13000)[c]	(641)
U–238 8–1	—	—	1.1014(–16)	0.2790	—	—	—
U–238 8–2	—	—	"	"	—	—	—
U–238 8–3	—	—	"	"	—	—	—
Np–237–56	1686.6	0.29	1.0264(–14)	26.08	0.1643(18)	64.7	12.8
Np–237–70	1740.2	0.60	"	"	0.1695(18)	66.7	13.2
Np–237–71	13469	0.18	"	"	1.312(18)	516.4	101.9
Np–237–72	6907.1	0.22	"	"	0.6729(18)	264.8	52.3
Np–237–73	3846.0	0.40	"	"	0.3747(18)	147.5	29.1
Np–237–74	28970	0.20	"	"	2.822(18)	1111.	219.3
Np–237–75	37527	0.13	"	"	3.656(18)	1439.	284.0
Np–237–76	46285	0.12	"	"	4,599(18)	1775.	350.3
Np–237–77	39038	0.35	"	"	3.803(18)	1497.	295.4
Np–237–78	6786.2	0.28	"	"	0.6612(18)	260.2	51.4
Np–237–79	17108	0.08	"	"	1.667(18)	656.0	129.5
Np–237–80	18340	0.21	"	"	1.787(18)	703.2	138.8
Pu–239–12	469590	0.16	9.3529(–13)	2356	0.5021(18)	199.3	—
Pu–239–13	662231	0.05	"	"	0.7080(18)	281.1	56.4
Pu–239–14	827860	0.04	"	"	0.8851(18)	351.4	—
Pu–239–146	1625146	0.04	9.1220(–13)	2301	1.782(18)	706.3	143.9
Pu–239–278	298311	0.07	"	"	0.3270(18)	129.6	26.4
49I–1–3	245700	(0.10)	9.3230(–13)	2349	0.2635(18)	104.6	82.6
Pu–242–49	76858	0.10	1.3973(–13)	349.1	0.5500(18)	220.2	44.9

[a]Number in parenthesis indicates power of 10.
[b]No. atoms based on comparison of fission rate with other samples.
[c]Weight determined by direct weighing.

Table V. Errors other than counting statistics and their sources in %

Sample Nos.	$t_{1/2}$	Isotopic Analysis	Sample Corr. Error Dist.	Dia.	Uniformity	Fully Correlated Error Apparatus	Dist.	Total Corr. Error
Th–230 (49–59)	0.4	N	0.05	0.06	0.1	0.10	0.03	0.43
Th–232 (30–34)	0.4	0.4 (230)	0.10	0.10	0.25	"	0.06	0.64
U–233 (1002–12)	0.13	N (233)	0.05	0.06	0.1	"	0.03	0.21
U–234 (1–6)	0.12	N (234)	0.05	0.06	0.1	"	0.03	0.20
U–234 (31–32)	0.12	N (234)	0.05	0.06	0.1	"	0.03	0.20
U–234–48	0.12	N (234)	0.05	0.06	0.1	"	0.03	0.20
U–235 (SST-1–SST-8)	0.12	0.43 (234)	0.10	0.10	N	"	0.06	0.48
U–235 (5-2–R5)	0.12	0.20 (234)	0.10	0.10	0.25	"	0.06	0.39
U–235 25S–5-3	0.16	0.4 (234,235)	0.22	0.10	N	"	0.10	0.51
U–235 (6–14)	0.13	0.2 (233)	0.10	0.10	0.25	"	0.06	0.39
U–235 (1–3)	0.16	10.0 (234,235)	0.22	0.22	0.44	"	0.10	10.02
U–235 (J–T)	0.12	— (234)	0.10	0.20	0.82	"	0.06	—
U–236 (1–6)	0.17	N (236)	0.10	0.10	0.25	"	0.10	0.36
U–236–35	0.17	N (236)	0.10	0.10	0.25	"	0.10	0.36
U–236 (36–47)	0.17	N (236)	0.10	0.10	0.25	"	0.10	0.36
U–238 (59–60	0.11	N (238)	0.22	0.22	0.44	"	0.10	0.57
U–238 (211–217)	0.12	0.4 (234)	0.10	0.10	0.25	"	0.06	0.52
U–238 (4–15)	0.13	0.20 (233)	0.10	0.10	0.25	"	0.06	0.39
U–238–8	0.13	0.10 (233)	0.10	0.10	0.25	"	0.06	0.35
U–238–9	0.13	0.10 (233)	0.10	0.10	0.25	"	0.06	0.35
U–238–26	0.11	6.3 (235)	0.22	0.22	N	"	0.10	6.31
U–238 (K–O)	0.16	10.0 (234,238)	0.10	0.10	0.82	"	0.10	10.04
U–238 (8-1–8-3)	0.12	5.0 (234)	0.22	0.22	0.44	"	0.10	5.03
Np–237 (56–80)	0.47	N (237)	0.10	0.10	0.06	"	0.06	0.51
Pu–239 (12–14)	0.12	N (239)	0.06	0.06	0.06	"	0.03	0.19
Pu–239 (146–267)	0.12	N (239)	0.06	0.06	0.06	"	0.03	0.19
Pu–239 491–I-3	0.12	N (239)	0.06	0.06	0.06	"	0.03	0.19
Pu–242–49	0.32	N (239,242)	0.06	0.06	0.06	"	0.03	0.35

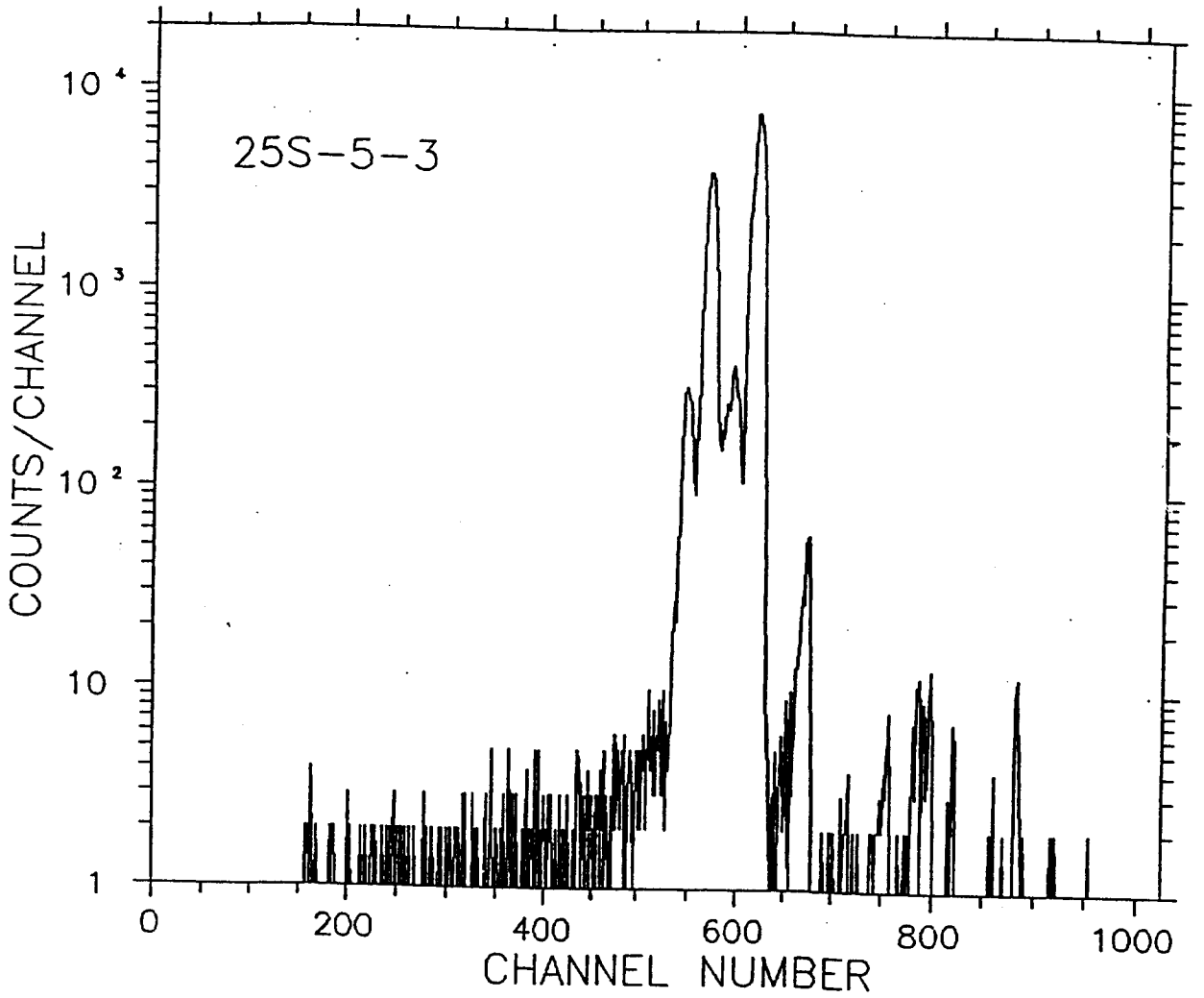

Fig. 1. The alpha spectrum of deposit 25S–5–3. The geometry factor is 213.3 and the live time is 614231 sec.

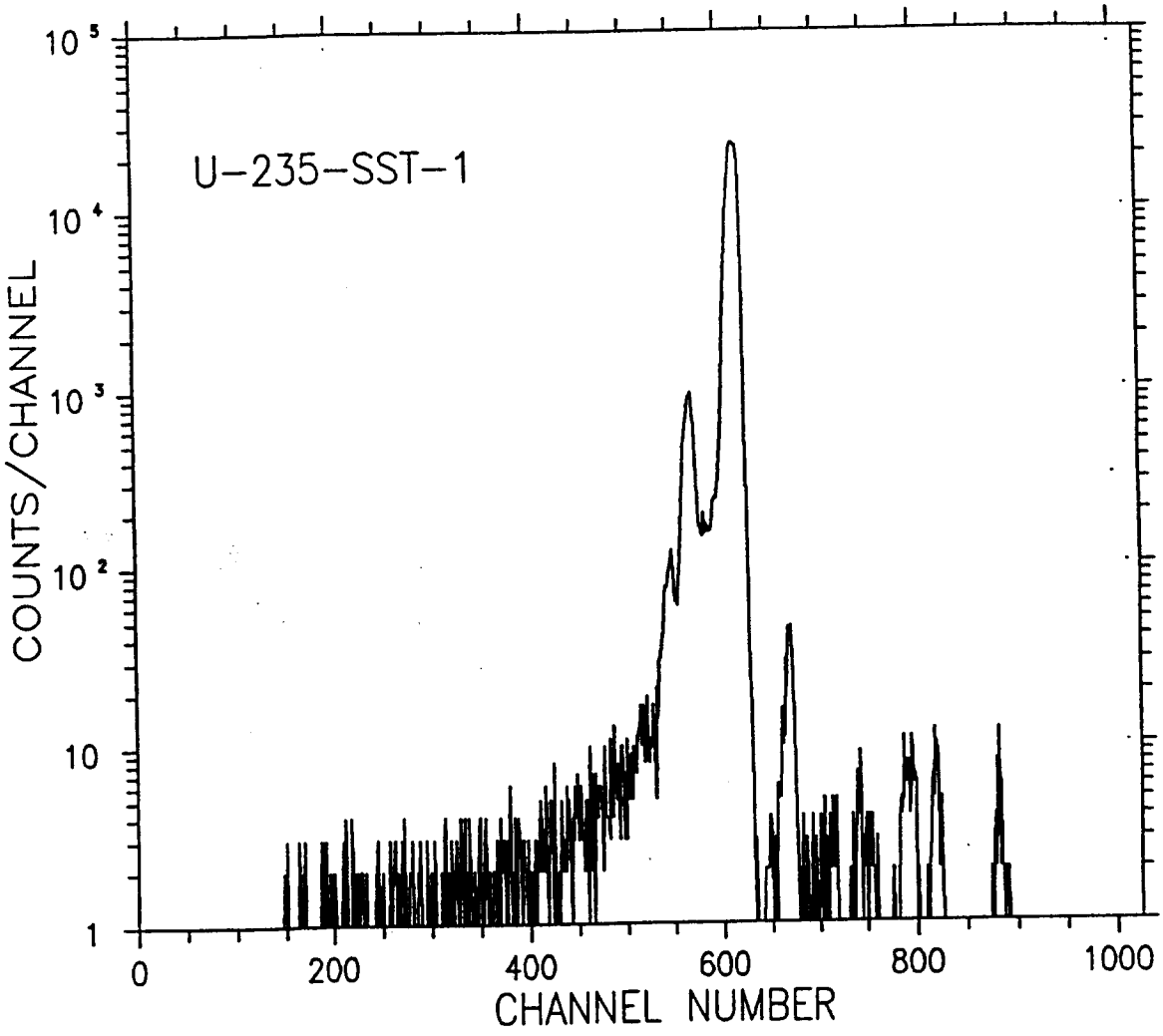

Fig. 2. The alpha spectrum of deposit U–235 SST–1. The geometry factor is 936.8 and the live time is 235090 sec.

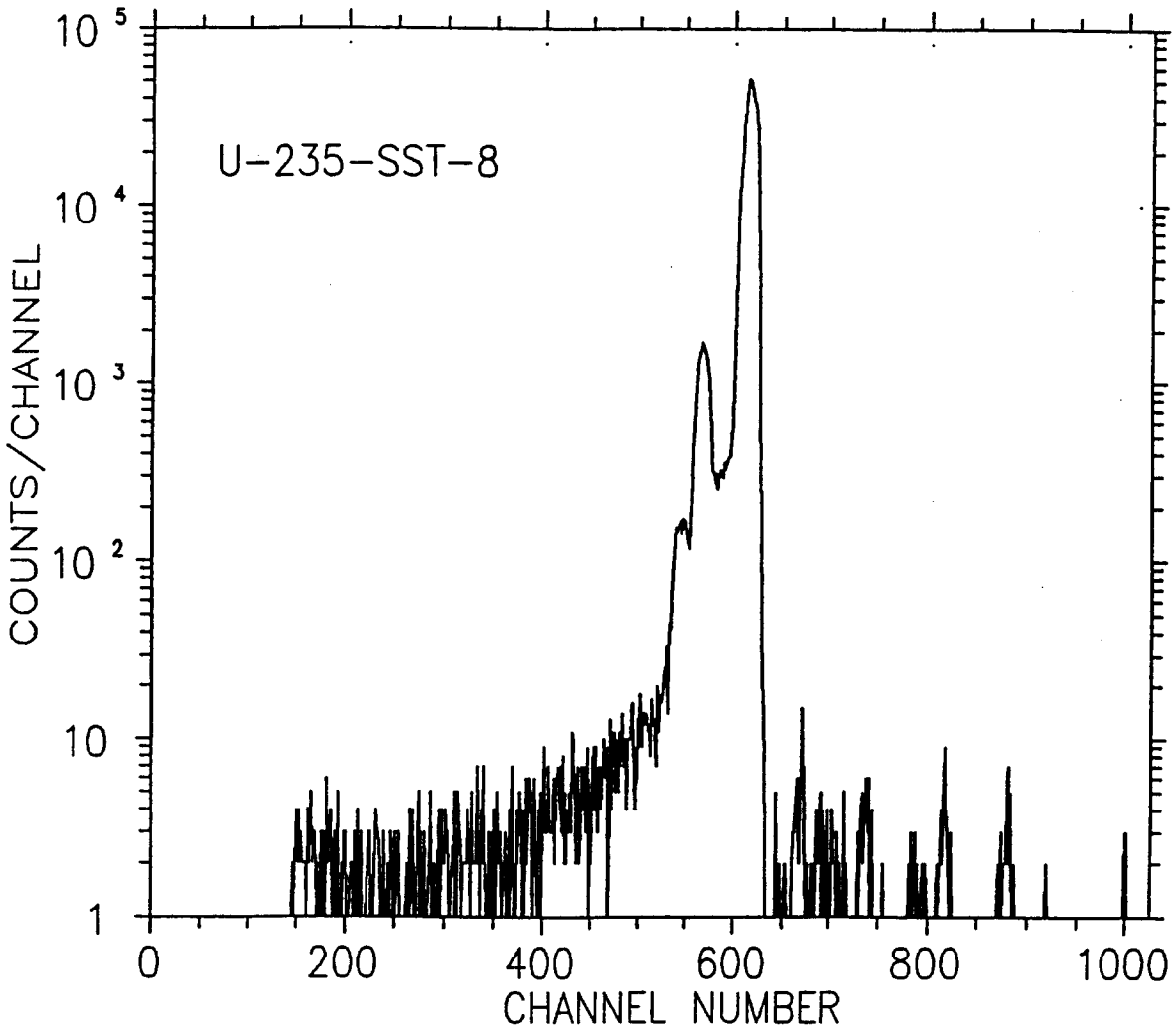

Fig. 3. The alpha spectrum of deposit U–235 SST–8. The geometry factor is 936.8 and the live time is 79349 sec.

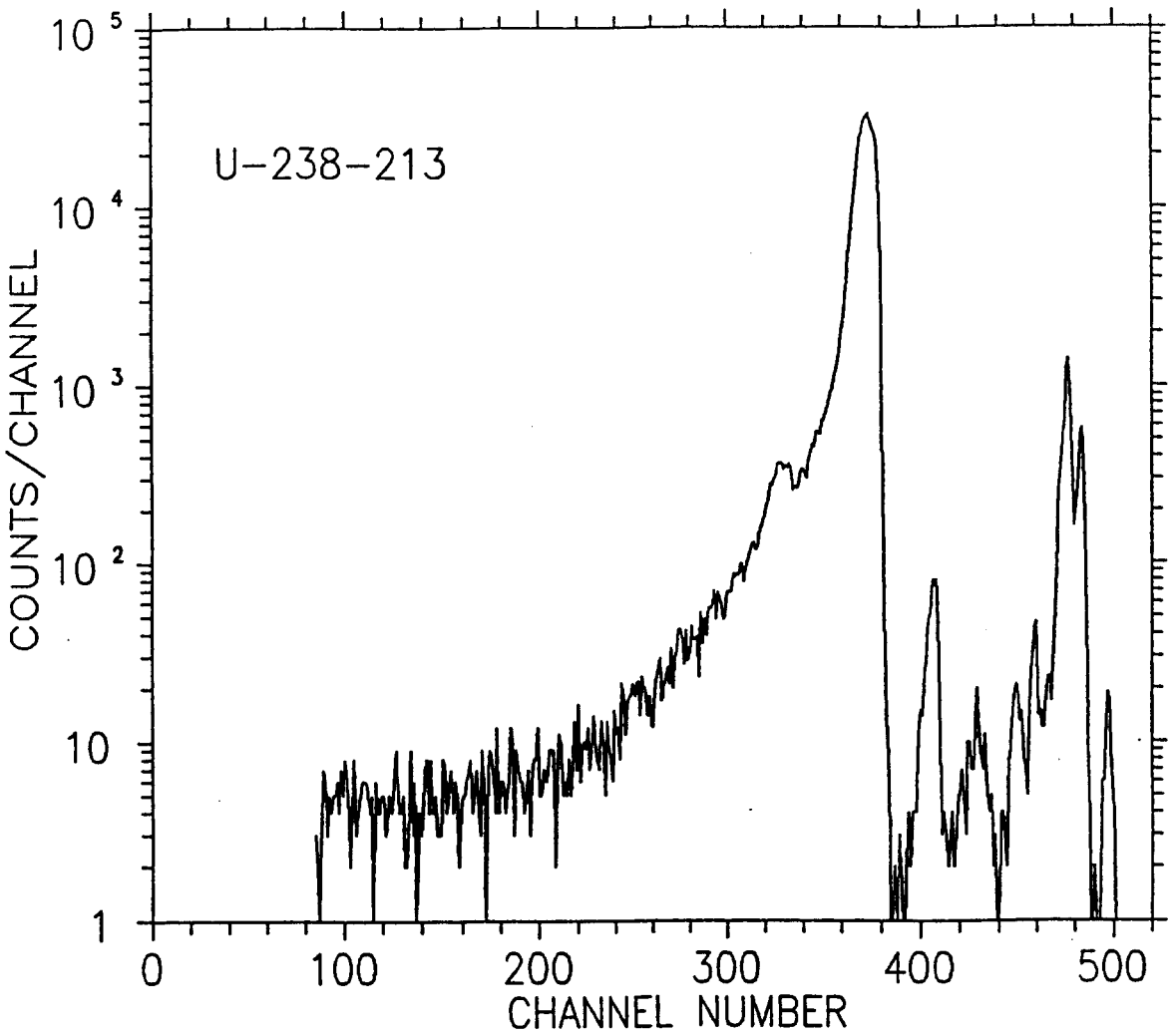

Fig. 4. The alpha spectrum of deposit U–238–213. The geometry factor is 938.9 and the live time is 241160 sec.

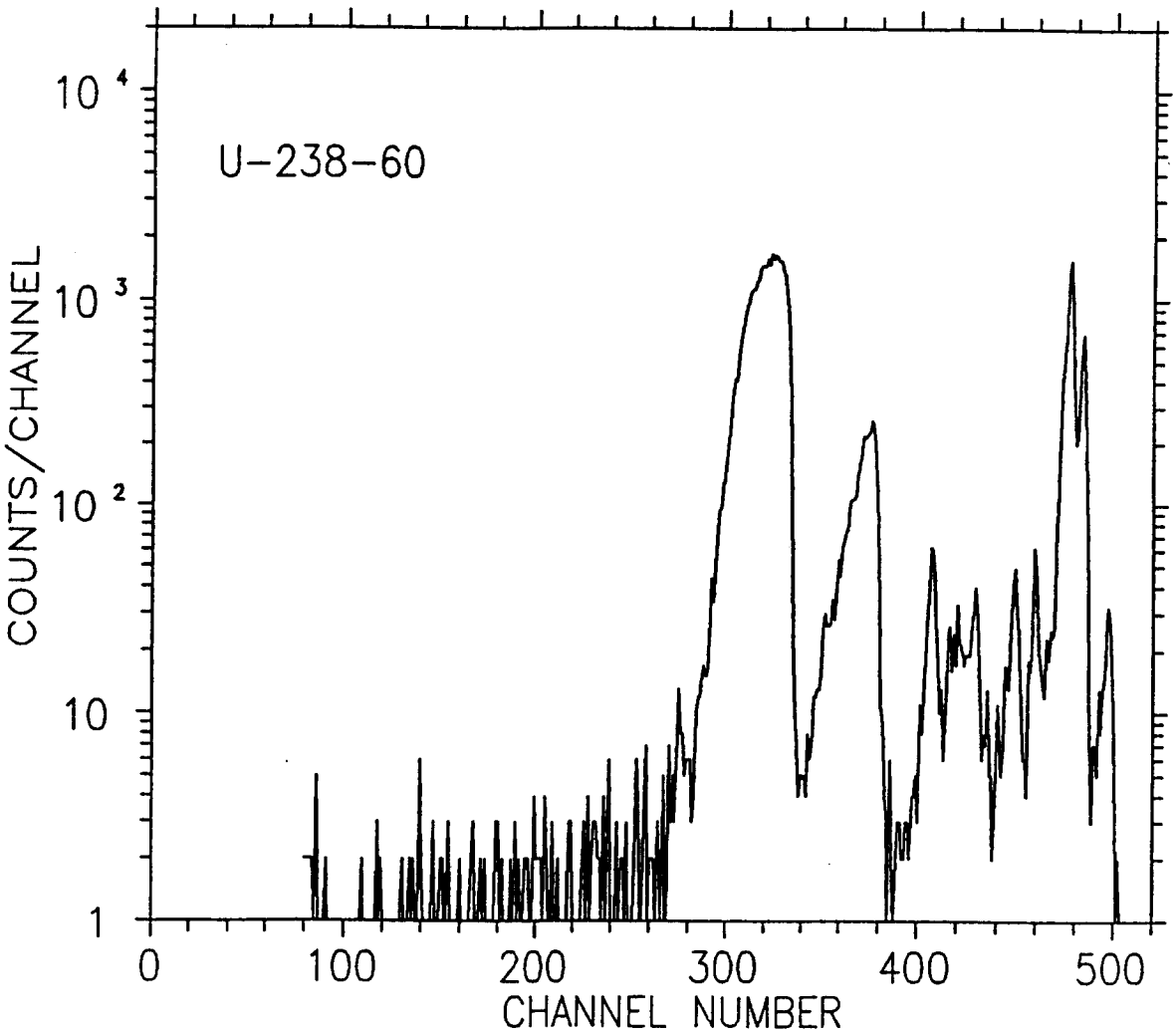

Fig. 5. The alpha spectrum of deposit U–238–60. The geometry factor is 221.0 and the live time is 329974 sec.

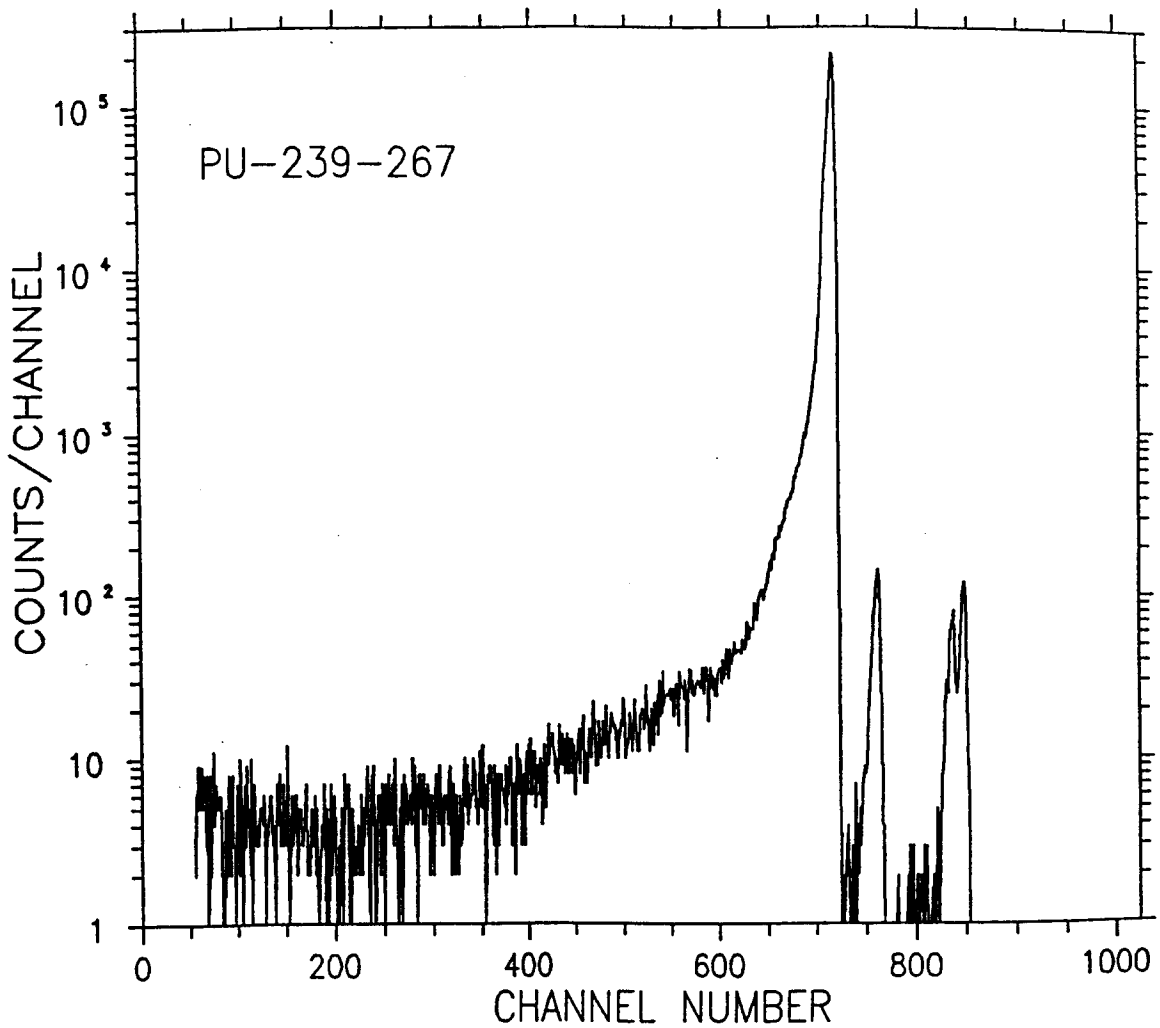

Fig. 6. The alpha spectrum of deposit Pu–239–267. The geometry factor is 2164 and the live time is 11089 sec.

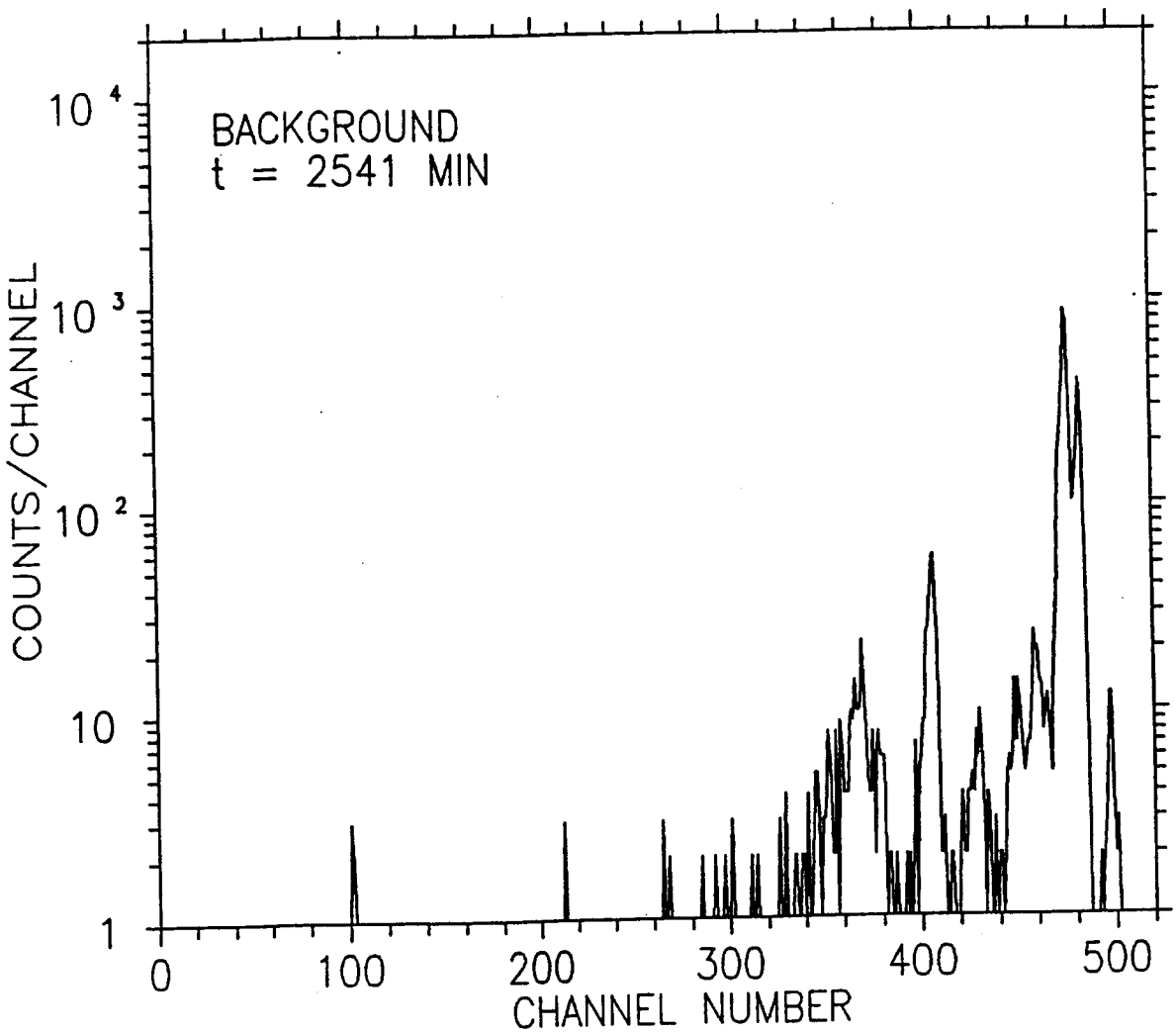

Fig. 7. A typical background spectrum. The live time is 152460 sec.

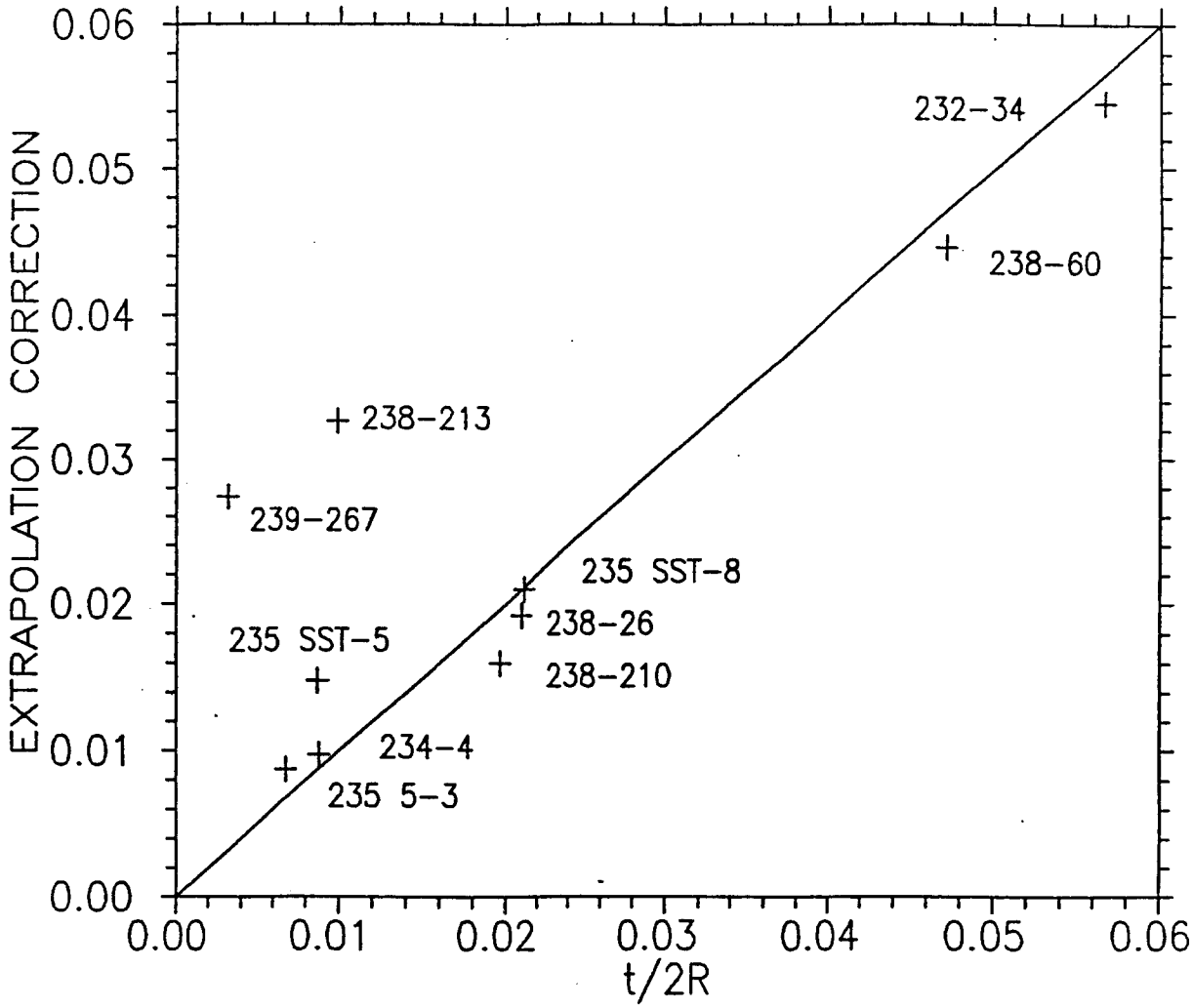

Fig. 8. The correlation of the fission spectrum extrapolation correction with the t/2R, the fraction of the fission lost in the deposit.

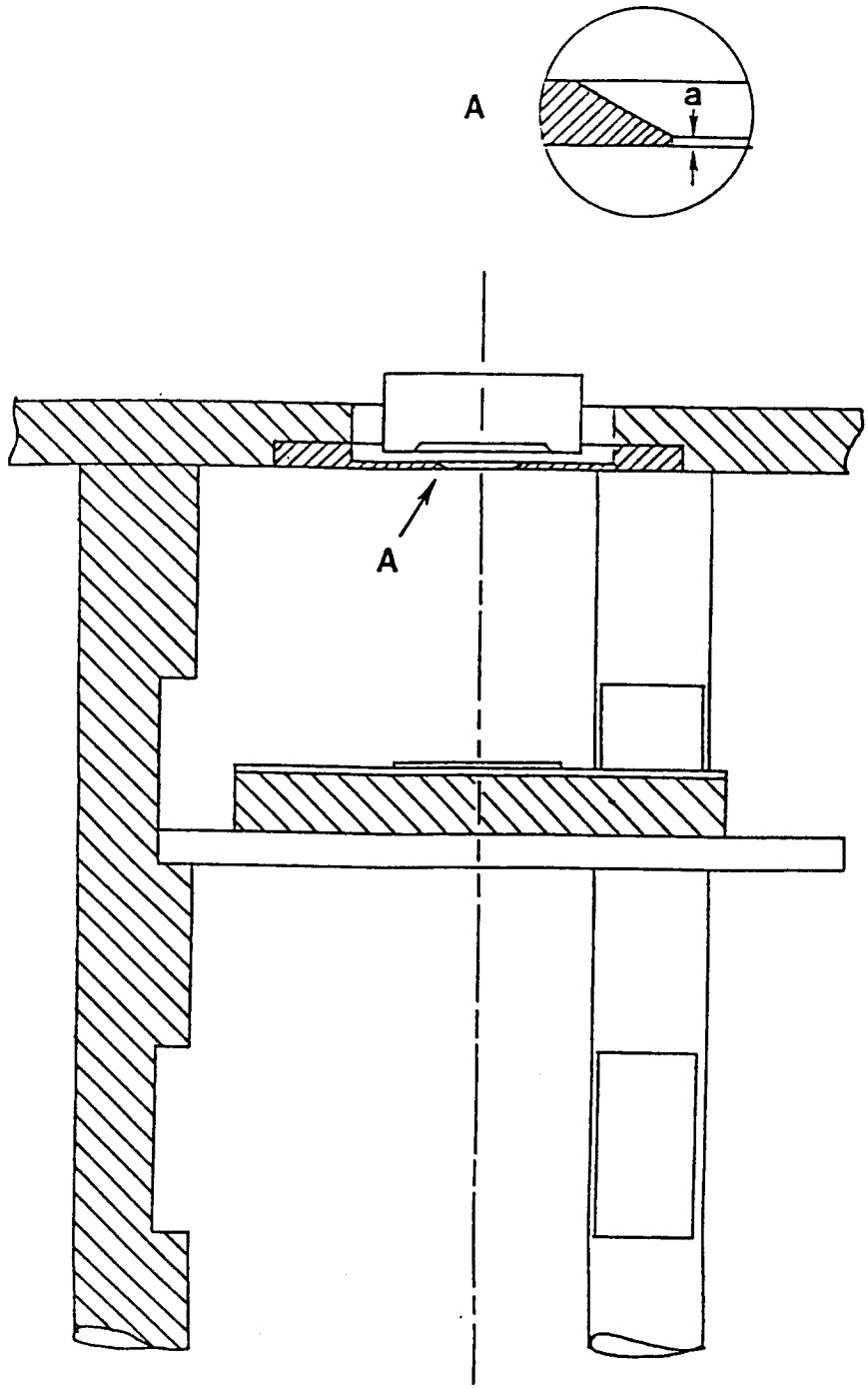

Fig. 9. A simplified diagram of the interior of the low geometry alpha counter. The vacuum chamber and the lower four counting positions are not shown. The drawing is approximately to scale, but the deposit thickness and the dimension "a" have been exaggerated.