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Technical Equivalency Documentation for a Newly Aquired 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 remove 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. Pulser 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. Pulser Measurement comparison – Older Alpha System[1]

ID	Avg. FWHM (keV)		1s	Avg. Energy (keV)		1s	Centroid Channel		1s	Rate (cps)		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		

[1] The pulser rate for this system is different due to the different clock speeds of the pulse generator contained in each system.

Table 3. Pulser Measurement comparison – "Red" Alpha Analyst System

ID	Avg. FWHM (keV)	1s	Avg. Energy (keV)	1s	Centroid Channel	1s	Rate (cps)	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. Pulser Measurement comparison – 'White' Alpha Analyst System

ID	Avg. FWHM (keV)		1s	Avg. Energy (keV)		1s	Centroid Channel		1s	Rate (cps)		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						
Detector	**Pu-239**	**±**	**1s**	**Am-241**	**±**	**1s**
101	1.2	±	1.2	0.7	±	0.9
102	1.1	±	1.2	0.8	±	1.1
103	0.9	±	1.1	0.8	±	0.9
104	1.0	±	1.1	0.8	±	1.0
105	1.0	±	1.0	0.3	±	0.5
106	1.1	±	1.0	0.8	±	0.8
107	0.8	±	0.9	0.4	±	0.6
108	1.0	±	1.0	0.8	±	0.9
109	1.2	±	1.2	0.8	±	0.8
110	0.8	±	1.0	0.9	±	0.9
111	1.2	±	1.2	0.7	±	0.9
112	1.2	±	1.0	0.8	±	0.8
113	1.0	±	1.2	0.8	±	1.0
114	1.2	±	1.0	0.7	±	0.9
115	1.0	±	1.2	0.9	±	1.0
116	0.9	±	1.0	0.4	±	0.5
117	1.5	±	1.1	0.6	±	0.7
118	1.4	±	1.3	0.8	±	1.1
119	1.1	±	1.0	0.5	±	0.6
120	1.1	±	1.2	0.5	±	0.8
121	1.1	±	1.2	1.2	±	1.1
122	1.3	±	0.9	1.0	±	0.9
123	1.6	±	1.5	1.1	±	1.0
124	1.3	±	1.1	0.6	±	0.7

Alpha Analyst "Blue" System						
Detector	**Pu-239**	**±**	**1s**	**Am-241**	**±**	**1s**
173	1.1	±	1.0	0.9	±	1.0
174	0.8	±	0.8	0.9	±	0.8
175	1.8	±	1.2	0.8	±	0.9
176	0.8	±	1.0	0.8	±	0.9
177	1.1	±	0.9	0.6	±	0.8
178	1.6	±	1.5	0.8	±	1.1
179	0.9	±	1.0	1.2	±	1.1
180	1.9	±	1.8	1.4	±	0.9
181	1.2	±	1.0	0.6	±	0.7
182	2.0	±	1.8	1.1	±	1.0
183	1.1	±	1.1	0.8	±	0.8
184	1.3	±	0.8	0.8	±	0.8
185	0.9	±	1.1	1.2	±	0.6
186	0.9	±	1.0	1.4	±	0.6
187	0.7	±	0.7	0.6	±	1.0
188	1.2	±	1.2	1.1	±	0.9
189	1.2	±	1.0	0.8	±	0.7
190	1.1	±	1.2	0.8	±	1.1
191	2.0	±	1.6	0.4	±	1.2
192	1.1	±	1.0	0.4	±	0.7
193	0.9	±	1.0	1.0	±	1.2
194	1.3	±	0.9	0.8	±	1.0
195	0.4	±	0.7	0.6	±	0.8
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)[2].

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

[2] Averages calculated using 8 years of data

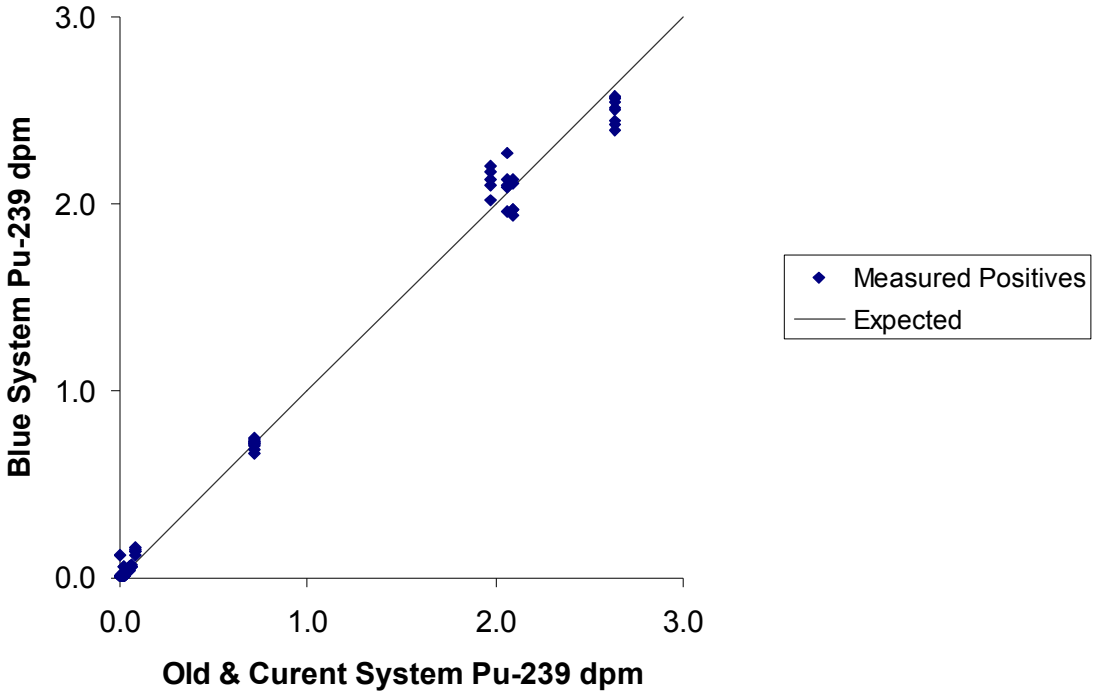
Table 8. Percent difference from the average computed activity to the known activity for radionuclides contained in the Prime calibration sources.

Prime Calibration Source ID	AA Detector No.	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.

	Alpha Detector		AA1 Detector		AA2 Detector		AA3 Detector	
Calibration Source ID	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

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

Detector 174

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

Detector 175

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

Detector 176

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

Detector 177

SOURCE	SUM-OF-SQUARES	DF	MEAN-SQUARE	F-RATIO	P
REGRESSION	0.096	1	0.096	13.153	0.007
RESIDUAL	0.058	8	0.007		

Detector 178

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

Detector 179

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

Detector 180

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

Detector 181

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

Detector 182

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

Detector 183

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

Detector 184

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

Detector 185

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

Detector 186

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

Detector 187

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

Detector 188

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

Detector 189

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

Detector 190

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

Detector 191

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

Detector 192

SOURCE	SUM-OF-SQUARES	DF	MEAN-SQUARE	F-RATIO	P
REGRESSION	0.027	1	0.027	11.877	0.005
RESIDUAL	0.027	12	0.002		

Detector 193

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

Detector 194

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

Detector 195

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

Detector 196

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

Detector 197

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

Detector 198

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

Detector 199

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

Detector 200

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

Detector 201

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

Detector 202

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

Detector 203

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

Detector 204

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

Detector 205

SOURCE	SUM-OF-SQUARES	DF	MEAN-SQUARE	F-RATIO	P
REGRESSION	0.130	1	0.130	34.637	0.000
RESIDUAL	0.034	9			

Detector 206

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

Detector 207

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

Detector 208

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

The authors thank Dale Hankins who laboriously cleaned the chambers, electronic components, vacuum system, reassembled the system, and checked the basic operations of electronic components to get newly acquired alpha system ready for evaluation and use.