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Document Title GLAST LAT ACD Performance Summary from Environmental Testing		

GLAST LAT ACD Performance Summary from Environmental Testing

ACD-RPT-000374

PERFORMANCE SUMMARY – ENVIRONMENTAL TESTING

1.0 - Introduction

The GLAST LAT ACD performance was monitored during environmental testing by measuring the light output of each Tile Detector Assembly (TDA) using both phototube readouts on each TDA.

1.1 - Purpose and Scope

This report summarizes the results of performance testing before, during, and after the ACD environmental test program.

2.0 - NASA STANDARD DOCUMENTS:

There are no NASA Standard documents explicitly for performance testing.

2.1 QA Requirements

The ACD Quality Assurance (QA) Representative reviewed all reports.

2.2 Safety Requirements

All ACD activities at GSFC will adhere to the occupational safety requirements described in the following instructions and directives:

Directive	Description
GMI-1700.2	GSFC Health and Safety Program
GMI-1780.1	GSFC Confined Space Policy
GMI-1800.1	Occupational Medicine
GPD-8870.1	Environmental Program

3.0 ACD Performance Monitoring

The primary purpose of the ACD is to identify charged particles that penetrate the LAT. In most cases, these are singly-charged cosmic rays, or Minimum Ionizing Particles (MIPs). On the ground, the secondary flux of atmospheric cosmic ray mu mesons (or muons) provides a source of MIPs. The ACD therefore uses these muons as a reference source.

The light produced by charged particles penetrating the scintillator TDAs is detected by photomultiplier tubes (phototubes, or PMTs), with two phototubes reading out each TDA. A MIP passing through a TDA at normal incidence deposits energy of 2 million electron volts (MeV). The ACD uses these MIP signals for self-calibration.

In particular, the test script called `AcidTriggeredOp` collects Pulse Height Analysis (PHA) signals from each of the 194 ACD phototubes, selecting signals that are likely to be MIPs by requiring a coincidence between two different parts of the ACD (top and side or side and side). The plot of the PHA data shows a characteristic shape as illustrated in Fig. 1.

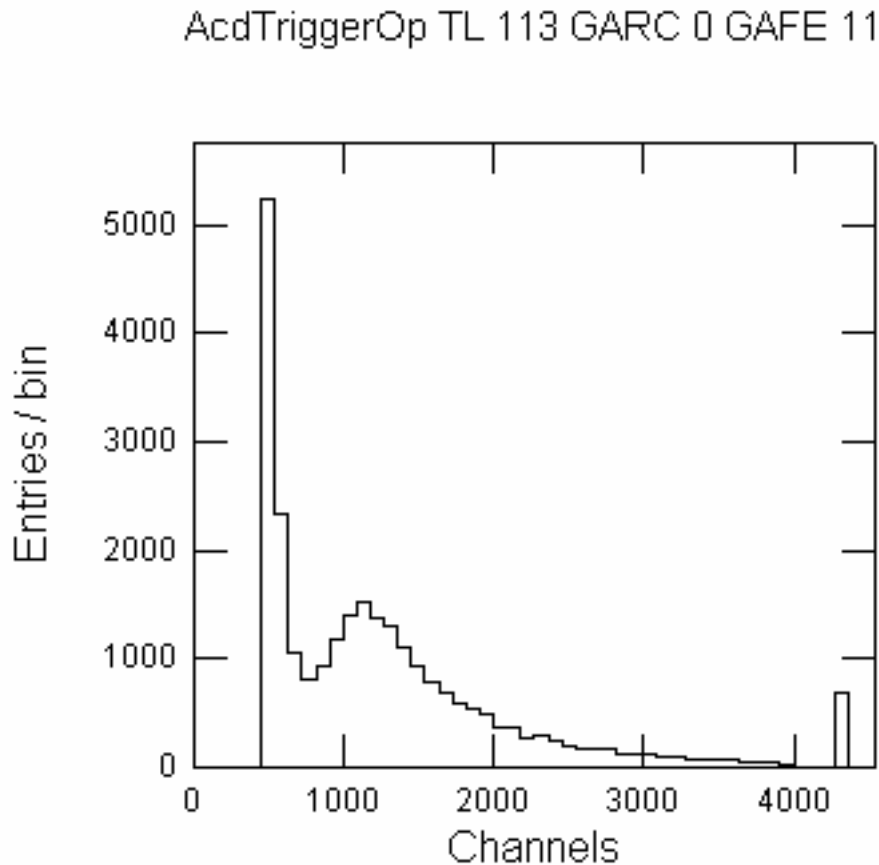


Fig. 1 – A Pulse Height Analysis (PHA) spectrum from one ACD phototube. The large sharp peak to the left is the “pedestal,” a minimum readout when no real signal is present. The broader peak centered near channel 1200 is the signal due to Minimum Ionizing Particles (MIPs).

The separation of the MIP peak from the pedestal in such a spectrum is a good measure of the performance. It shows how much light from the TDA is being seen by the phototube.

In monitoring the performance of the ACD during environmental testing, the positions of the pedestal and the MIP peak are measured (by fitting curves such as this) in the course of testing. These data provide information about possible changes in performance of the ACD.

Table 1 below shows the comparison between the reference test made at room temperature before any environmental testing and the final test made at room temperature after all environmental tests were completed. In this table, the columns from left to right are:

Tile location

Tile number

Phototube number

Mean pedestal – reference

Most Probable Value (MPV) for MIP peak location – reference

MIP peak (MPV minus Pedestal) - reference

Mean pedestal – after final thermal vacuum test

Most Probable Value (MPV) for MIP peak location – after final thermal vacuum test

MIP peak (MPV minus Pedestal) - after final thermal vacuum test

Percentage change in MIP peak

The average change per channel from beginning to end of environmental testing is about +1% (increase in light output), well within the uncertainties of the measurement. There are some individual changes, both positive and negative. Only two of these exceed 10%, which is the value we determined was a reasonable threshold for a possible real change. One of these (one of the tubes on tile 423) is a channel with low light to start with, showing an apparent 41% increase in light. This seems likely to result from the difficulty of fitting with a low signal. The low light throughput on tile 423 suggests that we will have to run a lower threshold than for other tubes, and this tile represents an area of potentially weak performance of the ACD. The other is a tube on tile 221, which shows an increase of just over 10%.

The net conclusion is that the ACD showed no significant change in performance over the course of all environmental testing.

Document ACD-RPT-000372 describes the analysis using the results of these performance tests to demonstrate that the full ACD meets its overall performance requirement of >0.9997 efficiency.

Table 2 shows the comparison between the reference data and a performance run taken at SLAC after the “environmental test” of a truck ride across the country. Again, there is no significant change in overall performance. Four channels show positive changes above 10%, no channels show negative changes that large. The average change is about + 1%.

Table 1	Tile #	Cable # [PMT #]	Mean Pedestal	Reference MPV (pol7 fit)	Reference MIP (pol7 fit)	Pedestal Thermal_11 Test	MPV Thermal_11 Test (pol7 fit)	MIP Thermal_11 Test (pol7 fit)	% Diff. Of Reference and Thermal_11 MIP
Center, top row	020	0-020	445.50	1108.69	663.19	445.93	1110.83	664.90	0.26
		1-020	213.83	1137.23	923.40	216.08	1133.78	917.70	-0.62
	021	0-021	265.50	977.35	711.85	264.81	978.63	713.82	0.28
		1-021	512.50	1424.22	911.72	512.48	1424.20	911.72	0.00
	022	0-022	520.50	1307.21	786.71	521.31	1260.58	739.27	-6.03
		1-022	496.50	1333.66	837.16	496.13	1324.33	828.20	-1.07
	023	0-023	204.50	707.92	503.42	206.67	708.99	502.33	-0.22
		1-023	151.50	772.10	620.60	150.49	757.36	606.87	-2.21
	024	0-024	120.50	627.18	506.68	117.73	612.08	494.35	-2.43
	1-024	109.50	843.34	733.84	107.58	832.28	724.70	-1.24	
Second, top rows	010	0-010	189.50	666.79	477.29	189.44	625.65	436.21	-8.61
		1-010	728.50	1316.80	588.30	728.83	1311.18	582.36	-1.01
	011	0-011	141.17	683.88	542.72	139.31	674.90	535.59	-1.31
		1-011	219.50	692.76	473.26	220.63	700.05	479.43	1.30
	012	0-012	174.83	929.76	754.93	171.28	921.36	750.08	-0.64
		1-012	372.50	1172.89	800.39	370.30	1159.45	789.15	-1.40
	013	0-013	197.17	734.46	537.29	198.13	723.07	524.94	-2.30
		1-013	172.17	858.42	686.25	172.63	863.83	691.20	0.72
	014	0-014	501.83	1102.73	600.90	501.06	1109.21	608.15	1.21
		1-014	395.83	1245.22	849.39	398.65	1263.88	865.23	1.87
	030	0-030	175.83	864.25	688.42	176.28	875.15	698.86	1.52
		1-030	134.50	805.59	671.09	134.91	817.93	683.01	1.78
	031	0-031	599.50	1220.65	621.15	599.69	1214.78	615.09	-0.98
		1-031	162.50	654.79	492.29	161.66	647.70	486.04	-1.27
	032	0-032	195.50	917.73	722.23	195.71	898.27	702.56	-2.72
		1-032	683.83	1495.29	811.46	684.07	1501.12	817.05	0.69
	033	0-033	150.83	668.33	517.50	149.79	660.63	510.84	-1.29
		1-033	211.17	710.43	499.26	210.12	721.65	511.53	2.46
034	0-034	199.50	718.03	518.53	197.32	715.39	518.06	-0.09	
	1-034	628.50	1224.90	596.40	629.90	1225.18	595.28	-0.19	

Outside, top rows (bent tiles)	000	0-000	207.83	845.51	637.68	208.68	851.93	643.25	0.87
		1-000	152.50	701.08	548.58	153.73	691.61	537.88	-1.95
	001	0-001	221.50	819.01	597.51	226.31	826.21	599.90	0.40
		1-001	163.50	764.07	600.57	164.47	761.04	596.57	-0.67
	002	0-002	207.17	679.82	472.65	203.60	687.30	483.70	2.34
		1-002	136.50	671.85	535.35	136.43	676.85	540.42	0.95
	003	0-003	454.50	971.10	516.60	455.00	980.68	525.68	1.76
		1-003	557.17	993.64	436.48	555.84	987.11	431.27	-1.19
	004	0-004	205.50	864.52	659.02	205.72	878.26	672.54	2.05
		1-004	129.83	1015.87	886.04	130.01	1015.16	885.15	-0.10
	040	0-040	339.17	1003.36	664.19	338.12	1009.60	671.48	1.10
		1-040	303.83	787.67	483.84	303.72	798.11	494.39	2.18
	041	0-041	209.17	639.73	430.56	206.45	629.76	423.32	-1.68
		1-041	567.17	1178.47	611.30	565.29	1181.86	616.57	0.86
	042	0-042	164.50	824.74	660.24	159.61	820.44	660.83	0.09
		1-042	411.50	941.49	529.99	410.79	944.77	533.98	0.75
043	0-043	232.50	710.47	477.97	231.43	678.41	446.98	-6.48	
	1-043	639.50	1211.24	571.74	637.20	1217.60	580.40	1.51	
044	0-044	230.50	654.44	423.94	230.62	646.04	415.41	-2.01	
	1-044	573.17	1125.93	552.76	574.43	1129.87	555.44	0.48	
-X Top Row	100	0-100	160.50	873.55	713.05	158.73	873.07	714.34	0.18
		1-100	437.50	1279.97	842.47	437.01	1284.97	847.96	0.65
	101	0-101	221.50	865.20	643.70	222.88	888.57	665.69	3.42
		1-101	149.83	639.31	489.47	149.28	640.51	491.24	0.36
	102	0-102	279.83	800.95	521.12	282.63	819.13	536.50	2.95
		1-102	124.83	900.79	775.95	126.02	919.88	793.86	2.31
	103	0-103	148.17	662.60	514.44	148.70	649.81	501.11	-2.59
		1-103	256.50	1039.69	783.19	258.83	1029.81	770.98	-1.56
104	0-104	547.17	1493.23	946.06	545.48	1482.10	936.62	-1.00	
	1-104	128.50	871.08	742.58	128.09	874.03	745.94	0.45	
-X Second Row	110	0-110	181.83	897.08	715.25	180.96	941.99	761.03	6.40
		1-110	260.17	1123.61	863.44	262.98	1113.66	850.68	-1.48
	111	0-111	192.50	855.96	663.46	189.18	867.25	678.07	2.20
		1-111	245.50	1094.76	849.26	243.45	1088.92	845.47	-0.45
	112	0-112	431.50	1001.04	569.54	431.07	1017.64	586.57	2.99

		1-112	372.50	1218.53	846.03	370.46	1230.77	860.32	1.69
	113	0-113	460.50	1133.11	672.61	459.25	1152.19	692.94	3.02
		1-113	344.17	975.48	631.31	343.72	1005.73	662.01	4.86
	114	0-114	297.50	1001.06	703.56	297.98	1020.90	722.92	2.75
		1-114	181.17	1315.27	1134.10	180.39	1331.31	1150.92	1.48
-X Third Row	120	0-120	241.50	799.16	557.66	242.33	813.07	570.74	2.35
		1-120	334.17	1151.92	817.75	335.69	1129.06	793.37	-2.98
	121	0-121	288.50	959.79	671.29	290.09	995.95	705.86	5.15
		1-121	512.50	1348.57	836.07	511.78	1386.89	875.11	4.67
	122	0-122	113.17	986.09	872.92	112.51	999.45	886.93	1.60
		1-122	619.83	1677.19	1057.36	619.63	1733.71	1114.08	5.37
	123	0-123	221.50	1111.35	889.85	220.95	1089.68	868.73	-2.37
		1-123	199.50	1075.40	875.90	197.98	1064.43	866.45	-1.08
-X, Bottom	124	0-124	141.50	687.74	546.24	142.22	731.74	589.52	7.92
		1-124	468.83	1137.40	668.57	462.58	1149.35	686.77	2.72
-Y Top Row	130	0-130	159.50	874.90	715.40	154.92	864.96	710.05	-0.75
		1-130	192.50	1107.53	915.03	192.55	1089.46	896.92	-1.98
	200	0-200	146.50	909.95	763.45	142.42	895.56	753.14	-1.35
		1-200	162.50	972.18	809.68	162.09	960.34	798.25	-1.41
	201	0-201	192.50	841.36	648.86	193.06	857.37	664.31	2.38
		1-201	376.83	902.20	525.37	375.15	928.43	553.28	5.31
	202	0-202	165.83	643.52	477.68	168.54	647.41	478.87	0.25
		1-202	115.83	876.88	761.05	115.43	908.63	793.20	4.22
-Y Second Row	203	0-203	202.17	779.57	577.40	203.50	825.52	622.02	7.73
		1-203	464.50	1181.57	717.07	465.25	1233.49	768.24	7.14
	204	0-204	686.50	1322.87	636.37	687.96	1343.32	655.36	2.98
		1-204	411.50	1089.73	678.23	410.51	1103.24	692.73	2.14
-Y Second Row	210	0-210	249.50	993.83	744.33	248.68	970.20	721.52	-3.06
		1-210	128.50	916.85	788.35	128.99	945.87	816.89	3.62
	211	0-211	128.50	844.00	715.50	125.04	863.66	738.62	3.23
		1-211	423.83	1123.83	700.00	425.64	1157.13	731.49	4.50
	212	0-212	281.50	993.46	711.96	279.74	988.95	709.21	-0.39
		1-212	154.17	862.59	708.42	152.65	887.24	734.60	3.69
	213	0-213	221.17	898.56	677.40	221.05	898.90	677.85	0.07
	1-213	198.50	969.79	771.29	198.35	991.07	792.72	2.78	

	214	0-214	592.50	1215.56	623.06	590.66	1248.85	658.19	5.64
		1-214	397.50	1346.50	949.00	397.79	1332.89	935.10	-1.47
-Y Third Row	220	0-220	128.50	849.03	720.53	128.56	887.20	758.65	5.29
		1-220	109.50	1098.47	988.97	108.20	1091.77	983.57	-0.55
	221	0-221	173.83	719.34	545.51	170.35	771.56	601.21	10.21
		1-221	297.50	940.80	643.30	297.57	935.34	637.77	-0.86
	222	0-222	165.50	943.92	778.42	163.01	962.02	799.01	2.64
		1-222	652.50	1496.13	843.63	647.86	1538.93	891.07	5.62
	223	0-223	372.50	1201.61	829.11	372.12	1232.28	860.16	3.75
		1-223	345.50	1096.97	751.47	343.27	1100.45	757.18	0.76
	224	0-224	168.50	892.13	723.63	165.74	851.91	686.17	-5.18
		1-224	264.17	1200.05	935.88	263.79	1113.56	849.77	-9.20
-Y, Bottom	230	0-230	213.17	995.12	781.95	205.28	1006.38	801.10	2.45
		1-230	112.50	990.18	877.68	106.60	997.58	890.99	1.52
+X Top Row	300	0-300	325.50	976.58	651.08	324.16	1017.25	693.09	6.45
		1-300	192.50	895.56	703.06	188.04	912.17	724.13	3.00
	301	0-301	437.17	1183.82	746.65	438.73	1182.36	743.63	-0.40
		1-301	453.83	1496.65	1042.82	453.77	1493.11	1039.34	-0.33
	302	0-302	115.17	810.13	694.96	115.49	815.35	699.87	0.71
		1-302	669.83	1344.63	674.80	671.16	1343.51	672.35	-0.36
	303	0-303	480.50	1109.42	628.92	482.23	1063.51	581.28	-7.57
		1-303	123.50	678.33	554.83	122.53	673.79	551.27	-0.64
	304	0-304	310.17	926.84	616.67	309.13	906.58	597.45	-3.12
		1-304	163.50	860.46	696.96	162.14	871.52	709.37	1.78
+X Second Row	310	0-310	207.83	918.98	711.15	204.28	937.16	732.88	3.06
		1-310	336.50	1034.31	697.81	334.15	1024.52	690.37	-1.07
	311	0-311	212.83	743.59	530.76	209.98	776.55	566.57	6.75
		1-311	210.83	714.29	503.45	212.24	713.17	500.94	-0.50
	312	0-312	153.50	1016.98	863.48	151.89	1003.30	851.41	-1.40
		1-312	121.83	819.96	698.13	121.02	800.03	679.01	-2.74
	313	0-313	241.50	1386.88	1145.38	241.54	1356.12	1114.58	-2.69
		1-313	224.50	1111.79	887.29	224.44	1109.86	885.42	-0.21
	314	0-314	253.50	931.30	677.80	252.43	994.67	742.25	9.51
		1-314	121.50	891.13	769.63	120.83	895.82	774.99	0.70
+X Third	320	0-320	154.50	1021.87	867.37	155.22	1067.36	912.14	5.16

		1-320	260.83	1232.44	971.61	255.44	1200.35	944.91	-2.75
	321	0-321	168.17	917.21	749.04	166.89	964.90	798.01	6.54
		1-321	152.50	1129.58	977.08	152.17	1143.53	991.36	1.46
	322	0-322	121.50	1200.13	1078.63	123.08	1186.64	1063.56	-1.40
		1-322	543.17	1384.85	841.68	543.52	1389.41	845.89	0.50
	323	0-323	459.50	1140.92	681.42	461.51	1147.02	685.51	0.60
		1-323	448.83	1610.44	1161.61	449.24	1594.21	1144.97	-1.43
	324	0-324	488.50	1443.32	954.82	488.10	1451.81	963.72	0.93
	1-324	203.50	1136.16	932.66	202.09	1125.46	923.37	-1.00	
+X, Bottom	330	0-330	205.50	1012.80	807.30	199.53	1018.74	819.21	1.48
		1-330	490.83	1341.91	851.08	490.44	1373.65	883.21	3.78
+Y Top Row	400	0-400	199.83	1221.86	1022.03	196.78	1250.90	1054.12	3.14
		1-400	684.17	1410.90	726.73	684.29	1439.90	755.61	3.97
	401	0-401	180.50	920.00	739.50	177.30	945.54	768.24	3.89
		1-401	457.17	1006.07	548.90	456.23	1028.06	571.83	4.18
	402	0-402	289.83	1283.98	994.15	288.96	1324.06	1035.10	4.12
		1-402	179.83	985.51	805.68	179.67	977.09	797.42	-1.03
	403	0-403	99.50	863.26	763.76	99.58	897.04	797.46	4.41
		1-403	112.50	788.73	676.23	111.15	810.72	699.57	3.45
404	0-404	165.17	688.73	523.57	163.80	699.92	536.12	2.40	
	1-404	124.50	856.15	731.65	123.51	882.68	759.16	3.76	
+Y Second Row	410	0-410	169.17	746.59	577.42	167.00	737.88	570.88	-1.13
		1-410	383.83	992.43	608.59	380.26	1017.45	637.19	4.70
	411	0-411	398.50	1300.32	901.82	399.01	1304.08	905.08	0.36
		1-411	314.83	944.47	629.63	315.81	939.50	623.69	-0.94
	412	0-412	270.50	1094.61	824.11	271.17	1093.15	821.98	-0.26
		1-412	216.50	1033.21	816.71	215.94	1016.47	800.53	-1.98
	413	0-413	480.83	1166.25	685.42	481.42	1191.84	710.42	3.65
		1-413	300.50	900.86	600.36	301.13	956.69	655.56	9.20
414	0-414	99.50	767.19	667.69	97.08	774.97	677.89	1.53	
	1-414	170.50	769.78	599.28	168.70	760.82	592.11	-1.20	
+Y Third Row	420	0-420	369.17	1446.39	1077.22	368.62	1482.00	1113.38	3.36
		1-420	212.50	937.06	724.56	210.94	962.46	751.52	3.72
	421	0-421	535.83	1018.84	483.01	536.91	1049.32	512.41	6.09
		1-421	218.50	636.65	418.15	218.14	655.82	437.68	4.67

	422	0-422	214.17	1224.68	1010.51	214.18	1250.96	1036.79	2.60
		1-422	179.50	1081.32	901.82	174.64	1051.60	876.96	-2.76
	423	0-423	182.83	315.64	132.80	182.09	369.89	187.80	41.41
		1-423	182.50	625.99	443.49	179.71	622.75	443.04	-0.10
	424	0-424	630.50	1635.78	1005.28	631.98	1640.87	1008.89	0.36
		1-424	166.50	915.52	749.02	165.41	891.28	725.87	-3.09
+Y, Bottom	430	0-430	632.50	1579.15	946.65	626.03	1588.32	962.29	1.65
		1-430	187.17	849.69	662.52	179.99	837.61	657.63	-0.74

Table 2	Tile #	Cable # [PMT #]	Mean Pedestal	Reference MPV (pol7 fit)	Reference MIP (pol7 fit)	Pedestal Post-delivery at SLAC	MPV Post-delivery at SLAC	MIP Post-delivery at SLAC	Percentage change SLAC-Reference
Center, top row	020	0-020	445.50	1108.69	663.19	445.879	1125.32	679.44	2.45%
		1-020	213.83	1137.23	923.40	216.105	1155.64	939.54	1.75%
	021	0-021	265.50	977.35	711.85	266.106	985.35	719.25	1.04%
		1-021	512.50	1424.22	911.72	512.378	1441.71	929.33	1.93%
	022	0-022	520.50	1307.21	786.71	521.627	1295.93	774.30	-1.58%
		1-022	496.50	1333.66	837.16	495.251	1337.25	842.00	0.58%
	023	0-023	204.50	707.92	503.42	208.575	714.24	505.67	0.45%
		1-023	151.50	772.10	620.60	150.957	773.75	622.79	0.35%
	024	0-024	120.50	627.18	506.68	118.485	615.83	497.34	-1.84%
	1-024	109.50	843.34	733.84	107.349	851.47	744.12	1.40%	
Second, top rows	010	0-010	189.50	666.79	477.29	190.215	624.90	434.68	-8.93%
		1-010	728.50	1316.80	588.30	727.019	1301.62	574.60	-2.33%
	011	0-011	141.17	683.88	542.72	138.513	673.46	534.94	-1.43%
		1-011	219.50	692.76	473.26	220.401	705.50	485.10	2.50%
	012	0-012	174.83	929.76	754.93	171.714	928.59	756.88	0.26%
		1-012	372.50	1172.89	800.39	372.453	1197.14	824.69	3.04%
	013	0-013	197.17	734.46	537.29	197.814	732.09	534.28	-0.56%
		1-013	172.17	858.42	686.25	173.123	893.94	720.82	5.04%
	014	0-014	501.83	1102.73	600.90	500.769	1110.17	609.40	1.42%
		1-014	395.83	1245.22	849.39	398.187	1258.74	860.55	1.31%
	030	0-030	175.83	864.25	688.42	176.046	886.03	709.99	3.13%
		1-030	134.50	805.59	671.09	134.587	826.77	692.19	3.14%
	031	0-031	599.50	1220.65	621.15	599.642	1229.80	630.16	1.45%
		1-031	162.50	654.79	492.29	161.268	652.32	491.05	-0.25%
	032	0-032	195.50	917.73	722.23	195.444	934.19	738.75	2.29%
		1-032	683.83	1495.29	811.46	684.53	1492.77	808.24	-0.40%
	033	0-033	150.83	668.33	517.50	149.528	661.14	511.61	-1.14%
	1-033	211.17	710.43	499.26	210.315	721.98	511.66	2.48%	
034	0-034	199.50	718.03	518.53	197.786	720.96	523.17	0.90%	

		1-034	628.50	1224.90	596.40	631.931	1240.15	608.22	1.98%
Outside, top rows (bent tiles)	000	0-000	207.83	845.51	637.68	206.124	865.37	659.24	3.38%
		1-000	152.50	701.08	548.58	153.049	700.38	547.34	-0.23%
	001	0-001	221.50	819.01	597.51	223.243	833.91	610.67	2.20%
		1-001	163.50	764.07	600.57	165.349	766.31	600.96	0.07%
	002	0-002	207.17	679.82	472.65	205.307	683.27	477.96	1.12%
		1-002	136.50	671.85	535.35	135.74	671.42	535.68	0.06%
	003	0-003	454.50	971.10	516.60	455.648	979.82	524.17	1.47%
		1-003	557.17	993.64	436.48	555.698	992.64	436.94	0.11%
	004	0-004	205.50	864.52	659.02	205.322	872.50	667.18	1.24%
		1-004	129.83	1015.87	886.04	130.577	1028.99	898.41	1.40%
	040	0-040	339.17	1003.36	664.19	338.388	1006.40	668.01	0.57%
		1-040	303.83	787.67	483.84	303.667	795.67	492.00	1.69%
	041	0-041	209.17	639.73	430.56	205.493	637.68	432.19	0.38%
		1-041	567.17	1178.47	611.30	564.768	1187.48	622.71	1.87%
	042	0-042	164.50	824.74	660.24	163.005	841.34	678.33	2.74%
		1-042	411.50	941.49	529.99	409.801	938.16	528.36	-0.31%
043	0-043	232.50	710.47	477.97	231.298	679.99	448.69	-6.13%	
	1-043	639.50	1211.24	571.74	637.325	1217.97	580.65	1.56%	
044	0-044	230.50	654.44	423.94	230.531	650.47	419.94	-0.94%	
	1-044	573.17	1125.93	552.76	575.059	1139.16	564.10	2.05%	
-X Top Row	100	0-100	160.50	873.55	713.05	157.74	878.20	720.46	1.04%
		1-100	437.50	1279.97	842.47	437.425	1310.88	873.46	3.68%
	101	0-101	221.50	865.20	643.70	222.302	905.26	682.96	6.10%
		1-101	149.83	639.31	489.47	146.953	666.98	520.02	6.24%
	102	0-102	279.83	800.95	521.12	281.969	806.04	524.07	0.57%
		1-102	124.83	900.79	775.95	127.352	884.57	757.22	-2.41%
	103	0-103	148.17	662.60	514.44	148.333	680.45	532.11	3.44%
		1-103	256.50	1039.69	783.19	259.876	1042.14	782.26	-0.12%
104	0-104	547.17	1493.23	946.06	547.109	1502.56	955.45	0.99%	
	1-104	128.50	871.08	742.58	129.523	888.21	758.69	2.17%	
-X Second Row	110	0-110	181.83	897.08	715.25	181.659	937.16	755.50	5.63%
		1-110	260.17	1123.61	863.44	260.8	1084.54	823.74	-4.60%
	111	0-111	192.50	855.96	663.46	189.348	855.74	666.39	0.44%
		1-111	245.50	1094.76	849.26	246.023	1097.81	851.79	0.30%

	112	0-112	431.50	1001.04	569.54	432.707	994.99	562.28	-1.27%
		1-112	372.50	1218.53	846.03	370.759	1234.19	863.43	2.06%
	113	0-113	460.50	1133.11	672.61	460.206	1141.87	681.66	1.35%
		1-113	344.17	975.48	631.31	344.654	1000.59	655.94	3.90%
	114	0-114	297.50	1001.06	703.56	300.065	985.29	685.22	-2.61%
		1-114	181.17	1315.27	1134.10	179.636	1370.15	1190.51	4.97%
-X Third Row	120	0-120	241.50	799.16	557.66	242.231	791.92	549.69	-1.43%
		1-120	334.17	1151.92	817.75	334.848	1113.59	778.74	-4.77%
	121	0-121	288.50	959.79	671.29	290.41	998.44	708.03	5.47%
		1-121	512.50	1348.57	836.07	512.801	1332.68	819.88	-1.94%
	122	0-122	113.17	986.09	872.92	112.097	989.17	877.07	0.47%
		1-122	619.83	1677.19	1057.36	618.344	1716.40	1098.06	3.85%
	123	0-123	221.50	1111.35	889.85	220.129	1069.87	849.74	-4.51%
		1-123	199.50	1075.40	875.90	197.996	1067.68	869.68	-0.71%
-X, Bottom	124	0-124	141.50	687.74	546.24	142.052	714.80	572.75	4.85%
		1-124	468.83	1137.40	668.57	465.02	1124.82	659.80	-1.31%
-Y Top Row	130	0-130	159.50	874.90	715.40	158.066	860.23	702.16	-1.85%
		1-130	192.50	1107.53	915.03	191.225	1077.94	886.72	-3.09%
	200	0-200	146.50	909.95	763.45	143.091	914.78	771.69	1.08%
		1-200	162.50	972.18	809.68	162.649	952.49	789.84	-2.45%
	201	0-201	192.50	841.36	648.86	193.867	874.36	680.49	4.87%
		1-201	376.83	902.20	525.37	374.694	916.87	542.17	3.20%
	202	0-202	165.83	643.52	477.68	167.741	659.18	491.44	2.88%
		1-202	115.83	876.88	761.05	114.384	885.22	770.83	1.29%
	203	0-203	202.17	779.57	577.40	204.054	805.95	601.89	4.24%
		1-203	464.50	1181.57	717.07	464.977	1211.31	746.33	4.08%
-Y Second Row	204	0-204	686.50	1322.87	636.37	688.357	1355.23	666.87	4.79%
		1-204	411.50	1089.73	678.23	410.639	1084.71	674.07	-0.61%
	210	0-210	249.50	993.83	744.33	248.097	1007.32	759.22	2.00%
		1-210	128.50	916.85	788.35	128.245	899.13	770.89	-2.22%
	211	0-211	128.50	844.00	715.50	124.603	855.85	731.25	2.20%
		1-211	423.83	1123.83	700.00	427.004	1173.94	746.94	6.71%
	212	0-212	281.50	993.46	711.96	278.845	990.42	711.58	-0.05%
		1-212	154.17	862.59	708.42	152.028	858.82	706.79	-0.23%
	213	0-213	221.17	898.56	677.40	221.006	895.54	674.53	-0.42%

		1-213	198.50	969.79	771.29	198.179	977.72	779.54	1.07%
	214	0-214	592.50	1215.56	623.06	590.447	1225.94	635.49	2.00%
		1-214	397.50	1346.50	949.00	397.632	1335.16	937.53	-1.21%
-Y Third Row	220	0-220	128.50	849.03	720.53	129.083	888.73	759.65	5.43%
		1-220	109.50	1098.47	988.97	110.431	1131.35	1020.92	3.23%
	221	0-221	173.83	719.34	545.51	169.551	738.93	569.38	4.38%
		1-221	297.50	940.80	643.30	296.474	885.49	589.01	-8.44%
	222	0-222	165.50	943.92	778.42	162.952	967.44	804.49	3.35%
		1-222	652.50	1496.13	843.63	650.817	1559.50	908.68	7.71%
	223	0-223	372.50	1201.61	829.11	372.73	1276.15	903.42	8.96%
		1-223	345.50	1096.97	751.47	343.165	1105.51	762.35	1.45%
	224	0-224	168.50	892.13	723.63	165.797	853.62	687.82	-4.95%
		1-224	264.17	1200.05	935.88	264.309	1176.28	911.97	-2.56%
-Y, Bottom	230	0-230	213.17	995.12	781.95	209.219	1009.15	799.93	2.30%
		1-230	112.50	990.18	877.68	109.875	1001.09	891.22	1.54%
+X Top Row	300	0-300	325.50	976.58	651.08	323.619	995.27	671.65	3.16%
		1-300	192.50	895.56	703.06	187.034	902.24	715.21	1.73%
	301	0-301	437.17	1183.82	746.65	439.314	1194.83	755.52	1.19%
		1-301	453.83	1496.65	1042.82	452.214	1474.42	1022.21	-1.98%
	302	0-302	115.17	810.13	694.96	113.735	818.69	704.96	1.44%
		1-302	669.83	1344.63	674.80	671.423	1338.63	667.21	-1.12%
	303	0-303	480.50	1109.42	628.92	483.117	1083.28	600.16	-4.57%
		1-303	123.50	678.33	554.83	122.306	659.87	537.57	-3.11%
	304	0-304	310.17	926.84	616.67	310.172	931.58	621.41	0.77%
		1-304	163.50	860.46	696.96	163.426	849.78	686.35	-1.52%
+X Second Row	310	0-310	207.83	918.98	711.15	204.177	919.87	715.69	0.64%
		1-310	336.50	1034.31	697.81	335.517	1001.14	665.62	-4.61%
	311	0-311	212.83	743.59	530.76	209.539	739.09	529.55	-0.23%
		1-311	210.83	714.29	503.45	211.324	700.38	489.06	-2.86%
	312	0-312	153.50	1016.98	863.48	151.717	951.32	799.61	-7.40%
		1-312	121.83	819.96	698.13	120.813	809.22	688.41	-1.39%
	313	0-313	241.50	1386.88	1145.38	242.152	1358.82	1116.67	-2.51%
		1-313	224.50	1111.79	887.29	224.243	1089.00	864.76	-2.54%
	314	0-314	253.50	931.30	677.80	251.743	968.54	716.80	5.75%
		1-314	121.50	891.13	769.63	120.152	884.12	763.97	-0.74%

+X Third Row	320	0-320	154.50	1021.87	867.37	155.212	1098.70	943.49	8.78%
		1-320	260.83	1232.44	971.61	258.543	1166.87	908.33	-6.51%
	321	0-321	168.17	917.21	749.04	165.908	930.77	764.86	2.11%
		1-321	152.50	1129.58	977.08	151.33	1133.04	981.71	0.47%
	322	0-322	121.50	1200.13	1078.63	121.61	1161.51	1039.90	-3.59%
		1-322	543.17	1384.85	841.68	543.743	1335.16	791.42	-5.97%
	323	0-323	459.50	1140.92	681.42	460.459	1212.10	751.64	10.31%
		1-323	448.83	1610.44	1161.61	449.666	1580.14	1130.47	-2.68%
	324	0-324	488.50	1443.32	954.82	488.006	1590.97	1102.96	15.52%
	1-324	203.50	1136.16	932.66	200.831	1170.01	969.18	3.92%	
+X, Bottom	330	0-330	205.50	1012.80	807.30	203.284	1017.89	814.61	0.90%
		1-330	490.83	1341.91	851.08	491.172	1368.40	877.23	3.07%
+Y Top Row	400	0-400	199.83	1221.86	1022.03	198.025	1224.08	1026.06	0.39%
		1-400	684.17	1410.90	726.73	686.294	1441.73	755.44	3.95%
	401	0-401	180.50	920.00	739.50	177.32	913.71	736.39	-0.42%
		1-401	457.17	1006.07	548.90	457.109	1018.01	560.90	2.19%
	402	0-402	289.83	1283.98	994.15	288.095	1321.59	1033.50	3.96%
		1-402	179.83	985.51	805.68	179.78	955.14	775.36	-3.76%
	403	0-403	99.50	863.26	763.76	97.117	877.50	780.38	2.18%
		1-403	112.50	788.73	676.23	110.448	825.60	715.15	5.76%
	404	0-404	165.17	688.73	523.57	164.516	680.91	516.40	-1.37%
	1-404	124.50	856.15	731.65	123.44	844.00	720.56	-1.52%	
+Y Second Row	410	0-410	169.17	746.59	577.42	168.604	724.18	555.58	-3.78%
		1-410	383.83	992.43	608.59	379.196	993.29	614.09	0.90%
	411	0-411	398.50	1300.32	901.82	399.03	1283.38	884.35	-1.94%
		1-411	314.83	944.47	629.63	315.132	916.80	601.67	-4.44%
	412	0-412	270.50	1094.61	824.11	272.151	1087.33	815.18	-1.08%
		1-412	216.50	1033.21	816.71	215.444	1010.11	794.67	-2.70%
	413	0-413	480.83	1166.25	685.42	481.221	1153.19	671.97	-1.96%
		1-413	300.50	900.86	600.36	301.093	932.22	631.13	5.13%
	414	0-414	99.50	767.19	667.69	98.862	761.43	662.57	-0.77%
	1-414	170.50	769.78	599.28	169.794	770.04	600.24	0.16%	
+Y Third Row	420	0-420	369.17	1446.39	1077.22	368.229	1477.74	1109.51	3.00%
		1-420	212.50	937.06	724.56	210.154	952.49	742.34	2.45%
	421	0-421	535.83	1018.84	483.01	537.704	1030.63	492.93	2.05%

		1-421	218.50	636.65	418.15	217.249	640.64	423.39	1.25%
	422	0-422	214.17	1224.68	1010.51	213.267	1227.62	1014.35	0.38%
		1-422	179.50	1081.32	901.82	176.989	1035.73	858.74	-4.78%
	423	0-423	182.83	315.64	132.80	182.151	349.67	167.52	26.14%
		1-423	182.50	625.99	443.49	179.095	612.23	433.13	-2.34%
	424	0-424	630.50	1635.78	1005.28	632.226	1772.20	1139.97	13.40%
		1-424	166.50	915.52	749.02	163.986	896.20	732.21	-2.24%
+Y, Bottom	430	0-430	632.50	1579.15	946.65	630.572	1585.84	955.27	0.91%
		1-430	187.17	849.69	662.52	182.493	865.54	683.05	3.10%

Other comparisons

Table 3 shows comparisons at various stages of testing relative to the reference. All of these are tests run at room temperature. None of these represent significant changes in overall performance of the ACD.

Table 3

Test Condition	Mean % change from reference
Post Z-axis vibration	< 1%
Post XY-axis vibration	< 1%
Post acoustics	- 2.6%
After first hot soak	+ 1.0%
After thermal vac, still in vacuum	+ 2.5%

Table 4 shows performance changes with temperature, as seen during the thermal vacuum tests. Such changes are statistically significant and were expected from component tests. Note that the expected operating temperature of the ACD on orbit is about 0 C.

Table 4

Test Condition	Mean % change from reference
Cold -25 C (average of 4 runs)	+ 38%
Hot +35 C (average of 2 runs)	- 8%
0 C	+ 20%