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To: SIS/CRIS Investigators
From: Dick Mewaldt, Christina Cohen
Subject: SIS/CRIS Gains and Offsets
1997.03.CMSC.a (CIT/C+S/VLSI Gains and Offsets)

This memo is to collect in one place the gains and offsets needed to convert PHA data in channels to energy losses in MeV. The numbers are primarily taken from a memo by Dick Mewaldt and Jay Cummings dated 6/28/96. It should be emphasized that these numbers are preliminary and subject to change upon further use. The offset values in particular may have systematic errors that will become evident when used for data analysis. Please inform us if any problems or inconsistencies arise using the gains and offsets presented here.

Two sets of numbers are required to calculate energy losses in the detectors: gains in MeV/channel and offsets in channels. Tests made at Teledyne with a calibrated test capacitor yielded the most accurate measurement of the instrument gain. Tests done at Caltech with an internal DAC produced the best values for the instrument offsets. In order to determine the gains in MeV/channel from the channels/Volt measured at Teledyne, the following equation must be used:

$$Eloss = 22.597 * Ctest / G$$

(for derivation see attached sheet)

where Eloss is the energy lost in the detector in MeV/channel, Ctest is the value of the capacitor in pF and G is the gain measured at Teledyne in channels/Volt. This equation is arrived at from the fact that ~44 fC (44×10^{-15} C) are collected for every 1 MeV of energy lost and the charge collected by the test capacitor is C * V, where C is the capacitor value in Farads and V is the measured voltage across it in Volts.

The Teledyne gains as well as the Caltech measured offsets for the various detectors of SIS and CRIS are given in a memo by Dick Mewaldt and Jay Cummings dated 6/28/96. These numbers (as well as the capacitances of the test capacitors) are included in the attached tables for completeness. In these tables you will find the calculated instrument gains in MeV/channel for each detector of the 2 (4) SIS (CRIS) telescopes. In addition, the average of the telescopes for each detector are given in case distinction between the two telescopes is not necessary (e.g., for simulations).

No gains or offsets are given for the individual SIS matrix detectors since each strip (on each side) has its own gain and offset. An offset value is determined by the instrument and subtracted prior to data transmission, so the offset given here can be taken to be zero. Currently Mark Wiedenbeck is working on determining typical gain values for each side of the matrix detectors. Until that is completed, we suggest

using the nominal value calculated by dividing the full scale energy value by the number of ADC channels (4096). The full scale values were taken from the SIS PHA characteristics sheet in the firmware documentation. It was found that calculated gains were consistently 10% higher than the nominal values for the stack detectors so we propose that the 'average' value for the gain of the matrix detectors be the nominal value + 10%. This value is given in the average section of the attached table. A future version of this memo will contain a better number based on Mark's work.

Derivation of energy loss (courtesy of Alan Cummings):

Question: If I put 1 volt on a test capacitor, C_t, how many electron-hole pairs does that represent and what is the equivalent energy loss for a charge particle in silicon?

$$Q \text{ (Coulombs)} = C_t \text{ (Farads)} * V \text{ (Volts)}$$

$$Q = 10^{-12}\, C_t \text{ (pF)} * V \text{ (Volts)}$$

$$Q_p \text{ (pairs)} = Q \,/\, 1.602 \times 10^{-19} \text{ (Coulomb / pair)}$$

A particle going through silicon losses ~ 3.62 eV / pair at 300 K (this is temperature dependent, at 77 K the loss is 3.76 eV; reference: G. Bertolini and A. Coche (eds.) *Semiconductor Detectors*, Elsevier-North Holland, Amsterdam, 1968).

So the equivalent energy loss in eV is

$$E_{loss} \text{ (eV)} = 3.62 \times 10^{-12} * C_t * V \,/\, 1.602 \times 10^{-19}$$

$$E_{loss} \text{ (eV)} = 22.597 \times 10^{6} * C_t * V$$

$$\mathbf{E_{loss} = 22.597 * C_t * V}$$

at 300 K

where E is in MeV, C is in pF and V is in Volts.

	Detector	TD Gain (Ch/Volt)	TD Ctest (pf)	Gain (MeV/ch)	Offset (ch)
0	Telescopes AB				
1	E1A	259.26	22.562	1.9665	47.6
2	E1B	253.81	22.562	2.0087	48.0
3	E2	259.61	22.562	1.9638	47.6
4	E3	254.95	34.541	3.0615	47.8
5	E4	257.32	34.541	3.0333	49.7
6	E5	255.19	34.541	3.0586	48.3
7	E6	256.38	34.541	3.0444	48.5
8	E7	262.26	34.541	2.9762	47.9
9	E8	258.98	34.541	3.0139	49.0
10	E9	472.00	2.7852	0.13334	48.4
11	G2	486.59	2.8027	0.13016	47.6
12	G3	476.80	2.7599	0.13080	45.7
13	G4	472.35	2.7599	0.13203	46.3
14	G5	464.90	2.7599	0.13415	45.9
15	G6	477.55	2.7599	0.13059	44.4
16	G7	479.89	2.7599	0.12996	44.1
17					
18	Telescopes CD				
19	E1C	257.09	22.562	1.9831	48.2
20	E1D	260.92	22.562	1.9540	48.4
21	E2	261.03	22.562	1.9532	48.3
22	E3	259.41	34.541	3.0089	47.3
23	E4	263.94	34.541	2.9572	48.3
24	E5	258.22	34.541	3.0227	47.9
25	E6	262.30	34.541	2.9757	48.7
26	E7	253.35	34.541	3.0808	47.8
27	E8	260.82	34.541	2.9926	48.2
28	E9	264.40	2.7852	0.23804	46.1
29	G2	470.07	2.8027	0.13473	46.9
30	G3	478.01	2.7599	0.13047	45.4
31	G4	459.50	2.7599	0.13572	46.2
32	G5	466.47	2.7599	0.13370	46.6
33	G6	447.56	2.7599	0.13935	46.4
34	G7	458.67	2.7599	0.13597	45.3
35					
36	Averages				
37					
38					
39	E1A/C			1.9748	47.9
40	E1B/D			1.9813	48.2
41	E2			1.9585	47.9
42	E3			3.0352	47.6
43	E4			2.9953	49.0
44	E5			3.0407	48.1
45	E6			3.0101	48.6
46	E7			3.0285	47.9

	Detector	TD Gain (Ch/Volt)	TD Ctest (pf)	Gain (MeV/ch)	Offset (ch)
47	E8			3.0032	48.6
48	E9			0.18569	47.2
49	G2			0.13244	47.2
50	G3			0.13063	45.6
51	G4			0.13388	46.2
52	G5			0.13392	46.2
53	G6			0.13497	45.4
54	G7			0.13296	44.7

	Detector	TD Gain (Ch/Volt)	TD Ctest (pf)	Gain (MeV/ch)	Offset (ch)
0	Telescope A				
1	M1				
2	M2				
3	T1	296.16	2.9720	0.22676	48.0
4	T2	295.17	2.9720	0.22752	47.6
5	T3	369.74	7.2310	0.44193	49.7
6	T4	267.50	8.4490	0.71373	48.5
7	T5	269.41	12.411	1.0410	49.0
8	T6	254.13	22.447	1.9960	47.6
9	T7	257.90	34.662	3.0371	46.3
10	T8	512.50	2.9650	0.13073	44.4
11					
12	Telescope B				
13	M1				
14	M2				
15	T1	293.02	2.9720	0.22919	47.6
16	T2	303.99	2.9720	0.22092	47.8
17	T3	372.04	7.2310	0.43920	48.3
18	T4	273.38	8.4490	0.69838	47.9
19	T5	271.83	12.411	1.0317	48.4
20	T6	248.63	22.447	2.0401	45.7
21	T7	263.86	34.662	2.9685	45.9
22	T8	495.39	2.9650	0.13525	44.1
23					
24	Averages				
25	M1			0.18000	0.00
26	M2			0.18000	0.00
27	T1			0.22798	47.8
28	T2			0.22422	47.7
29	T3			0.44056	49.0
30	T4			0.70605	48.2
31	T5			1.0363	48.7
32	T6			2.0180	46.7
33	T7			3.0028	46.1
34	T8			0.13299	44.3