

ACD Performance Validation and Calibration

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ACD-RPT-000372

Outline

- I. Performance Validation**
- II. High Voltage settings**
- III. VETO threshold calibration**
- IV. Performance Monitoring**

I. Performance Validation

1. TDA Light Yield determination – **results of ACD Performance Test**

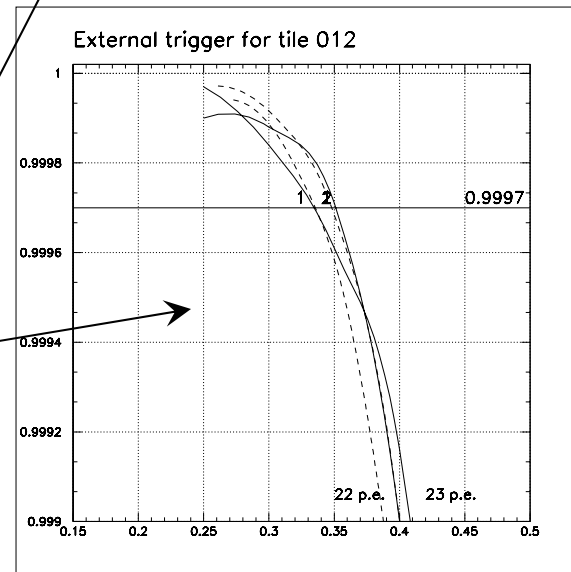
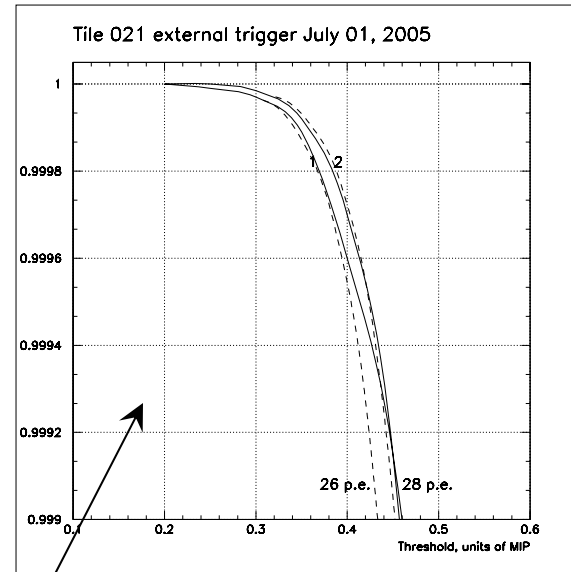
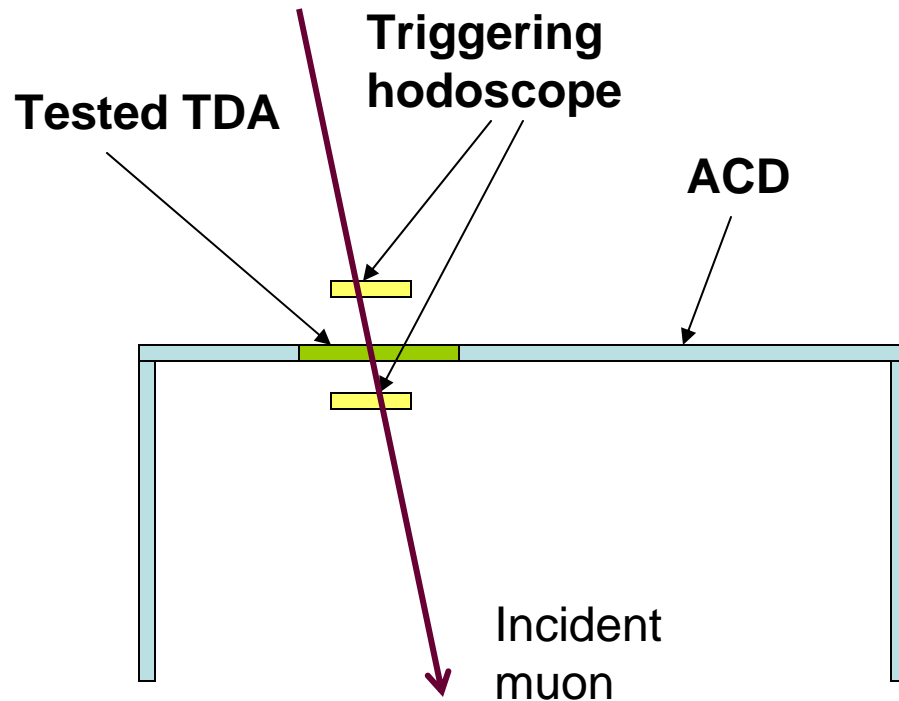
- approach is given in ACD-PLAN-000332 “ACD On-Ground Science Performance Calibration and Monitoring”
- The idea is based on determining the light yield (L.Y.) for 3 arbitrarily selected TDA’s (012, 021, and 022) by carefully measuring their efficiency and deriving L.Y. from obtained efficiency value. From these measurements we determined the ADC sensitivity A_{fl} ,

$$A_{fl} = \frac{1}{6} \times \sum_{i=1}^6 \frac{P_i}{LY_i \times G_{i,fl}}$$

and after that **determined L.Y. for all remaining TDA channels** as

$$LY = \frac{P}{A_{fl} \times G_{fl}}$$

where P is the MIP peak position obtained in performed tests, G is the given PMT gain (taken from PMT data sheets)



Results obtained in ACD Performance Test:

Notice that tile 021 is thicker than 012 and consequently has higher L.Y. All obtained L.Y. values (can be found in "Light Budget Table") were put in ACD Performance Simulation model to determine ACD entire efficiency

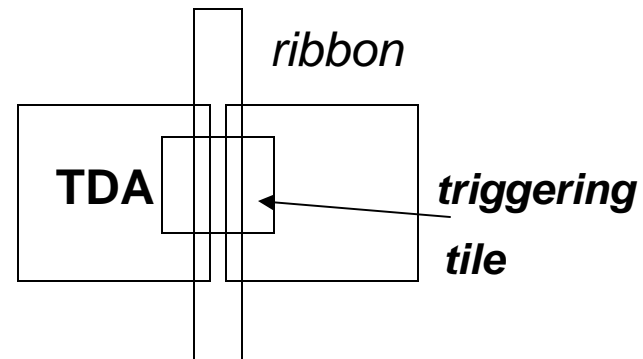
The example: First page of “Light Budget Table”

Light Yield, determined in this test

Tile Number	Cable # [PMT #]	Pedestal @ 700	Pedestal @ 750	Pedestal @ 800	Mean Pedestal	via Landau fit	using Landau fit	via polynomia	reference, TOP	coeff. Applied	position for	previous but	PMT Gain at 1250V	Flight PMT Q.E	L.Y. with reference	L.Y., inferred
020	0-020	445.5	445.5	445.5	445.5	1169.39	723.89	1101.68	660.07	0.92	607	607	15.7	22.1	16	26.9
	1-020	214.5	213.5	213.5	213.8	1209.48	995.68	1132.26	916.4	0.92	843	739	20.7	20.3	16.3	24.9
021	0-021	265.5	265.5	265.5	265.5	1036.91	771.41	972.228	707.976	0.82	579	579	18	20	16	22.4
	1-021	512.5	512.5	512.5	512.5	1465.25	952.75	1426.67	910.17	0.82	746	654	19.5	20	16.7	23.4
022	0-022	520.5	520.5	520.5	520.5	1369.83	849.33	1343.74	790.61	0.73	577	577	18.5	18.7	16.3	21.7
	1-022	496.5	496.5	496.5	496.5	1365.8	869.3	1333.81	826.49	0.73	603	529	14.9	18.6	16.5	24.7
023	0-023	204.5	204.5	204.5	204.5	756.982	552.482	705.823	499.8	0.82	410	283	8.1	21.8	17.3	24.3
	1-023	153.5	150.5	150.5	151.5	798.43	646.93	762.939	614.1	0.82	503	406	10	21.4	17	28.3
024	0-024	120.5	120.5	120.5	120.5	668.028	547.528	622.373	499.51	0.92	460	317	9	20.3	17.3	24.6
	1-024	109.5	109.5	109.5	109.5	901.267	791.767	839.302	729.4	0.92	671	541	11.8	19.9	14.5	32
010	0-010	189.5	189.5	189.5	189.5	704.501	515.001	664.391	472.3	0.92	434	434	19	20.1	14	15.9
	1-010	728.5	728.5	728.5	728.5	1333.15	604.65	1313.11	581.83	0.92	535	469	14.4	23.7	13.8	22.7
011	0-011	140.5	141.5	141.5	141.5	709.57	568.07	679.382	533.5	0.82	437	437	15.6	18.8	15.2	20.4
	1-011	219.5	219.5	219.5	219.5	729.833	510.333	692.2	471.8	0.82	386	339	14.5	18.2	14.4	16.3
012	0-012	173.5	174.5	176.5	174.8	1008.07	833.27	926.294	745	0.82	611	647	18.3	22.2	15.8	24.6
	1-012	372.5	372.5	372.5	372.5	1222.07	849.57	1166.74	790.87	0.82	649	497	14.9	21.4	16.4	23.2
013	0-013	196.5	197.5	197.5	197.2	771.264	574.064	732.644	534.9	0.82	439	465	15.2	21.5	17.5	21.3
	1-013	172.5	172.5	171.5	172.2	905.555	733.355	847.513	669.2	0.82	548	420	13.6	21.3	15.8	21.5
014	0-014	501.5	501.5	502.5	501.8	1150.17	648.37	1099.3	597.2	0.92	549	582	16.3	22.2	14.6	24.9
	1-014	396.5	395.5	395.5	395.8	1293.7	897.9	1244.37	846.3	0.92	778	596	17.8	21.1	16.4	23.3
030	0-030	174.5	176.5	176.5	175.8	894.538	718.738	866.488	687	0.92	632	415	15	18.7	14.4	19.2
	1-030	134.5	134.5	134.5	134.5	841.562	707.062	801.26	664.67	0.92	612	469	14.6	21.6	14.1	22.3
031	0-031	599.5	599.5	599.5	599.5	1290.09	690.59	1221.78	615.84	0.82	505	331	11.3	21.6	14.1	20.3
	1-031	162.5	162.5	162.5	162.5	699.638	537.138	651.966	489.2	0.82	401	307	14.9	20.1	14.9	14.4
032	0-032	195.5	195.5	195.5	195.5	981.309	785.809	916.545	715.3	0.82	586	384	10.5	21.7	16.5	25.5
	1-032	684.5	683.5	683.5	683.8	1555.4	871.6	1494.17	806.8	0.82	662	507	13.3	21.4	16.6	26.6
033	0-033	150.5	150.5	151.5	150.8	715.075	564.275	665.606	513	0.82	421	290	9.4	21.2	18.2	21.5
	1-033	210.5	211.5	211.5	211.2	761.241	550.041	704.267	495.6	0.82	407	328	14.2	18.1	17	16.1

2. Ribbon Light Yield Determination

- This was the issue of our concern
 - by the design the ribbons performance is marginal
 - ACD would never achieve required performance without proper functioning ribbons
 - required L.Y. from the ribbons is 3 p.e. from the ribbon center (average for both ends) and 6 p.e. at the crown tile level
- Approach to the measurement was similar to that used for the TDA's. Triggering hodoscope was installed such a way to cover the ribbon and both adjacent TDA's



- Each of 8 ribbons was tested in 2 points to confirm light attenuation along the ribbon

Ribbons Light yield

Ribbon	PMT	End (level of crown tiles)	Center	End (level of crown tiles)	Attenuation coefficient
500	0	11.1		2.0	0.18
	1	2.7		12.0	0.23
501	0	10.7		1.7	0.16
	1	2.2		11.4	0.19
502	0	1.3 ?		8.5	0.15
	1	11.9		1.1	0.09
503	0	2.3		10.0	0.23
	1	11.4		1.8	0.16
600	0	10.1	2.8		0.28
	1	1.6	4.1		0.39
601	0	1.6	4.1		0.39
	1	8.5	2.4		0.29
602	0	8.9	2.7		0.30
	1	1.7	3.8		0.45
603	0	1.5	3.8		0.39
	1	12.9	3.3		0.26

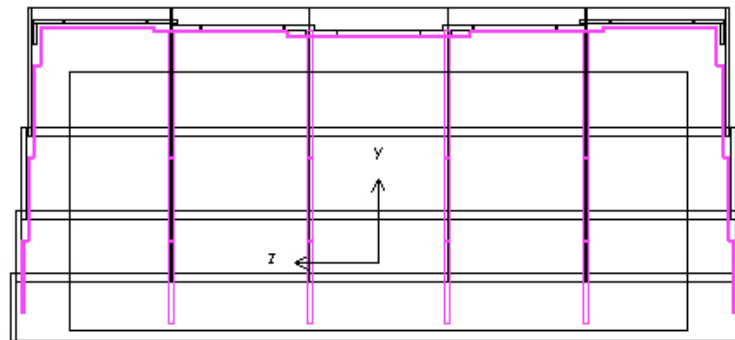
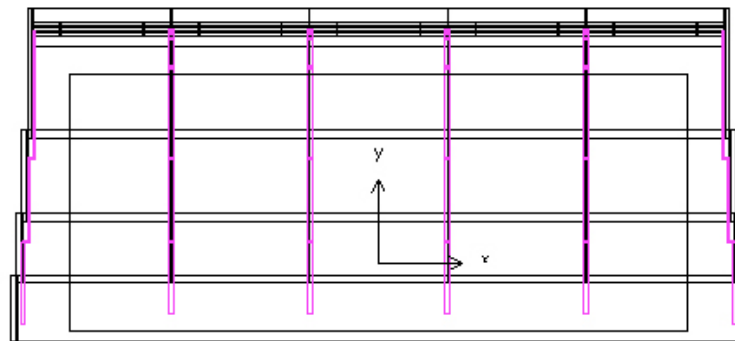
Ribbons Performance test data demonstrates that all they meet L.Y. requirements. Obtained data put in ACD Performance Simulation model

3. ACD Mechanical properties

- **All gaps and clearances between TDA's and ribbons were carefully measured on the flight unit**
- **The gap requirements at room temperature were as follows:**
 - **tile butt joints – 2 mm**
 - **tile vertical gaps – 3 mm**
 - **tile – to ribbon gaps 2 mm except bending and corner areas**
 - **corner gaps 4 mm**
- **All gaps measured at room temperature were corrected to - 20C**
- **Given above gap values (increased for the lower temperature) were put in ACD Performance Simulation model**
- **All measured gaps are found to be less than required (in average)**

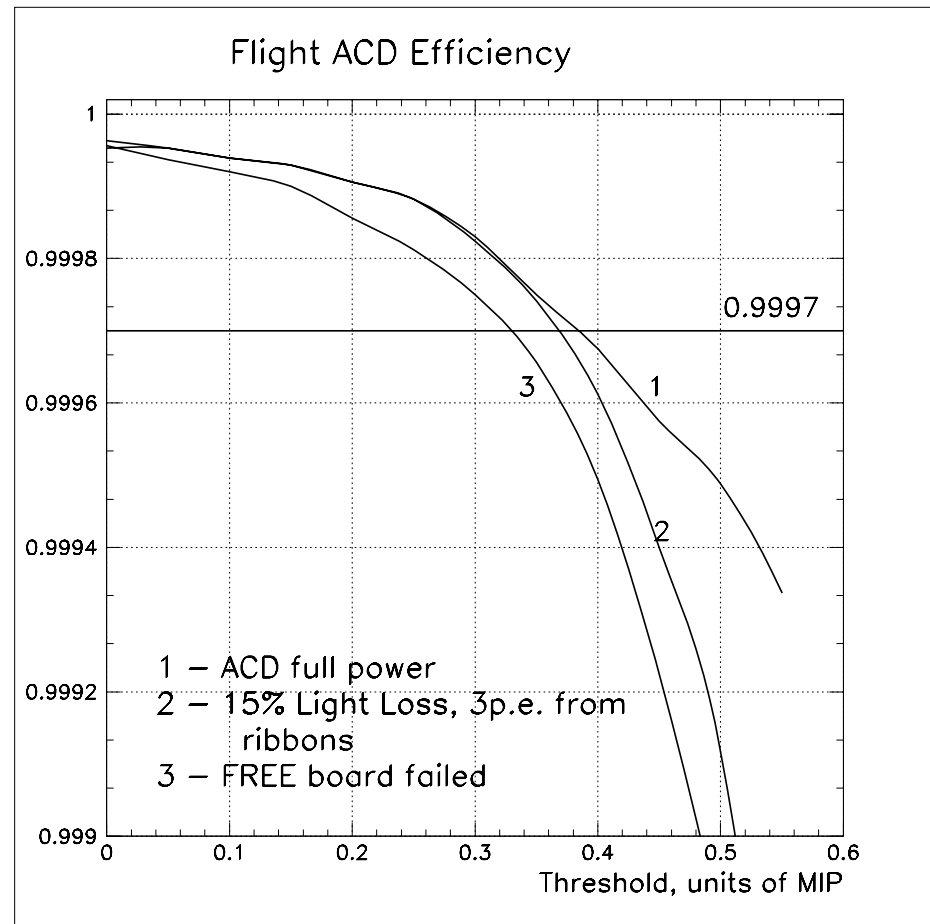
Flight ACD Total Efficiency

Simulation Model



Simulations were performed for the following cases:

- **all determined L.Y. values; ribbon L.Y. 4 p.e. from the ribbon center – line 1**
- **1 FREE board failed; 17 tiles operate with only 1 PMT (including 8 tiles on the top) – line 3**
- **L.Y. from every detector is reduced by 15%; L.Y. from the ribbon center is 3 p.e. – line 2**



ACD does meet particle detection efficiency requirement with margins

II. High Voltage Selection

- This action provides the fulfillment of the Level III Requirement *(precision of threshold setting – please insert number from ACD Level III Reqt)*
- High Voltage affects the *MIP* peak position as $\sim HV^{7.8}$, so HV setting has to be done very carefully
- The task is to have a *MIP* peak position for Low Gain Range to be separated from the pedestal by at least 400 ADC bins
- The approach is to select the HV to have the *MIP* peak of the weakest PMT in the FREE board to be separated from the pedestal by at least 400 ADC bins; doing this the strongest PMT in the FREE board can have a *MIP* peak position distanced from the pedestal by 800 or more ADC

Several special test runs were performed to select High Voltage Settings; final values are as follows:

1L – 740 V	1R – 760 V	2LA – 720 V
2LB – 730 V	2RA – 715 V	2RB – 745 V
3L – 820 V	3R – 800 V	4LA – 755 V
4LB – 740 V	4RA – 760 V	4RB – 745 V

These values will be used for all future Performance Monitoring Tests in order to compare current (for the test time) *MIP* peak positions with that reference values taken during ACD Performance Tests at Goddard

III. VETO Threshold Calibration

- **ACD efficiency depends strongly on the VETO threshold setting**
- **Task of VETO threshold calibration is to find a dependence of VETO threshold in units of PHA bins vs. threshold setting units, for every ACD channel**
- **The problem is that there is a very small muon statistics in the cosmic muon pulse height spectrum (which we used in this test) with pulse heights below ~ 0.4 mip. To get more statistics of these events, tests were run at lowered HV.**
- **Test runs were performed with VETO threshold settings 0.064, 0.096, 0.128, 0.196, 0.256, 0.32, and 0.64 pC**
- **Obtained results were used to make calibration dependences. Pretty good linearity was found.**

IV. Performance Monitoring

- **As a result of ACD Performance Test the efficiency of charged particle detection was determined.**
- **Now we will have to continuously monitor *mip* peak positions for every ACD channel and make appropriate corrections in Light Budget Table and run Performance Simulation model again if needed**
- **First step of this monitoring was done during ACD Environmental Tests at Goddard in July 2005. We allowed for 10% *mip* peak position variation from test to test.**
- **Test results – variations are within 10% range**

Example of ACD Performance monitoring table

Tile Number	Cable # [PMT #]	Mean Pedestal	Reference MIP position	Post-Z	% diff., Post-Z and reference	Post-XY	% diff., Post-ZX and reference	Pre-thermal	% diff., Pre-thermal and reference	Thermal 1 23C	% diff., Thermal 1 and reference	Thermal 2 -25C	% diff., Thermal 2 and reference	Thermal 3 +35C	% diff., Thermal 3 and reference	Thermal 4 -25C	% diff., Thermal 4 and reference
000	0-000	207.83	637.68	643.50	0.91	657.77	3.15	629.22	-1.33	661.79	3.78	898.012	35.40795	634.249	-4.36391	887.982	33.89557
000	1-000	152.50	548.58	545.66	-0.53	545.77	-0.51	532.12	-3.00	542.85	-1.04	1299.768	40.75944	856.267	-7.26986	1276.592	38.24958
001	0-001	221.50	597.51	600.99	0.58	606.69	1.54	576.13	-3.58	611.95	2.42	973.54	36.76138	646.964	-9.11551	932.004	30.92647
001	1-001	163.50	600.57	603.14	0.43	601.34	0.13	585.03	-2.59	596.94	-0.60	1148.374	25.95687	822.165	-9.82264	1141.516	25.20467
002	0-002	207.17	472.65	472.88	0.05	487.77	3.20	466.60	-1.28	480.29	1.62	963.24	22.43902	625.013	-20.5536	968.623	23.12326
002	1-002	136.50	535.35	535.07	-0.05	528.24	-1.33	517.69	-3.30	525.63	-1.82	1019.558	21.78771	694.674	-17.0202	1074.428	28.34201
003	0-003	454.50	516.60	526.42	1.90	501.49	-2.93	505.58	-2.13	502.13	-2.80	649.722	29.06187	421.368	-16.2987	661.583	31.41796
003	1-003	557.17	436.48	443.89	1.70	440.29	0.87	426.70	-2.24	449.94	3.09	800.627	29.00896	530.229	-14.5616	827.429	33.32769
004	0-004	205.50	659.02	668.91	1.50	643.66	-2.33	643.51	-2.35	633.94	-3.81	682.887	34.77731	435.886	-13.9718	677.292	33.67306
004	1-004	129.83	886.04	890.28	0.48	896.81	1.22	869.74	-1.84	929.07	4.86	999.042	36.1395	663.244	-9.61971	996.692	35.81926
010	0-010	189.50	477.29	485.66	1.75	500.32	4.83	471.61	-1.19	449.50	-5.82	603.259	26.39281	422.543	-11.4702	592.019	24.03785
010	1-010	728.50	588.30	587.07	-0.21	585.40	-0.49	569.82	-3.14	590.04	0.30	800.602	36.08737	545.263	-7.31549	786.028	33.61006
011	0-011	141.17	542.72	538.07	-0.86	550.36	1.41	510.61	-5.92	542.88	0.03	751.298	38.43291	498.993	-8.05639	754.348	38.9949
011	1-011	219.50	473.26	484.40	2.35	482.43	1.94	455.55	-3.74	474.42	0.25	664.259	40.35845	424.051	-10.3977	651.672	37.69881
012	0-012	174.83	754.93	763.58	1.15	724.25	-4.06	717.25	-4.99	711.21	-5.79	922.056	22.13816	658.164	-12.8177	966.401	28.01223
012	1-012	372.50	800.39	806.60	0.78	808.55	1.02	745.37	-6.87	794.56	-0.73	1059.256	32.34248	728.344	-9.00136	1117.152	39.57596
013	0-013	197.17	537.29	534.67	-0.49	524.20	-2.44	504.75	-6.06	518.71	-3.46	718.634	33.75053	451.234	-16.0174	708.416	31.84878
013	1-013	172.17	686.25	704.17	2.61	696.53	1.50	663.65	-3.29	727.41	6.00	912.23	32.92885	653.878	-4.71783	935.616	36.33663
014	0-014	501.83	600.90	610.69	1.63	579.72	-3.52	590.25	-1.77	582.15	-3.12	832.286	38.50734	531.605	-11.5314	824.442	37.20196
014	1-014	395.83	849.39	857.04	0.90	846.54	-0.34	826.30	-2.72	888.32	4.58	1158.552	36.39866	824.842	-2.88969	1168.074	37.5197
020	0-020	445.50	663.19	656.62	-0.99	681.12	2.70	654.81	-1.26	696.10	4.96	1027.327	49.22976	610.868	-11.2652	981.666	42.59703
020	1-020	213.83	923.40	919.21	-0.45	924.03	0.07	888.44	-3.79	929.22	0.63	978.473	45.80267	696.895	3.844618	961.248	43.23597
021	0-021	265.50	711.85	727.01	2.13	735.24	3.29	676.95	-4.90	709.44	-0.34	858.324	38.18305	518.158	-16.5809	846.417	36.26612
021	1-021	512.50	911.72	922.67	1.20	909.05	-0.29	846.51	-7.15	896.55	-1.66	647.926	31.61497	478.183	-2.86539	643.288	30.67284
022	0-022	520.50	786.71	771.57	-1.92	798.30	1.47	686.94	-12.68	714.96	-9.12	950.435	31.59655	606.197	-16.0664	951.344	31.72241
022	1-022	496.50	837.16	830.43	-0.80	835.63	-0.18	746.10	-10.88	740.44	-11.55	1078.532	32.91307	814.816	0.413988	1072.868	32.21507
023	0-023	204.50	503.42	490.17	-2.63	487.43	-3.18	468.93	-6.85	463.67	-7.90	695.563	34.40917	444.35	-14.1347	701.234	35.50503
023	1-023	151.50	620.60	619.16	-0.23	619.95	-0.10	583.66	-5.95	607.64	-2.09	662.935	32.78263	465.525	-6.75762	681.205	36.44202
024	0-024	120.50	506.68	505.88	-0.16	483.65	-4.55	491.12	-3.07	480.31	-5.20	728.236	40.44213	454.016	-12.4419	723.105	39.45261
024	1-024	109.50	733.84	718.74	-2.06	745.43	1.58	714.97	-2.57	752.62	2.56	838.166	40.53756	561.56	-5.84172	834.813	39.97535
030	0-030	175.83	688.42	693.15	0.69	665.07	-3.39	670.83	-2.56	672.09	-2.37	917.252	43.84235	616.879	-3.26178	898.161	40.84853
030	1-030	134.50	671.09	677.85	1.01	676.39	0.79	668.17	-0.44	762.80	13.67	725.469	32.24392	519.515	-5.29892	703.329	28.20808
031	0-031	599.50	621.15	619.29	-0.30	593.77	-4.41	576.47	-7.19	573.55	-7.66	810.516	35.64804	581.565	-2.66923	797.086	33.40039