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# Technical Equivalency Documentation for a Newly Acquired Alpha Spectroscopy System

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## **Introduction**

The response of a recently acquired Canberra™ Alpha Analyst ‘Blue’ system (Chamber #'s 173 – 208) used by the Hazards Control, Radiation Safety Section, WBC/Spectroscopy Team has been studied with respect to an existing Canberra system. The existing Canberra system consists of thirty Alpha Analyst dual chambers Model XXXX comprising a total of sixty detectors (Chambers #'s 101 – 124 and 137-172). The existing chambers were previously compared to an older system consisting of thirty-six Model 7401 alpha spectrometry chambers (Chamber #'s 1-36) Chambers 101 – 124 and 137-172 are DOELAP accredited. The older system was previously DOELAP accredited for the routine Alpha Spectroscopy program used in LLNL's *in vitro* bioassay program.

The newly acquired Alpha Analyst system operates on a network with software that controls and performs analysis of the current Alpha Analyst system (Chamber #'s 101 – 124 and 137 -172). This exact same software is used for the current system and the newly acquired system and is DOELAP accredited. This document compares results from the existing Alpha System with the newer Alpha Analyst system.

## **History**

The newly acquired Alpha Analyst system was acquired from the U.S. Department of Energy Mound Closure Project. Past usage of this system was largely unknown, however the Alpha Analyst technology is newer and has significant improvements over the older LLNL Alpha spectroscopy system consisting of thirty-six Model 7401 alpha spectrometry chambers. Upon receipt at LLNL, the newly acquired system was completely cleaned including the interior of the counting chambers and vacuum piping. Dust and dirt was removed from the top of and internal portions of the modular electrical components. All detectors from the system were replaced with new (unused) detectors. Polyvinyl tubing and rubber seal rings were also replaced to assure proper vacuum draw and minimal contamination from previous uses of the system. New vacuum pumps and oil filters were also installed onto the vacuum lines. The system connects to a VMS network containing the existing 60-chamber Alpha Analyst system.

## Methods

Standard quality control measures for the newly acquired Alpha Analyst “Blue” system were compared with the existing Alpha Analyst systems. Comparison of the following measures was performed: Pulser measurements; Background measurements; and Calibration/efficiency as measured with NIST traceable standards.

Compared parameters for the Pulser measurements were the full width half-maximum (FWHM), Energy, Centroid, and count rate. The average values of these parameters were compared to the Quality control limits established in Section 8.8.3 for the WBC/Spectroscopy procedures manual. Average values for these parameters on the older Alpha Spectroscopy system are also provided for comparison.

Compared parameters for the Background measurements were the average counts obtained for a 2.5 day background count in the Pu-239 and Am-241 regions. Background rates for both the older Alpha and newer Alpha Analyst systems are included in this report.

Comparison of Calibration parameters (Primes) was performed by evaluating the deviation of the average activity for the calibration source to the known activities. The average efficiencies were also compared.

Comparison counts of routine samples counts containing known quantities of internal tracer were performed on the existing Alpha system and on the newly acquired Alpha Analyst ‘Blue’ system (chamber #'s 173 – 208). Each individual AA detector has at least 7 comparative sample counts associated with different detectors from the ALPHA system. Parameters were compared with tracer data (Pu-242) and positive count data for Pu-239. Comparison of tracer data was evaluated by subsidiary Analysis of Variance (ANOVA) tests of individual detectors within the AA system.

Over 600 sample count comparisons were made.

## Conclusions

The Pulser FWHM, Centroid Energy, Centroid Channel, and Pulser rates for the existing Alpha systems and the 'Blue' Alpha Analyst system provide consistent results that are well within established limits for these parameters. Overall, the measured pulse rates for both systems are measured to within a few percent (Tables 1, 2, &3). This demonstrated stability in the pulser signal measurements indicates that the electronic portions of the system is stable from count period to count period.

The background for the newly acquired Alpha Analyst system is equal or lower than the background for the existing Alpha system (Tables 5 through 7). The background for the newly acquired Alpha Analyst is, for most chambers, equivalent to the background obtained from the 1 year-old "White" Alpha Analyst system.

The average computed activity when measuring the Prime calibration sources is typically a few percent of the known standard activity (Table 8). The average efficiency for the "Blue" Alpha Analyst system is equivalent to the efficiency obtained from the other Alpha Analyst systems. The average efficiency for all of the Alpha Analyst systems is slightly lower than the average efficiency observed for the older Alpha system (Table 9). This difference in efficiency could be due to the recoil suppression methodology employed by the Alpha Analyst system or due to slight differences in shelf distance from the source to the detector employed by each system. Regardless, the average efficiency of both systems is adequate to assure detection level (Lc) criteria established by the Internal Dosimetry Team.

Analyses of positive sample results are evaluated for measurements performed on the newly acquired Alpha Analyst System. There was a non-significant difference between the Alpha Analyst measurements for Pu-239 (Figure 1) and Pu-242 tracer with measurements of the same samples on the existing Alpha systems (see ANOVA result tables). There were sufficient numbers of comparative sample measurements that contained Pu-242 tracer to evaluate multiple detectors of the Alpha Analyst system with measurements of the same sample sets on detectors of the existing Alpha system. There was a non-significant difference between the Alpha Analyst measurements of Pu-242 and measurements of the same samples performed on existing Alpha Analyst systems (see ANOVA result tables). One detector (number 195) failed to demonstrate equivalent results for the Pu-242 tracer analysis. This detector will not be used until the cause is fully investigated and resolved.

## Results

Table 1. Pulsar Measurement Data – Newly Acquired Alpha Analyst System “Blue”

| ID                  | Avg. FWHM (keV) | 1s   | Avg. Energy (keV) | 1s   | Centroid Channel | 1s   | Rate (cps)  | 1s  |
|---------------------|-----------------|------|-------------------|------|------------------|------|-------------|-----|
| 173                 | 11.74           | 0.20 | 4985.4            | 6.0  | 507.0            | 3.5  | 41.5        | 0.2 |
| 174                 | 12.46           | 0.20 | 5000.4            | 4.3  | 508.2            | 3.4  | 41.5        | 0.1 |
| 175                 | 12.78           | 0.25 | 5007.9            | 1.4  | 500.0            | 3.6  | 41.5        | 0.1 |
| 176                 | 13.04           | 0.30 | 5009.1            | 2.3  | 505.6            | 3.4  | 41.5        | 0.1 |
| 177                 | 12.99           | 0.42 | 5017.8            | 2.0  | 500.1            | 3.6  | 41.5        | 0.1 |
| 178                 | 12.92           | 0.25 | 5024.3            | 1.8  | 503.6            | 3.5  | 41.5        | 0.1 |
| 179                 | 11.62           | 0.30 | 4994.4            | 4.7  | 507.1            | 3.5  | 41.5        | 0.1 |
| 180                 | 12.19           | 0.19 | 5000.2            | 0.9  | 510.1            | 2.9  | 41.5        | 0.1 |
| 181                 | 11.66           | 0.27 | 5007.1            | 1.0  | 501.2            | 3.5  | 41.4        | 0.1 |
| 182                 | 12.36           | 0.87 | 5004.5            | 1.4  | 504.5            | 3.3  | 41.5        | 0.2 |
| 183                 | 11.25           | 0.18 | 5002.4            | 1.8  | 500.8            | 3.5  | 41.5        | 0.1 |
| 184                 | 11.21           | 0.22 | 5012.0            | 2.2  | 504.6            | 0.1  | 41.5        | 0.2 |
| 185                 | 14.80           | 0.24 | 5021.2            | 3.2  | 500.5            | 3.9  | 41.5        | 0.1 |
| 186                 | 11.90           | 0.18 | 5031.1            | 2.7  | 504.6            | 4.0  | 41.5        | 0.1 |
| 187                 | 12.31           | 0.25 | 5014.8            | 2.5  | 498.6            | 4.0  | 41.5        | 0.1 |
| 188                 | 12.25           | 0.17 | 5017.5            | 1.3  | 504.1            | 4.0  | 41.5        | 0.1 |
| 189                 | 14.91           | 1.08 | 5014.7            | 4.9  | 494.9            | 4.0  | 41.5        | 0.1 |
| 190                 | 12.29           | 0.26 | 5027.0            | 2.6  | 502.8            | 4.2  | 41.5        | 0.1 |
| 191                 | 12.37           | 0.85 | 5019.9            | 8.4  | 499.1            | 6.7  | 41.4        | 0.2 |
| 192*                | 18.98           | 6.36 | 5038.6            | 42.2 | 503.3            | 12.5 | 40.7        | 5.4 |
| 193                 | 14.38           | 0.37 | 4981.2            | 4.4  | 501.9            | 4.1  | 41.5        | 0.1 |
| 194                 | 16.75           | 0.74 | 4993.8            | 3.93 | 504.0            | 4.0  | 41.5        | 0.1 |
| 195                 | 15.14           | 0.27 | 5011.4            | 1.7  | 500.6            | 3.7  | 41.5        | 0.1 |
| 196                 | 12.72           | 0.85 | 5008.5            | 1.6  | 501.1            | 3.9  | 41.5        | 0.1 |
| 197                 | 11.20           | 0.15 | 5017.5            | 1.6  | 504.2            | 0.2  | 41.5        | 0.2 |
| 198                 | 15.67           | 0.32 | 5023.6            | 1.4  | 508.7            | 0.2  | 41.5        | 0.1 |
| 199                 | 16.91           | 0.56 | 5009.9            | 1.4  | 501.1            | 0.2  | 41.5        | 0.1 |
| 200                 | 13.87           | 0.42 | 5019.0            | 1.8  | 500.4            | 0.2  | 41.5        | 0.1 |
| 201                 | 12.62           | 0.33 | 5008.9            | 1.8  | 499.2            | 1.2  | 41.5        | 0.2 |
| 202                 | 11.44           | 0.20 | 5015.1            | 3.6  | 505.3            | 0.4  | 41.5        | 0.1 |
| 203                 | 12.06           | 0.16 | 5013.9            | 1.0  | 498.6            | 0.2  | 41.5        | 0.1 |
| 204                 | 12.98           | 0.21 | 5009.1            | 1.0  | 501.5            | 0.2  | 41.5        | 0.1 |
| 205                 | 11.49           | 0.16 | 4979.3            | 5.5  | 494.1            | 1.3  | 41.5        | 0.1 |
| 206                 | 11.47           | 0.15 | 4980.2            | 7.5  | 497.0            | 2.3  | 41.4        | 0.2 |
| 207                 | 16.66           | 2.51 | 5007.3            | 13.6 | 502.2            | 1.1  | 41.4        | 0.2 |
| 208                 | 11.28           | 0.32 | 4999.6            | 7.3  | 504.1            | 0.7  | 41.4        | 0.2 |
| Established Limits: | 8 - 20 keV      |      | 4900 - 5100 keV   |      | 480 - 540 keV    |      | 39 - 43 cps |     |

\* Detector was replaced. Data shown is a combination of old detector and new detector data.

Table 2. Pulsar Measurement comparison – Older Alpha System<sup>1</sup>

| ID                  | Avg. FWHM (keV) |       | Avg. Energy (keV) |        | Centroid Channel |        | Rate (cps)    |       |
|---------------------|-----------------|-------|-------------------|--------|------------------|--------|---------------|-------|
|                     |                 | 1s    |                   | 1s     |                  | 1s     |               | 1s    |
| 1                   | 10.7            | ± 0.5 | 4990.1            | ± 4.4  | 504.1            | ± 1.1  | 509           | ± 2.6 |
| 2                   | 12.2            | ± 0.3 | 5031.2            | ± 3.4  | 519.2            | ± 1.3  | 498.5         | ± 0.3 |
| 3                   | 14              | ± 3.2 | 4995.5            | ± 5.9  | 502.8            | ± 1.5  | 511.7         | ± 0.3 |
| 4                   | 12.2            | ± 0.4 | 4999.3            | ± 3.2  | 508.7            | ± 1.1  | 514.7         | ± 0.4 |
| 5                   | 11.4            | ± 0.2 | 5042.8            | ± 4.4  | 521.9            | ± 1.9  | 495.7         | ± 0.3 |
| 6                   | 11.5            | ± 0.3 | 4996.6            | ± 3.8  | 502.8            | ± 1    | 508.3         | ± 0.3 |
| 7                   | 11.6            | ± 0.3 | 5006.8            | ± 4    | 506              | ± 1.2  | 506.6         | ± 1.2 |
| 8                   | 10.8            | ± 1.8 | 5058.7            | ± 4.5  | 528.3            | ± 6.4  | 511           | ± 1.5 |
| 9                   | 10.9            | ± 0.3 | 4967.1            | ± 4.3  | 500.8            | ± 3.6  | 511.1         | ± 1.4 |
| 10                  | 11              | ± 0.4 | 5043.9            | ± 7.7  | 517.1            | ± 2.2  | 493.9         | ± 1.6 |
| 11                  | 12.8            | ± 1.2 | 5049.5            | ± 5.1  | 521.5            | ± 1.2  | 510.3         | ± 3   |
| 12                  | 11.5            | ± 1   | 4982.9            | ± 10.6 | 501.9            | ± 1.8  | 512           | ± 0.4 |
| 13                  | 10.9            | ± 2.9 | 5014.3            | ± 27.4 | 515.3            | ± 12.5 | 500           | ± 0.3 |
| 14                  | 13.2            | ± 0.1 | 4987.4            | ± 5.1  | 506.9            | ± 1    | 509.9         | ± 0.3 |
| 15                  | 14.6            | ± 2.4 | 5049.4            | ± 8.1  | 521.4            | ± 5    | 499.7         | ± 2.3 |
| 16                  | 13.5            | ± 3   | 5054.2            | ± 8.8  | 517.1            | ± 10.5 | 503.9         | ± 17  |
| 17                  | 12.2            | ± 0.5 | 4967              | ± 5    | 494.7            | ± 1.6  | 511.6         | ± 0.7 |
| 18                  | 16.9            | ± 2.4 | 4992.4            | ± 9.6  | 508.1            | ± 4.3  | 509.1         | ± 1.7 |
| 19                  | 11.3            | ± 3.3 | 5050.3            | ± 9.2  | 520.1            | ± 3.2  | 510           | ± 3.7 |
| 20                  | 11.5            | ± 0.2 | 4954.7            | ± 2.7  | 510.3            | ± 0.6  | 510.7         | ± 0.3 |
| 21                  | 11.6            | ± 0.2 | 5044.5            | ± 2    | 507.6            | ± 0.7  | 498.5         | ± 0.3 |
| 22                  | 12.2            | ± 1   | 5048.7            | ± 8.4  | 523.7            | ± 0.9  | 500.8         | ± 0.6 |
| 23                  | 14.1            | ± 0.8 | 4989.8            | ± 4    | 503.2            | ± 2    | 502.5         | ± 2.4 |
| 24                  | 12.9            | ± 1.5 | 5002.3            | ± 4.7  | 510              | ± 0.8  | 506.1         | ± 0.3 |
| 25                  | 13.9            | ± 0.2 | 4962.7            | ± 44.9 | 503.9            | ± 1.8  | 501.7         | ± 0.3 |
| 26                  | 10.9            | ± 0.2 | 5058.9            | ± 4.8  | 522.7            | ± 1.9  | 513.1         | ± 0.6 |
| 27                  | 14.2            | ± 0.4 | 5051.7            | ± 5.1  | 521.2            | ± 1.7  | 508.2         | ± 0.8 |
| 28                  | 14.4            | ± 2.4 | 4983.6            | ± 5.6  | 500.5            | ± 2.3  | 151.9         | ± 0.5 |
| 29                  | 11.9            | ± 2.4 | 4969.2            | ± 5.2  | 495.8            | ± 1    | 510.1         | ± 0.4 |
| 30                  | 10.2            | ± 0.3 | 5057.8            | ± 5.7  | 522.7            | ± 1.5  | 505.2         | ± 0.5 |
| 31                  | 11              | ± 0.3 | 5064.1            | ± 9.7  | 520.7            | ± 3.1  | 518.4         | ± 0.4 |
| 32                  | 12.9            | ± 2.1 | 4974.4            | ± 6.9  | 496.3            | ± 1.2  | 510.3         | ± 1.2 |
| 33                  | 13.6            | ± 1.3 | 4994              | ± 3.9  | 506.6            | ± 1.7  | 503.4         | ± 1.2 |
| 34                  | 11.7            | ± 0.2 | 5029.7            | ± 50   | 518.6            | ± 16.4 | 502.4         | ± 0.3 |
| 35                  | 12.1            | ± 1.3 | 5051.2            | ± 6.7  | 520.4            | ± 4.2  | 515.3         | ± 2   |
| 36                  | 12.4            | ± 0.2 | 4966.4            | ± 5    | 498.6            | ± 1.2  | 509.1         | ± 0.3 |
| Established Limits: | 8 - 20 keV      |       | 4900 - 5100 keV   |        | 480 - 540 keV    |        | 475 - 525 cps |       |

<sup>1</sup> The pulsar rate for this system is different due to the different clock speeds of the pulse generator contained in each system.

Table 3. Pulsar Measurement comparison – “Red” Alpha Analyst System

| ID                  | Avg. FWHM  |       | Avg. Energy     |        | Centroid Channel | Rate (cps) |             |  |
|---------------------|------------|-------|-----------------|--------|------------------|------------|-------------|--|
|                     | (keV)      | 1s    | (keV)           | 1s     |                  | 1s         | 1s          |  |
| 101                 | 11         | ± 0.2 | 5048.5          | ± 0.8  | 514.7            | ± 0.2      | 41.5 ± 0.2  |  |
| 102                 | 11.1       | ± 0.2 | 4044.1          | ± 0.9  | 513.8            | ± 0.1      | 41.5 ± 0.2  |  |
| 103                 | 11         | ± 0.1 | 4997.3          | ± 0.6  | 513              | ± 0.2      | 41.5 ± 0.2  |  |
| 104                 | 11.4       | ± 0.2 | 4993.7          | ± 1.2  | 513.8            | ± 0.1      | 41.5 ± 0.1  |  |
| 105                 | 12.1       | ± 0.3 | 4996.6          | ± 1    | 509.9            | ± 0.1      | 41.5 ± 0.1  |  |
| 106                 | 11.6       | ± 0.2 | 4990.7          | ± 0.9  | 511.7            | ± 0.1      | 41.5 ± 0.1  |  |
| 107                 | 12.4       | ± 0.8 | 4997.8          | ± 1.1  | 508.9            | ± 0.1      | 41.5 ± 0.1  |  |
| 108                 | 11         | ± 0.2 | 4986.2          | ± 1    | 513.1            | ± 0.1      | 41.5 ± 0.1  |  |
| 109                 | 11.2       | ± 0.2 | 4981.9          | ± 0.7  | 513.8            | ± 0.2      | 41.5 ± 0.1  |  |
| 110                 | 11.2       | ± 0.2 | 4979.6          | ± 1.4  | 514              | ± 0.2      | 41.5 ± 0.1  |  |
| 111                 | 11.4       | ± 0.1 | 4981.3          | ± 0.9  | 511.2            | ± 0.2      | 41.5 ± 0.1  |  |
| 112                 | 11.2       | ± 0.2 | 1973.9          | ± 0.8  | 512.2            | ± 0.1      | 41.5 ± 0.1  |  |
| 113                 | 16.9       | ± 0.3 | 4991            | ± 0.5  | 502.8            | ± 0.2      | 41.5 ± 0.2  |  |
| 114                 | 11.3       | ± 0.2 | 4993            | ± 1.1  | 505.6            | ± 0.2      | 41.5 ± 0.1  |  |
| 115                 | 11.1       | ± 0.2 | 4993.4          | ± 0.6  | 503.3            | ± 0.2      | 41.5 ± 0.1  |  |
| 116                 | 12.2       | ± 0.2 | 5000.8          | ± 1.4  | 505.2            | ± 0.2      | 41.5 ± 0.1  |  |
| 117                 | 14.6       | ± 0.3 | 5003.6          | ± 0.7  | 507.5            | ± 0.2      | 41.5 ± 0.2  |  |
| 118                 | 13.8       | ± 1.6 | 4991.8          | ± 3.8  | 506.5            | ± 0.3      | 41.5 ± 0.1  |  |
| 119                 | 13.3       | ± 0.2 | 4996.2          | ± 1.7  | 504.9            | ± 0.3      | 41.5 ± 0.1  |  |
| 120                 | 12.2       | ± 0.2 | 5000.0          | ± 1.3  | 506.1            | ± 0.1      | 41.5 ± 0.1  |  |
| 121                 | 11.1       | ± 0.2 | 5014.0          | ± 40.3 | 492.4            | ± 5.5      | 41.4 ± .02  |  |
| 122                 | 11.8       | ± 0.2 | 4982.8          | ± 1.8  | 508.1            | ± 0.2      | 41.5 ± 0.1  |  |
| 123                 | 16.1       | ± 0.7 | 4986.1          | ± 1.7  | 503.5            | ± 0.3      | 41.5 ± 0.1  |  |
| 124                 | 13.2       | ± 0.2 | 4980.5          | ± 1.5  | 503              | ± 0.1      | 41.5 ± 0.1  |  |
| Established Limits: | 8 - 20 keV |       | 4900 - 5100 keV |        | 480 - 540 keV    |            | 39 - 43 cps |  |



Table 4. Pulsar Measurement comparison – ‘White’ Alpha Analyst System

| ID                  | Avg. FWHM (keV) |       | Avg. Energy (keV) |        | Centroid Channel |       | Rate (cps)  |       |
|---------------------|-----------------|-------|-------------------|--------|------------------|-------|-------------|-------|
|                     |                 | 1s    |                   | 1s     |                  | 1s    |             | 1s    |
| 137                 | 13              | ± 0.2 | 4993.8            | ± 9.3  | 521.1            | ± 1.3 | 41.6        | ± 0.1 |
| 138                 | 13.3            | ± 0.3 | 5002.9            | ± 8    | 529.7            | ± 0.5 | 41.5        | ± 0.1 |
| 139                 | 11.2            | ± 0.3 | 5014.8            | ± 8.7  | 523.5            | ± 0.9 | 41.6        | ± 0.1 |
| 140                 | 11.5            | ± 0.2 | 5018.5            | ± 8    | 529.8            | ± 0.4 | 41.6        | ± 0.1 |
| 141                 | 11.5            | ± 0.2 | 5022.1            | ± 10.2 | 531.9            | ± 0.3 | 41.6        | ± 0.1 |
| 142                 | 11.6            | ± 0.2 | 5011.2            | ± 6.7  | 530.4            | ± 0.2 | 41.6        | ± 0.1 |
| 143                 | 11.3            | ± 0.2 | 5000.3            | ± 13.9 | 527.4            | ± 0.2 | 41.6        | ± 0.1 |
| 144                 | 10.9            | ± 0.2 | 5004.1            | ± 9.8  | 530.9            | ± 0.2 | 41.6        | ± 0.1 |
| 145                 | 11              | ± 0.2 | 4946              | ± 3.5  | 499              | ± 0.2 | 41.6        | ± 0.1 |
| 146                 | 11.1            | ± 0.2 | 4998.1            | ± 5.7  | 519.3            | ± 0.2 | 41.6        | ± 0.1 |
| 147                 | 11.14           | ± 0.2 | 4981              | ± 8.1  | 512.1            | ± 0.9 | 41.6        | ± 0.1 |
| 148                 | 11.23           | ± 0.2 | 4980.4            | ± 3.1  | 512.8            | ± 0.2 | 41.6        | ± 0.1 |
| 149                 | 11              | ± 0.2 | 4994.3            | ± 3.1  | 517.4            | ± 0.1 | 41.5        | ± 0.1 |
| 150                 | 11.01           | ± 0.2 | 5003.7            | ± 4.3  | 520.4            | ± 0.1 | 41.5        | ± 0.1 |
| 151                 | 10.8            | ± 0.3 | 4986              | ± 7.8  | 520.5            | ± 0.3 | 41.5        | ± 0.1 |
| 152                 | 10.8            | ± 0.2 | 4993.2            | ± 7.7  | 519.7            | ± 0.2 | 41.5        | ± 0.1 |
| 153                 | 10.8            | ± 0.2 | 4991.1            | ± 10.9 | 518.6            | ± 0.1 | 41.5        | ± 0.3 |
| 154                 | 10.8            | ± 0.2 | 4992.3            | ± 9.4  | 521.6            | ± 0.1 | 41.5        | ± 0.1 |
| 155                 | 11.3            | ± 0.5 | 5031.5            | ± 0.9  | 526.0            | ± 0.3 | 41.5        | ± 0.1 |
| 156                 | 11.7            | ± 0.2 | 5023.2            | ± 8.4  | 524.8            | ± 0.2 | 41.5        | ± 0.1 |
| 157                 | 11.9            | ± 0.2 | 5003.7            | ± 11   | 521.8            | ± 0.1 | 41.5        | ± 0.2 |
| 158                 | 11.16           | ± 0.1 | 5008.4            | ± 10.4 | 524.6            | ± 0.2 | 41.5        | ± 0.1 |
| 159                 | 10.95           | ± 0.2 | 4992.4            | ± 8.3  | 524.1            | ± 0.1 | 41.5        | ± 0.1 |
| 160                 | 11.16           | ± 0.2 | 4995.5            | ± 6.1  | 522.5            | ± 0.2 | 41.5        | ± 0.1 |
| 161                 | 11.52           | ± 0.2 | 5006.5            | ± 4.2  | 520.8            | ± 0.2 | 41.5        | ± 0.1 |
| 162                 | 11.58           | ± 0.2 | 5018.5            | ± 4.7  | 523.4            | ± 0.2 | 41.5        | ± 0.1 |
| 163                 | 11.37           | ± 0.2 | 5014.3            | ± 8.9  | 520.8            | ± 0.1 | 41.5        | ± 0.1 |
| 164                 | 11.35           | ± 0.2 | 5026.4            | ± 8.2  | 529.1            | ± 0.1 | 41.6        | ± 0.1 |
| 165                 | 11.53           | ± 0.2 | 4996.5            | ± 3.7  | 527.9            | ± 0.3 | 41.6        | ± 0.1 |
| 166                 | 11.54           | ± 0.2 | 4996.3            | ± 8.9  | 529.4            | ± 0.2 | 41.6        | ± 0.1 |
| 167                 | 12.1            | ± 0.3 | 5018.9            | ± 7.8  | 522.4            | ± 0.1 | 41.6        | ± 0.1 |
| 168                 | 11.46           | ± 0.2 | 5017.3            | ± 3.8  | 524.9            | ± 0.2 | 41.6        | ± 0.1 |
| 169                 | 11.52           | ± 0.2 | 5002.8            | ± 5.1  | 522.8            | ± 0.3 | 41.6        | ± 0.1 |
| 170                 | 11.33           | ± 0.2 | 5007.3            | ± 1.4  | 521.1            | ± 0.2 | 41.5        | ± 0.1 |
| 171                 | 11.53           | ± 0.2 | 5007.7            | ± 3    | 519.8            | ± 0.2 | 41.5        | ± 0.1 |
| 172                 | 11.61           | ± 0.2 | 5004.1            | ± 3.7  | 520.9            | ± 0.2 | 41.5        | ± 0.1 |
| Established Limits: | 8 - 20 keV      |       | 4900 - 5100 keV   |        | 480 - 540 keV    |       | 39 - 43 cps |       |

Table 5. Average background for Alpha Analyst Systems (counts per 2.5 days).

| Alpha Analyst "Red" System |        |   |     |        |   | Alpha Analyst "Blue" System |          |        |   |     |        |   |     |
|----------------------------|--------|---|-----|--------|---|-----------------------------|----------|--------|---|-----|--------|---|-----|
| Detector                   | Pu-239 | ± | 1s  | Am-241 | ± | 1s                          | Detector | Pu-239 | ± | 1s  | Am-241 | ± | 1s  |
| 101                        | 1.2    | ± | 1.2 | 0.7    | ± | 0.9                         | 173      | 1.1    | ± | 1.0 | 0.9    | ± | 1.0 |
| 102                        | 1.1    | ± | 1.2 | 0.8    | ± | 1.1                         | 174      | 0.8    | ± | 0.8 | 0.9    | ± | 0.8 |
| 103                        | 0.9    | ± | 1.1 | 0.8    | ± | 0.9                         | 175      | 1.8    | ± | 1.2 | 0.8    | ± | 0.9 |
| 104                        | 1.0    | ± | 1.1 | 0.8    | ± | 1.0                         | 176      | 0.8    | ± | 1.0 | 0.8    | ± | 0.9 |
| 105                        | 1.0    | ± | 1.0 | 0.3    | ± | 0.5                         | 177      | 1.1    | ± | 0.9 | 0.6    | ± | 0.8 |
| 106                        | 1.1    | ± | 1.0 | 0.8    | ± | 0.8                         | 178      | 1.6    | ± | 1.5 | 0.8    | ± | 1.1 |
| 107                        | 0.8    | ± | 0.9 | 0.4    | ± | 0.6                         | 179      | 0.9    | ± | 1.0 | 1.2    | ± | 1.1 |
| 108                        | 1.0    | ± | 1.0 | 0.8    | ± | 0.9                         | 180      | 1.9    | ± | 1.8 | 1.4    | ± | 0.9 |
| 109                        | 1.2    | ± | 1.2 | 0.8    | ± | 0.8                         | 181      | 1.2    | ± | 1.0 | 0.6    | ± | 0.7 |
| 110                        | 0.8    | ± | 1.0 | 0.9    | ± | 0.9                         | 182      | 2.0    | ± | 1.8 | 1.1    | ± | 1.0 |
| 111                        | 1.2    | ± | 1.2 | 0.7    | ± | 0.9                         | 183      | 1.1    | ± | 1.1 | 0.8    | ± | 0.8 |
| 112                        | 1.2    | ± | 1.0 | 0.8    | ± | 0.8                         | 184      | 1.3    | ± | 0.8 | 0.8    | ± | 0.8 |
| 113                        | 1.0    | ± | 1.2 | 0.8    | ± | 1.0                         | 185      | 0.9    | ± | 1.1 | 1.2    | ± | 0.6 |
| 114                        | 1.2    | ± | 1.0 | 0.7    | ± | 0.9                         | 186      | 0.9    | ± | 1.0 | 1.4    | ± | 0.6 |
| 115                        | 1.0    | ± | 1.2 | 0.9    | ± | 1.0                         | 187      | 0.7    | ± | 0.7 | 0.6    | ± | 1.0 |
| 116                        | 0.9    | ± | 1.0 | 0.4    | ± | 0.5                         | 188      | 1.2    | ± | 1.2 | 1.1    | ± | 0.9 |
| 117                        | 1.5    | ± | 1.1 | 0.6    | ± | 0.7                         | 189      | 1.2    | ± | 1.0 | 0.8    | ± | 0.7 |
| 118                        | 1.4    | ± | 1.3 | 0.8    | ± | 1.1                         | 190      | 1.1    | ± | 1.2 | 0.8    | ± | 1.1 |
| 119                        | 1.1    | ± | 1.0 | 0.5    | ± | 0.6                         | 191      | 2.0    | ± | 1.6 | 0.4    | ± | 1.2 |
| 120                        | 1.1    | ± | 1.2 | 0.5    | ± | 0.8                         | 192      | 1.1    | ± | 1.0 | 0.4    | ± | 0.7 |
| 121                        | 1.1    | ± | 1.2 | 1.2    | ± | 1.1                         | 193      | 0.9    | ± | 1.0 | 1.0    | ± | 1.2 |
| 122                        | 1.3    | ± | 0.9 | 1.0    | ± | 0.9                         | 194      | 1.3    | ± | 0.9 | 0.8    | ± | 1.0 |
| 123                        | 1.6    | ± | 1.5 | 1.1    | ± | 1.0                         | 195      | 0.4    | ± | 0.7 | 0.6    | ± | 0.8 |
| 124                        | 1.3    | ± | 1.1 | 0.6    | ± | 0.7                         | 196      | 1.2    | ± | 0.9 | 1.1    | ± | 0.9 |
|                            |        |   |     |        |   |                             | 197      | 2.2    | ± | 1.5 | 1.1    | ± | 0.9 |
|                            |        |   |     |        |   |                             | 198      | 0.4    | ± | 0.6 | 0.5    | ± | 0.6 |
|                            |        |   |     |        |   |                             | 199      | 0.8    | ± | 1.0 | 0.7    | ± | 0.9 |
|                            |        |   |     |        |   |                             | 200      | 1.7    | ± | 1.4 | 1.1    | ± | 1.3 |
|                            |        |   |     |        |   |                             | 201      | 2.0    | ± | 1.3 | 1.3    | ± | 1.0 |
|                            |        |   |     |        |   |                             | 202      | 0.9    | ± | 0.9 | 0.5    | ± | 0.6 |
|                            |        |   |     |        |   |                             | 203      | 1.4    | ± | 1.1 | 0.6    | ± | 0.9 |
|                            |        |   |     |        |   |                             | 204      | 0.5    | ± | 0.5 | 1.0    | ± | 1.1 |
|                            |        |   |     |        |   |                             | 205      | 1.1    | ± | 1.0 | 0.8    | ± | 1.1 |
|                            |        |   |     |        |   |                             | 206      | 1.2    | ± | 1.1 | 0.6    | ± | 1.0 |
|                            |        |   |     |        |   |                             | 207      | 1.1    | ± | 1.2 | 0.8    | ± | 1.0 |
|                            |        |   |     |        |   |                             | 208      | 1.1    | ± | 1.2 | 0.7    | ± | 1.0 |

Table 6. Average background for Alpha Analyst Systems (counts per 2.5 days).

| Alpha Analyst "Red" System |        |   |     |        |   | Alpha Analyst "White" System |          |        |   |     |        |   |     |
|----------------------------|--------|---|-----|--------|---|------------------------------|----------|--------|---|-----|--------|---|-----|
| Detector                   | Pu-239 | ± | 1s  | Am-241 | ± | 1s                           | Detector | Pu-239 | ± | 1s  | Am-241 | ± | 1s  |
| 101                        | 1.2    | ± | 1.2 | 0.7    | ± | 0.9                          | 137      | 0.8    | ± | 1   | 0.6    | ± | 0.9 |
| 102                        | 1.1    | ± | 1.2 | 0.8    | ± | 1.1                          | 138      | 0.8    | ± | 1.1 | 1.5    | ± | 1.6 |
| 103                        | 0.9    | ± | 1.1 | 0.8    | ± | 0.9                          | 139      | 1.0    | ± | 0.9 | 0.6    | ± | 0.7 |
| 104                        | 1.0    | ± | 1.1 | 0.8    | ± | 1.0                          | 140      | 0.7    | ± | 0.8 | 0.6    | ± | 0.7 |
| 105                        | 1.0    | ± | 1.0 | 0.3    | ± | 0.5                          | 141      | 1.2    | ± | 1.2 | 1      | ± | 1   |
| 106                        | 1.1    | ± | 1.0 | 0.8    | ± | 0.8                          | 142      | 0.8    | ± | 0.7 | 0.9    | ± | 1.1 |
| 107                        | 0.8    | ± | 0.9 | 0.4    | ± | 0.6                          | 143      | 0.6    | ± | 0.8 | 3.4    | ± | 3.2 |
| 108                        | 1.0    | ± | 1.0 | 0.8    | ± | 0.9                          | 144      | 0.5    | ± | 0.8 | 0.5    | ± | 0.7 |
| 109                        | 1.2    | ± | 1.2 | 0.8    | ± | 0.8                          | 145      | 1.1    | ± | 1   | 1      | ± | 1.2 |
| 110                        | 0.8    | ± | 1.0 | 0.9    | ± | 0.9                          | 146      | 1.1    | ± | 0.8 | 1.2    | ± | 1.1 |
| 111                        | 1.2    | ± | 1.2 | 0.7    | ± | 0.9                          | 147      | 0.9    | ± | 1   | 1.1    | ± | 1.1 |
| 112                        | 1.2    | ± | 1.0 | 0.8    | ± | 0.8                          | 148      | 1.1    | ± | 1.2 | 0.8    | ± | 0.8 |
| 113                        | 1.0    | ± | 1.2 | 0.8    | ± | 1.0                          | 149      | 2.1    | ± | 1.6 | 3.7    | ± | 4.2 |
| 114                        | 1.2    | ± | 1.0 | 0.7    | ± | 0.9                          | 150      | 1.4    | ± | 0.7 | 0.8    | ± | 0.6 |
| 115                        | 1.0    | ± | 1.2 | 0.9    | ± | 1.0                          | 151      | 1.4    | ± | 1.5 | 1.3    | ± | 1.4 |
| 116                        | 0.9    | ± | 1.0 | 0.4    | ± | 0.5                          | 152      | 2.3    | ± | 1.9 | 1.2    | ± | 1.4 |
| 117                        | 1.5    | ± | 1.1 | 0.6    | ± | 0.7                          | 153      | 1.4    | ± | 1.9 | 1.3    | ± | 1.8 |
| 118                        | 1.4    | ± | 1.3 | 0.8    | ± | 1.1                          | 154      | 0.9    | ± | 0.9 | 1.5    | ± | 1.6 |
| 119                        | 1.1    | ± | 1.0 | 0.5    | ± | 0.6                          | 155      | 1.1    | ± | 1.5 | 0.6    | ± | 0.8 |
| 120                        | 1.1    | ± | 1.2 | 0.5    | ± | 0.8                          | 156      | 1.0    | ± | 0.9 | 0.7    | ± | 0.9 |
| 121                        | 1.1    | ± | 1.2 | 1.2    | ± | 1.1                          | 157      | 1.8    | ± | 1.2 | 0.8    | ± | 0.8 |
| 122                        | 1.3    | ± | 0.9 | 1.0    | ± | 0.9                          | 158      | 0.6    | ± | 0.8 | 1.2    | ± | 1.2 |
| 123                        | 1.6    | ± | 1.5 | 1.1    | ± | 1.0                          | 159      | 0.9    | ± | 0.8 | 0.5    | ± | 0.7 |
| 124                        | 1.3    | ± | 1.1 | 0.6    | ± | 0.7                          | 160      | 0.8    | ± | 0.9 | 0.3    | ± | 0.6 |
|                            |        |   |     |        |   |                              | 161      | 1.3    | ± | 1.2 | 0.9    | ± | 1.1 |
|                            |        |   |     |        |   |                              | 162      | 0.9    | ± | 0.9 | 0.7    | ± | 1   |
|                            |        |   |     |        |   |                              | 163      | 1.5    | ± | 1.2 | 1.5    | ± | 1.5 |
|                            |        |   |     |        |   |                              | 164      | 1.3    | ± | 1.1 | 0.6    | ± | 0.9 |
|                            |        |   |     |        |   |                              | 165      | 0.7    | ± | 1   | 1      | ± | 1   |
|                            |        |   |     |        |   |                              | 166      | 0.8    | ± | 0.9 | 0.7    | ± | 0.9 |
|                            |        |   |     |        |   |                              | 167      | 0.9    | ± | 1.1 | 0.4    | ± | 0.8 |
|                            |        |   |     |        |   |                              | 168      | 0.6    | ± | 0.8 | 0.9    | ± | 1.1 |
|                            |        |   |     |        |   |                              | 169      | 0.6    | ± | 0.8 | 0.7    | ± | 0.8 |
|                            |        |   |     |        |   |                              | 170      | 0.6    | ± | 0.8 | 0.6    | ± | 0.6 |
|                            |        |   |     |        |   |                              | 171      | 1.2    | ± | 1   | 1      | ± | 0.9 |
|                            |        |   |     |        |   |                              | 172      | 1.1    | ± | 1.3 | 0.7    | ± | 0.9 |

Table 7. Average background for Older Alpha System (counts per 2.5 days)<sup>2</sup>.

| Detector | Pu-239 | 1s    | Am-241 | 1s    |
|----------|--------|-------|--------|-------|
| 1        | 4.7    | ± 2.5 | 3.5    | ± 2.5 |
| 2        | 4.5    | ± 3.2 | 4.1    | ± 3.0 |
| 3        | 4.3    | ± 2.5 | 3.2    | ± 2.4 |
| 4        | 4.1    | ± 2.7 | 3.6    | ± 4.2 |
| 5        | 3.5    | ± 2.1 | 3.2    | ± 2.3 |
| 6        | 5.1    | ± 2.6 | 4.2    | ± 3.0 |
| 7        | 3.2    | ± 2.8 | 3.6    | ± 2.5 |
| 8        | 4.0    | ± 2.6 | 4.7    | ± 3.0 |
| 9        | 3.7    | ± 2.2 | 3.0    | ± 2.2 |
| 10       | 3.5    | ± 2.5 | 3.4    | ± 2.7 |
| 11       | 3.5    | ± 2.5 | 3.4    | ± 2.7 |
| 12       | 3.8    | ± 2.9 | 3.6    | ± 2.8 |
| 13       | 3.4    | ± 2.1 | 3.7    | ± 2.3 |
| 14       | 3.3    | ± 2.3 | 2.8    | ± 2.1 |
| 15       | 4.4    | ± 2.7 | 3.7    | ± 2.8 |
| 16       | 3.6    | ± 2.6 | 3.0    | ± 2.2 |
| 17       | 3.8    | ± 2.9 | 3.3    | ± 2.6 |
| 18       | 5.0    | ± 3.1 | 4.1    | ± 2.7 |
| 19       | 4.6    | ± 3.4 | 4.5    | ± 3.2 |
| 20       | 4.0    | ± 2.9 | 3.5    | ± 2.5 |
| 21       | 2.8    | ± 2.2 | 2.7    | ± 2.3 |
| 22       | 4.1    | ± 2.4 | 3.9    | ± 2.2 |
| 23       | 4.0    | ± 2.8 | 4.1    | ± 2.8 |
| 24       | 3.9    | ± 2.5 | 5.4    | ± 2.8 |
| 25       | 3.2    | ± 2.2 | 2.4    | ± 2.0 |
| 26       | 4.5    | ± 2.9 | 4.2    | ± 2.9 |
| 27       | 4.3    | ± 2.9 | 4.0    | ± 2.9 |
| 28       | 4.3    | ± 2.9 | 4.5    | ± 2.8 |
| 29       | 4.2    | ± 2.6 | 3.8    | ± 2.5 |
| 30       | 4.5    | ± 2.7 | 4.2    | ± 2.5 |
| 31       | 5.0    | ± 3.3 | 4.9    | ± 2.9 |
| 32       | 4.9    | ± 3.2 | 4.1    | ± 2.8 |
| 33       | 2.8    | ± 2.2 | 2.7    | ± 2.2 |
| 34       | 4.7    | ± 3.0 | 4.6    | ± 3.0 |
| 35       | 2.7    | ± 2.0 | 2.8    | ± 2.2 |
| 36       | 3.2    | ± 2.4 | 3.3    | ± 2.5 |

<sup>2</sup> Averages calculated using 8 years of data

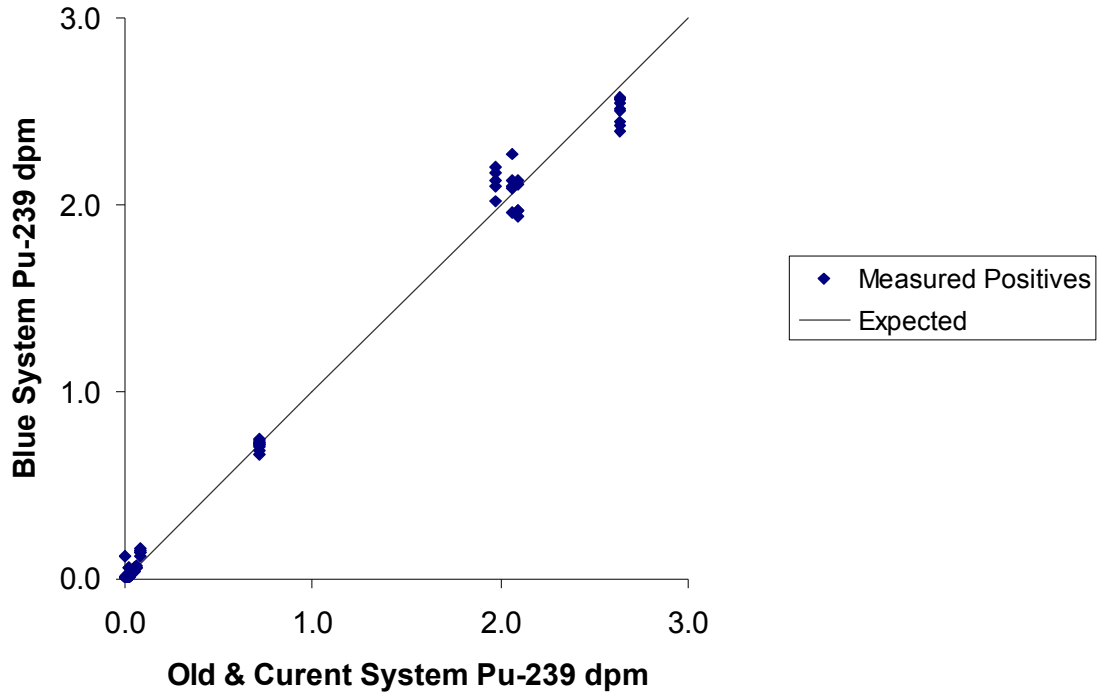
Table 8. Percent difference from the average computed activity to the known activity for radionuclides contained in the Prime calibration sources.

| Prime Calibration Source ID | AA Detector No. | AA Detector |       |        |        |
|-----------------------------|-----------------|-------------|-------|--------|--------|
|                             |                 | U-238       | U-234 | Pu-239 | Am-241 |
| 311                         | 173             | 1.6%        | -0.6% | -0.3%  | -0.9%  |
| 312                         | 174             | 1.1%        | -0.5% | -0.6%  | -0.3%  |
| 313                         | 175             | 1.2%        | -0.1% | -0.1%  | -1.1%  |
| 314                         | 176             | 1.1%        | 0.3%  | -0.7%  | -0.7%  |
| 315                         | 177             | 2.7%        | -2.0% | -0.6%  | -0.7%  |
| 316                         | 178             | 1.1%        | -0.4% | -0.4%  | -0.4%  |
| 317                         | 179             | 1.9%        | -0.6% | 0.2%   | -1.9%  |
| 318                         | 180             | 0.8%        | 2.3%  | -2.4%  | -0.3%  |
| 3985                        | 181             | 3.2%        | -0.4% | -0.6%  | -1.7%  |
| 3986                        | 182             | 2.5%        | -2.5% | -0.3%  | -0.6%  |
| 3987                        | 183             | -0.3%       | -2.1% | 0.5%   | 0.5%   |
| 3988                        | 184             | -0.8%       | -0.9% | -0.1%  | 0.3%   |
| 311                         | 185             | 0.5%        | -0.6% | 1.6%   | -0.1%  |
| 312                         | 186             | -0.4%       | 1.9%  | -0.2%  | -1.7%  |
| 313                         | 187             | 0.2%        | -0.8% | -1.5%  | 1.4%   |
| 314                         | 188             | 1.8%        | -1.9% | -1.2%  | 0.7%   |
| 315                         | 189             | 1.6%        | 0.4%  | -1.3%  | -0.8%  |
| 316                         | 190             | 0.4%        | -1.6% | -0.6%  | 0.9%   |
| 317                         | 191             | 0.6%        | -0.5% | -0.2%  | -0.4%  |
| 318                         | 192             | 1.5%        | 0.7%  | -1.9%  | -0.2%  |
| 3985                        | 193             | 1.4%        | 2.1%  | 0.0%   | -2.9%  |
| 3986                        | 194             | 2.3%        | -2.7% | 0.5%   | -1.3%  |
| 3987                        | 195             | 0.8%        | -2.5% | 0.6%   | -0.2%  |
| 3988                        | 196             | -2.3%       | -0.5% | 1.0%   | 0.0%   |
| 311                         | 197             | 2.7%        | -1.0% | -0.1%  | -1.8%  |
| 312                         | 198             | 1.1%        | 0.3%  | -0.2%  | -1.5%  |
| 313                         | 199             | 0.6%        | 0.5%  | -0.8%  | -0.6%  |
| 314                         | 200             | 0.5%        | -0.4% | -1.3%  | 0.7%   |
| 315                         | 201             | 0.3%        | -0.7% | 0.1%   | -0.2%  |
| 316                         | 202             | 1.8%        | -1.1% | 0.0%   | -0.1%  |
| 317                         | 203             | 0.8%        | 0.2%  | 0.0%   | -1.3%  |
| 318                         | 204             | 1.5%        | 1.2%  | -2.6%  | 0.1%   |
| 3985                        | 205             | 1.4%        | 1.0%  | 0.3%   | -2.3%  |
| 3986                        | 206             | 1.9%        | -1.6% | -0.4%  | -0.7%  |
| 3987                        | 207             | 0.1%        | -1.6% | 0.5%   | 0.0%   |
| 3988                        | 208             | -2.2%       | 0.9%  | 0.4%   | -0.4%  |

Table 9. Comparison of average Prime source efficiencies for the Alpha and the Alpha Analyst systems.

| Calibration Source ID | Alpha Detector |            | AA1 Detector |            | AA2 Detector |            | AA3 Detector |            |
|-----------------------|----------------|------------|--------------|------------|--------------|------------|--------------|------------|
|                       | No.            | Efficiency | No.          | Efficiency | No.          | Efficiency | No.          | Efficiency |
| 311                   | 1              | 0.35       | 101          | 0.31       | 137          | 0.29       | 173          | 0.30       |
| 312                   | 2              | 0.37       | 102          | 0.30       | 138          | 0.29       | 174          | 0.30       |
| 313                   | 3              | 0.35       | 103          | 0.30       | 139          | 0.29       | 175          | 0.30       |
| 314                   | 4              | 0.34       | 104          | 0.31       | 140          | 0.29       | 176          | 0.29       |
| 315                   | 5              | 0.34       | 105          | 0.31       | 141          | 0.29       | 177          | 0.30       |
| 316                   | 6              | 0.35       | 106          | 0.31       | 142          | 0.29       | 178          | 0.31       |
| 317                   | 7              | 0.35       | 107          | 0.31       | 143          | 0.29       | 179          | 0.31       |
| 318                   | 8              | 0.36       | 108          | 0.30       | 144          | 0.29       | 180          | 0.29       |
| 3985                  | 9              | 0.33       | 109          | 0.29       | 145          | 0.29       | 181          | 0.29       |
| 3986                  | 10             | 0.30       | 110          | 0.30       | 146          | 0.27       | 182          | 0.30       |
| 3987                  | 11             | 0.34       | 111          | 0.30       | 147          | 0.29       | 183          | 0.29       |
| 3988                  | 12             | 0.35       | 112          | 0.29       | 148          | 0.29       | 184          | 0.30       |
| 311                   | 13             | 0.36       | 113          | 0.30       | 149          | 0.31       | 185          | 0.30       |
| 312                   | 14             | 0.34       | 114          | 0.30       | 150          | 0.29       | 186          | 0.30       |
| 313                   | 15             | 0.36       | 115          | 0.30       | 151          | 0.30       | 187          | 0.31       |
| 314                   | 16             | 0.32       | 116          | 0.30       | 152          | 0.30       | 188          | 0.29       |
| 315                   | 17             | 0.35       | 117          | 0.31       | 153          | 0.30       | 189          | 0.31       |
| 316                   | 18             | 0.35       | 118          | 0.30       | 154          | 0.30       | 190          | 0.30       |
| 317                   | 19             | 0.37       | 119          | 0.30       | 155          | 0.29       | 191          | 0.30       |
| 318                   | 20             | 0.33       | 120          | 0.29       | 156          | 0.29       | 192          | 0.30       |
| 3985                  | 21             | 0.34       | 121          | 0.29       | 157          | 0.29       | 193          | 0.29       |
| 3986                  | 22             | 0.35       | 122          | 0.29       | 158          | 0.29       | 194          | 0.29       |
| 3987                  | 23             | 0.34       | 123          | 0.30       | 159          | 0.30       | 195          | 0.29       |
| 3988                  | 24             | 0.33       | 124          | 0.30       | 160          | 0.30       | 196          | 0.30       |
| 311                   | 25             | 0.35       |              |            | 161          | 0.30       | 197          | 0.32       |
| 312                   | 26             | 0.36       |              |            | 162          | 0.30       | 198          | 0.29       |
| 313                   | 27             | 0.37       |              |            | 163          | 0.30       | 199          | 0.31       |
| 314                   | 28             | 0.33       |              |            | 164          | 0.30       | 200          | 0.31       |
| 315                   | 29             | 0.34       |              |            | 165          | 0.29       | 201          | 0.31       |
| 316                   | 30             | 0.36       |              |            | 166          | 0.30       | 202          | 0.30       |
| 317                   | 31             | 0.34       |              |            | 167          | 0.29       | 203          | 0.29       |
| 318                   | 32             | 0.34       |              |            | 168          | 0.31       | 204          | 0.29       |
| 3985                  | 33             | 0.35       |              |            | 169          | 0.29       | 205          | 0.29       |
| 3986                  | 34             | 0.35       |              |            | 170          | 0.29       | 206          | 0.28       |
| 3987                  | 35             | 0.35       |              |            | 171          | 0.30       | 207          | 0.30       |
| 3988                  | 36             | 0.37       |              |            | 172          | 0.30       | 208          | 0.29       |

Figure 1. Measurement results for positive Pu-239 Samples – All Detectors



*Pu-242 Tracer Activity ANOVAs – by detector*

Detector 173

| <b>SOURCE</b> | <b>SUM-OF-SQUARES</b> | <b>DF</b> | <b>MEAN-SQUARE</b> | <b>F-RATIO</b> | <b>P</b> |
|---------------|-----------------------|-----------|--------------------|----------------|----------|
| REGRESSION    | 0.164                 | 1         | 0.164              | 12.625         | 0.007    |
| RESIDUAL      | 0.104                 | 8         | 0.013              |                |          |

Detector 174

| <b>SOURCE</b> | <b>SUM-OF-SQUARES</b> | <b>DF</b> | <b>MEAN-SQUARE</b> | <b>F-RATIO</b> | <b>P</b> |
|---------------|-----------------------|-----------|--------------------|----------------|----------|
| REGRESSION    | 0.122                 | 1         | 0.122              | 20.787         | 0.004    |
| RESIDUAL      | 0.035                 | 6         | 0.006              |                |          |

Detector 175

| <b>SOURCE</b> | <b>SUM-OF-SQUARES</b> | <b>DF</b> | <b>MEAN-SQUARE</b> | <b>F-RATIO</b> | <b>P</b> |
|---------------|-----------------------|-----------|--------------------|----------------|----------|
| REGRESSION    | 0.075                 | 1         | 0.075              | 10.127         | 0.011    |
| RESIDUAL      | 0.066                 | 9         | 0.007              |                |          |

Detector 176

| <b>SOURCE</b> | <b>SUM-OF-SQUARES</b> | <b>DF</b> | <b>MEAN-SQUARE</b> | <b>F-RATIO</b> | <b>P</b> |
|---------------|-----------------------|-----------|--------------------|----------------|----------|
| REGRESSION    | 0.138                 | 1         | 0.138              | 58.724         | 0.000    |
| RESIDUAL      | 0.017                 | 7         | 0.002              |                |          |

Detector 177

| <b>SOURCE</b> | <b>SUM-OF-SQUARES</b> | <b>DF</b> | <b>MEAN-SQUARE</b> | <b>F-RATIO</b> | <b>P</b> |
|---------------|-----------------------|-----------|--------------------|----------------|----------|
| REGRESSION    | 0.096                 | 1         | 0.096              | 13.153         | 0.007    |
| RESIDUAL      | 0.058                 | 8         | 0.007              |                |          |

Detector 178

| <b>SOURCE</b> | <b>SUM-OF-SQUARES</b> | <b>DF</b> | <b>MEAN-SQUARE</b> | <b>F-RATIO</b> | <b>P</b> |
|---------------|-----------------------|-----------|--------------------|----------------|----------|
| REGRESSION    | 0.171                 | 1         | 0.171              | 29.913         | 0.001    |
| RESIDUAL      | 0.046                 | 8         | 0.006              |                |          |

Detector 179

| <b>SOURCE</b> | <b>SUM-OF-SQUARES</b> | <b>DF</b> | <b>MEAN-SQUARE</b> | <b>F-RATIO</b> | <b>P</b> |
|---------------|-----------------------|-----------|--------------------|----------------|----------|
| REGRESSION    | 0.178                 | 1         | 0.178              | 25.833         | 0.001    |
| RESIDUAL      | 0.062                 | 9         | 0.007              |                |          |



Detector 180

| <b>SOURCE</b> | <b>SUM-OF-SQUARES</b> | <b>DF</b> | <b>MEAN-SQUARE</b> | <b>F-RATIO</b> | <b>P</b> |
|---------------|-----------------------|-----------|--------------------|----------------|----------|
| REGRESSION    | 0.090                 | 1         | 0.090              | 27.344         | 0.001    |
| RESIDUAL      | 0.026                 | 8         | 0.003              |                |          |

Detector 181

| <b>SOURCE</b> | <b>SUM-OF-SQUARES</b> | <b>DF</b> | <b>MEAN-SQUARE</b> | <b>F-RATIO</b> | <b>P</b> |
|---------------|-----------------------|-----------|--------------------|----------------|----------|
| REGRESSION    | 0.230                 | 1         | 0.230              | 57.202         | 0.000    |
| RESIDUAL      | 0.036                 | 9         | 0.004              |                |          |

Detector 182

| <b>SOURCE</b> | <b>SUM-OF-SQUARES</b> | <b>DF</b> | <b>MEAN-SQUARE</b> | <b>F-RATIO</b> | <b>P</b> |
|---------------|-----------------------|-----------|--------------------|----------------|----------|
| REGRESSION    | 0.124                 | 1         | 0.124              | 13.661         | 0.005    |
| RESIDUAL      | 0.081                 | 9         | 0.009              |                |          |

Detector 183

| <b>SOURCE</b> | <b>SUM-OF-SQUARES</b> | <b>DF</b> | <b>MEAN-SQUARE</b> | <b>F-RATIO</b> | <b>P</b> |
|---------------|-----------------------|-----------|--------------------|----------------|----------|
| REGRESSION    | 0.262                 | 1         | 0.262              | 18.908         | 0.003    |
| RESIDUAL      | 0.097                 | 7         | 0.014              |                |          |

Detector 184

| <b>SOURCE</b> | <b>SUM-OF-SQUARES</b> | <b>DF</b> | <b>MEAN-SQUARE</b> | <b>F-RATIO</b> | <b>P</b> |
|---------------|-----------------------|-----------|--------------------|----------------|----------|
| REGRESSION    | 0.202                 | 1         | 0.202              | 35.650         | 0.000    |
| RESIDUAL      | 0.057                 | 10        | 0.006              |                |          |

Detector 185

| <b>SOURCE</b> | <b>SUM-OF-SQUARES</b> | <b>DF</b> | <b>MEAN-SQUARE</b> | <b>F-RATIO</b> | <b>P</b> |
|---------------|-----------------------|-----------|--------------------|----------------|----------|
| REGRESSION    | 0.203                 | 1         | 0.203              | 68.182         | 0.000    |
| RESIDUAL      | 0.027                 | 9         | 0.003              |                |          |

Detector 186

| <b>SOURCE</b> | <b>SUM-OF-SQUARES</b> | <b>DF</b> | <b>MEAN-SQUARE</b> | <b>F-RATIO</b> | <b>P</b> |
|---------------|-----------------------|-----------|--------------------|----------------|----------|
| REGRESSION    | 0.183                 | 1         | 0.183              | 22.667         | 0.001    |
| RESIDUAL      | 0.081                 | 10        | 0.008              |                |          |

Detector 187

| <b>SOURCE</b> | <b>SUM-OF-SQUARES</b> | <b>DF</b> | <b>MEAN-SQUARE</b> | <b>F-RATIO</b> | <b>P</b> |
|---------------|-----------------------|-----------|--------------------|----------------|----------|
| REGRESSION    | 0.019                 | 1         | 0.019              | 11.746         | 0.008    |
| RESIDUAL      | 0.015                 | 9         | 0.002              |                |          |

Detector 188

| <b>SOURCE</b> | <b>SUM-OF-SQUARES</b> | <b>DF</b> | <b>MEAN-SQUARE</b> | <b>F-RATIO</b> | <b>P</b> |
|---------------|-----------------------|-----------|--------------------|----------------|----------|
| REGRESSION    | 0.736                 | 1         | 0.736              | 287            | 0.000    |
| RESIDUAL      | 0.023                 | 9         | 0.003              |                |          |

Detector 189

| <b>SOURCE</b> | <b>SUM-OF-SQUARES</b> | <b>DF</b> | <b>MEAN-SQUARE</b> | <b>F-RATIO</b> | <b>P</b> |
|---------------|-----------------------|-----------|--------------------|----------------|----------|
| REGRESSION    | 0.044                 | 1         | 0.044              | 21.069         | 0.001    |
| RESIDUAL      | 0.019                 | 9         | 0.002              |                |          |

Detector 190

| <b>SOURCE</b> | <b>SUM-OF-SQUARES</b> | <b>DF</b> | <b>MEAN-SQUARE</b> | <b>F-RATIO</b> | <b>P</b> |
|---------------|-----------------------|-----------|--------------------|----------------|----------|
| REGRESSION    | 2.225                 | 1         | 2.225              | 249            | 0.000    |
| RESIDUAL      | 0.125                 | 14        | 0.009              |                |          |

Detector 191

| <b>SOURCE</b> | <b>SUM-OF-SQUARES</b> | <b>DF</b> | <b>MEAN-SQUARE</b> | <b>F-RATIO</b> | <b>P</b> |
|---------------|-----------------------|-----------|--------------------|----------------|----------|
| REGRESSION    | 1.975                 | 1         | 1.975              | 17.148         | 0.001    |
| RESIDUAL      | 2.189                 | 19        | 0.115              |                |          |

Detector 192

| <b>SOURCE</b> | <b>SUM-OF-SQUARES</b> | <b>DF</b> | <b>MEAN-SQUARE</b> | <b>F-RATIO</b> | <b>P</b> |
|---------------|-----------------------|-----------|--------------------|----------------|----------|
| REGRESSION    | 0.027                 | 1         | 0.027              | 11.877         | 0.005    |
| RESIDUAL      | 0.027                 | 12        | 0.002              |                |          |

Detector 193

| <b>SOURCE</b> | <b>SUM-OF-SQUARES</b> | <b>DF</b> | <b>MEAN-SQUARE</b> | <b>F-RATIO</b> | <b>P</b> |
|---------------|-----------------------|-----------|--------------------|----------------|----------|
| REGRESSION    | 0.066                 | 1         | 0.066              | 21.675         | 0.002    |
| RESIDUAL      | 0.024                 | 8         | 0.003              |                |          |

Detector 194

| <b>SOURCE</b> | <b>SUM-OF-SQUARES</b> | <b>DF</b> | <b>MEAN-SQUARE</b> | <b>F-RATIO</b> | <b>P</b> |
|---------------|-----------------------|-----------|--------------------|----------------|----------|
| REGRESSION    | 0.101                 | 1         | 0.101              | 22.960         | 0.001    |
| RESIDUAL      | 0.044                 | 10        | 0.004              |                |          |

Detector 195

| <b>SOURCE</b> | <b>SUM-OF-SQUARES</b> | <b>DF</b> | <b>MEAN-SQUARE</b> | <b>F-RATIO</b> | <b>P</b> |
|---------------|-----------------------|-----------|--------------------|----------------|----------|
| REGRESSION    | 0.015                 | 1         | 0.015              | 3.222          | 0.093    |
| RESIDUAL      | 0.071                 | 15        | 0.005              |                |          |

Detector 196

| <b>SOURCE</b> | <b>SUM-OF-SQUARES</b> | <b>DF</b> | <b>MEAN-SQUARE</b> | <b>F-RATIO</b> | <b>P</b> |
|---------------|-----------------------|-----------|--------------------|----------------|----------|
| REGRESSION    | 1.932                 | 1         | 1.932              | 15.742         | 0.001    |
| RESIDUAL      | 2.209                 | 18        | 0.123              |                |          |

Detector 197

| <b>SOURCE</b> | <b>SUM-OF-SQUARES</b> | <b>DF</b> | <b>MEAN-SQUARE</b> | <b>F-RATIO</b> | <b>P</b> |
|---------------|-----------------------|-----------|--------------------|----------------|----------|
| REGRESSION    | 2.623                 | 1         | 2.623              | 28.013         | 0.000    |
| RESIDUAL      | 2.060                 | 22        | 0.094              |                |          |

Detector 198

| <b>SOURCE</b> | <b>SUM-OF-SQUARES</b> | <b>DF</b> | <b>MEAN-SQUARE</b> | <b>F-RATIO</b> | <b>P</b> |
|---------------|-----------------------|-----------|--------------------|----------------|----------|
| REGRESSION    | 2.119                 | 1         | 2.119              | 271            | 0.000    |
| RESIDUAL      | 0.172                 | 22        | 0.008              |                |          |

Detector 199

| <b>SOURCE</b> | <b>SUM-OF-SQUARES</b> | <b>DF</b> | <b>MEAN-SQUARE</b> | <b>F-RATIO</b> | <b>P</b> |
|---------------|-----------------------|-----------|--------------------|----------------|----------|
| REGRESSION    | 0.877                 | 1         | 0.877              | 181            | 0.000    |
| RESIDUAL      | 0.097                 | 20        | 0.005              |                |          |

Detector 200

| <b>SOURCE</b> | <b>SUM-OF-SQUARES</b> | <b>DF</b> | <b>MEAN-SQUARE</b> | <b>F-RATIO</b> | <b>P</b> |
|---------------|-----------------------|-----------|--------------------|----------------|----------|
| REGRESSION    | 2.126                 | 1         | 2.126              | 326            | 0.000    |
| RESIDUAL      | 0.117                 | 18        | 0.007              |                |          |

Detector 201

| <b>SOURCE</b> | <b>SUM-OF-SQUARES</b> | <b>DF</b> | <b>MEAN-SQUARE</b> | <b>F-RATIO</b> | <b>P</b> |
|---------------|-----------------------|-----------|--------------------|----------------|----------|
| REGRESSION    | 0.678                 | 1         | 0.678              | 176            | 0.000    |
| RESIDUAL      | 0.031                 | 8         | 0.004              |                |          |

Detector 202

| <b>SOURCE</b> | <b>SUM-OF-SQUARES</b> | <b>DF</b> | <b>MEAN-SQUARE</b> | <b>F-RATIO</b> | <b>P</b> |
|---------------|-----------------------|-----------|--------------------|----------------|----------|
| REGRESSION    | 0.088                 | 1         | 0.088              | 23.023         | 0.001    |
| RESIDUAL      | 0.034                 | 9         | 0.004              |                |          |

Detector 203

| <b>SOURCE</b> | <b>SUM-OF-SQUARES</b> | <b>DF</b> | <b>MEAN-SQUARE</b> | <b>F-RATIO</b> | <b>P</b> |
|---------------|-----------------------|-----------|--------------------|----------------|----------|
| REGRESSION    | 0.192                 | 1         | 0.192              | 36.414         | 0.000    |
| RESIDUAL      | 0.047                 | 9         | 0.005              |                |          |

Detector 204

| <b>SOURCE</b> | <b>SUM-OF-SQUARES</b> | <b>DF</b> | <b>MEAN-SQUARE</b> | <b>F-RATIO</b> | <b>P</b> |
|---------------|-----------------------|-----------|--------------------|----------------|----------|
| REGRESSION    | 0.197                 | 1         | 0.197              | 34.346         | 0.000    |
| RESIDUAL      | 0.046                 | 8         | 0.006              |                |          |

Detector 205

| <b>SOURCE</b> | <b>SUM-OF-SQUARES</b> | <b>DF</b> | <b>MEAN-SQUARE</b> | <b>F-RATIO</b> | <b>P</b> |
|---------------|-----------------------|-----------|--------------------|----------------|----------|
| REGRESSION    | 0.130                 | 1         | 0.130              | 34.637         | 0.000    |
| RESIDUAL      | 0.034                 | 9         |                    |                |          |

Detector 206

| <b>SOURCE</b> | <b>SUM-OF-SQUARES</b> | <b>DF</b> | <b>MEAN-SQUARE</b> | <b>F-RATIO</b> | <b>P</b> |
|---------------|-----------------------|-----------|--------------------|----------------|----------|
| REGRESSION    | 0.189                 | 1         | 0.189              | 52.258         | 0.000    |
| RESIDUAL      | 0.040                 | 11        | 0.004              |                |          |

Detector 207

| <b>SOURCE</b> | <b>SUM-OF-SQUARES</b> | <b>DF</b> | <b>MEAN-SQUARE</b> | <b>F-RATIO</b> | <b>P</b> |
|---------------|-----------------------|-----------|--------------------|----------------|----------|
| REGRESSION    | 0.140                 | 1         | 0.140              | 44.324         | 0.000    |
| RESIDUAL      | 0.022                 | 7         | 0.003              |                |          |

Detector 208

| <b>SOURCE</b> | <b>SUM-OF-SQUARES</b> | <b>DF</b> | <b>MEAN-SQUARE</b> | <b>F-RATIO</b> | <b>P</b> |
|---------------|-----------------------|-----------|--------------------|----------------|----------|
| REGRESSION    | 0.143                 | 1         | 1.151              | 16.254         | 0.004    |
| RESIDUAL      | 0.071                 | 8         | 0.009              |                |          |

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