Heavy Ion Single Event Effect (SEE) Report

AAHS298B

(8 Channel 700mA High Side Driver)

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CHANGE RECORD

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1) General

This report details the heavy ions single event radiation tests performed on the AAHS298B by Microsemi engineers on October 9th at LBNL (Lawrence Berkeley National Laboratory, see website http://www.lbl.gov/nsd/user88/). We used LBNL's 10 MeV per nucleon cocktail with LET's ranging from 11.49 to 117.56 MeV-cm^2/mg. Our goal was to measure Single Event Transients (SET) to determine if this part is suitable for space applications. Single Event Latch-up (SEL), Single Event Burnout (SEB) and Single Event Gate Rupture (SEGR) were also monitored.

2) Test Plan & Test Setup

We used two test boards for this experiment. The device under test (DUT) board was attached to the cooling plate inside the LBNL vacuum chamber. The schematic for this board is shown in Fig. 1. Twelve feet of BNC cables were connected from the vacuum's feed-through to the control board located in the control room above the chamber room. The schematic for the control board is shown in Fig. 2. The following five tests were conducted for all LET's selected:

1. No channels On, Vs=50V, Trigger on CH1 being turned on due to SET
2. CH1 On, 70Ohm load, 630mA current, Vs=50V, Trigger on CH1 being turned off due to SET
3. CH1 On, 70Ohm load, 110mA current, Vs=10V, Trigger on CH1 being turned off due to SET
4. No channels On, Vs=10V, Trigger on CH1 being turned on due to SET
5. CH2 On, 500Ohm load, 100mA current, Vs=50V, Trigger on CH2 being turned off due to SET

In addition to these five tests the supply current was recorded before and after every run and monitored during each run to determine if any SEL's were seen. Post functionality testing was done to determine if any SEB or SEGR events occurred.

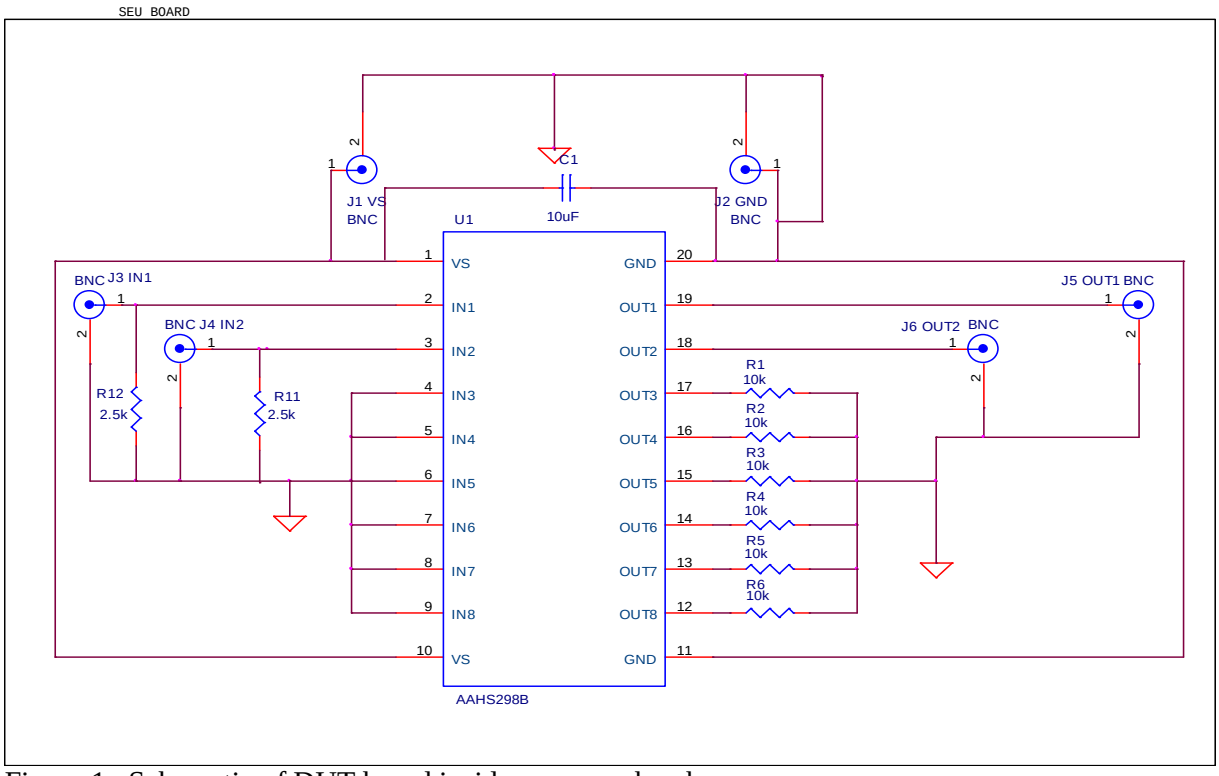

Figure 1. Schematic of DUT board inside vacuum chamber

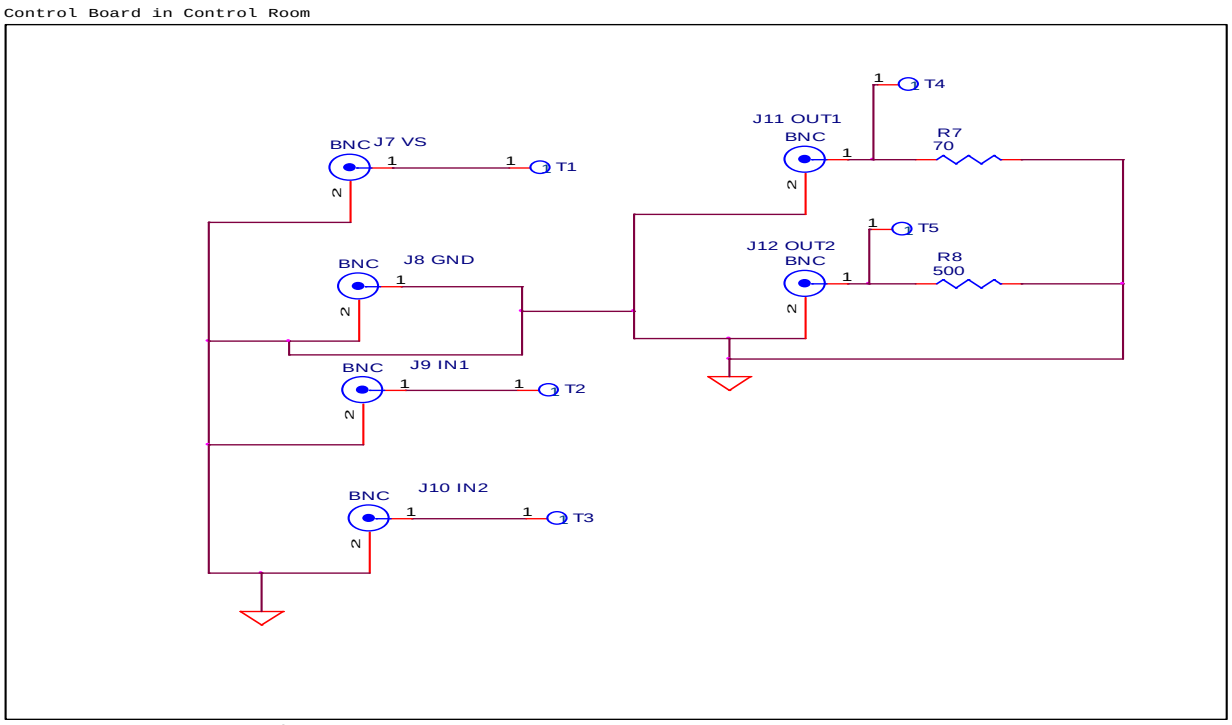

Figure 2. Schematic of Control Room board with channel and load selection.

A scope was used to trigger and count the number of SET's seen per run. In addition to the scope an event counter was used to validate the number of events triggered on the scope. This setup can be seen in Figure 3.

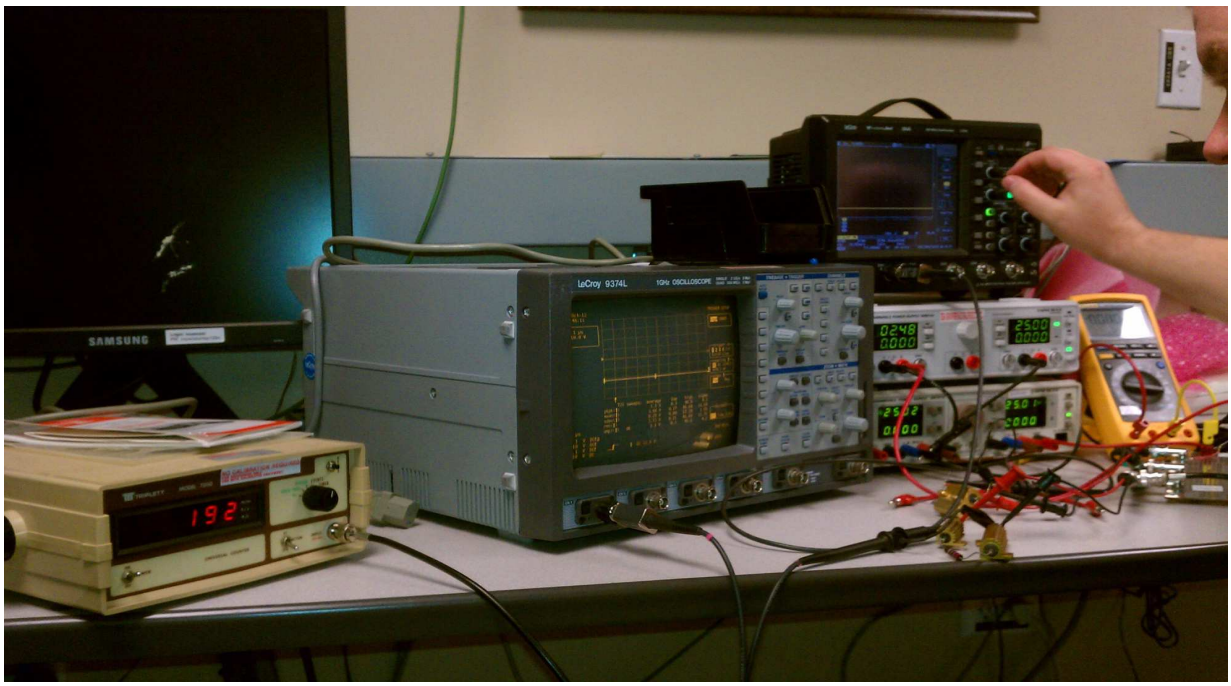

Figure 3. Photograph of control room set-up

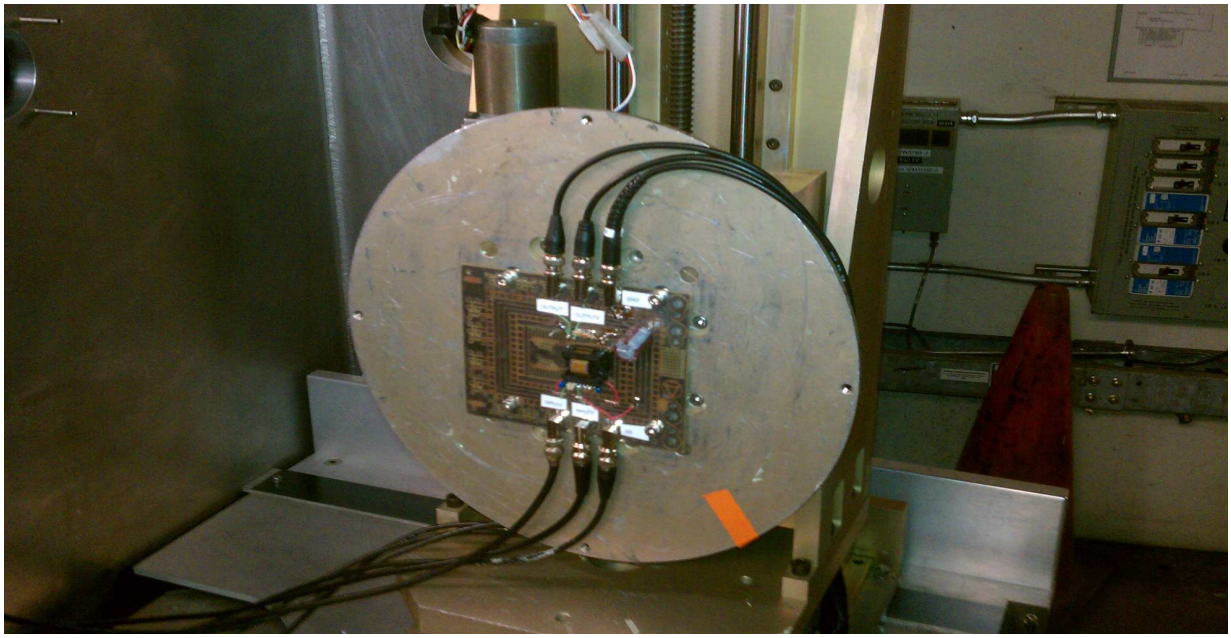

Figure 4. Photograph of DUT attached to cooling plate inside the vacuum chamber

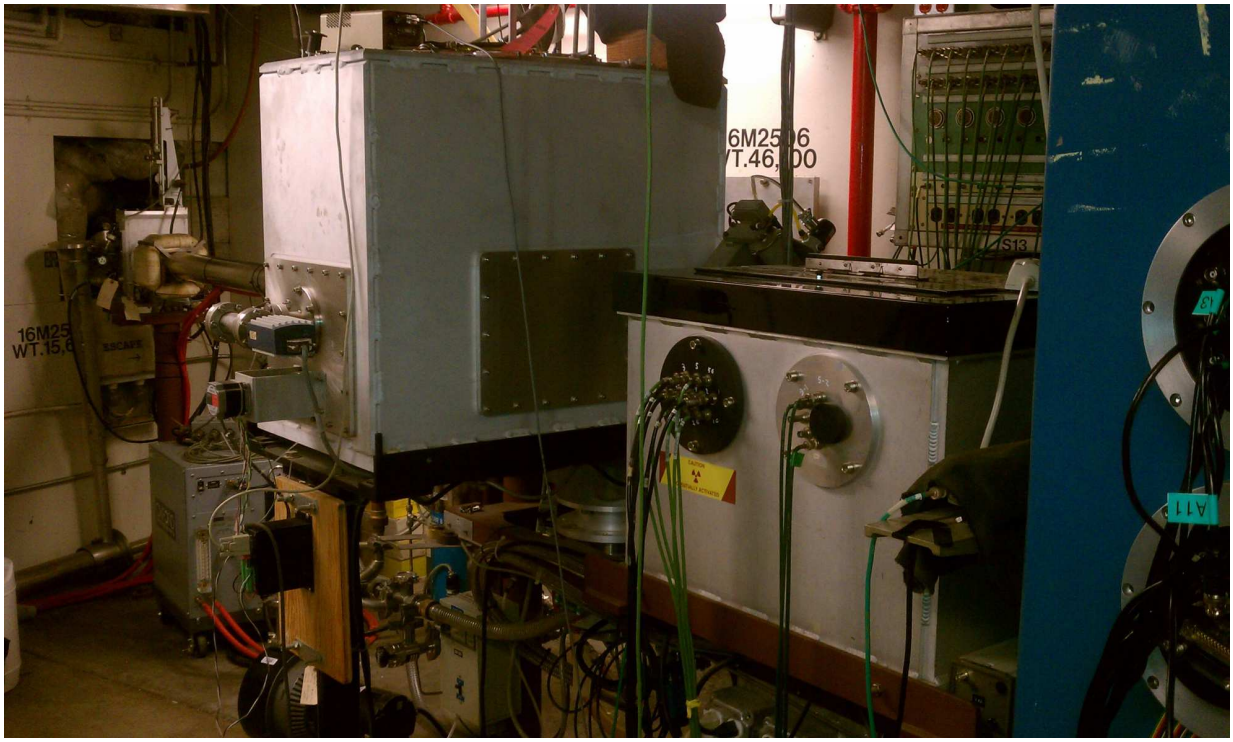

Figure 5. Photograph of beam line attached to chamber with feed-throughs on right.

3) SEE Run Data

The run summary of all runs performed during the AAHS298B SEE testing at LBNL can be seen in Figure 6. In addition to this log a few scope captures were taken in order to illustrate the nature of the SETs. These can be found in Figures 7-10.

3.1 Run Log

RUN #	Part #SN	Ion	Initial LET [MeV-cm^2/mg]	Tilt Angle	Effective Fluence	Effective LET [MeV-cm^2/mg]	DUT ICC (mA) PRE RUN	DUT ICC (mA) POST RUN	Events Count		
									SEL Events	SET Events	SET Events [cm2/device]
1	all off 50V	Xe	58.78	60.00	1.00E+07	117.56	0.000	0.000	0	740	7.40E-05
2	all off 50V	Xe	58.78	60.00	1.00E+06	117.56	0.000	0.000	0	72	7.20E-05
3	out1/630ma/50	Xe	58.78	60.00	1.00E+07	117.56	631.200	630.600	0	394	3.94E-05
4	out1/110ma/10V	Xe	58.78	60.00	1.00E+06	117.56	113.500	113.400	0	103	1.03E-04
5	all off/10V	Xe	58.78	60.00	1.00E+06	117.56	0.000	0.000	0	63	6.30E-05
6	out2/100mA/50V	Xe	58.78	60.00	1.00E+06	117.56	97.400	97.400	0	88	8.80E-05
7	out2/100mA/50V	Xe	58.78	60.00	1.00E+06	117.56	97.400	97.500	0	84	8.40E-05
8	all off 50V	Xe	58.78	0.00	1.00E+07	58.78	0.000	0.000	0	491	4.91E-05
9	out1/630ma/50	Xe	58.78	0.00	2.00E+06	58.78	628.800	628.900	0	70	3.50E-05
10	out1/110ma/10V	Xe	58.78	0.00	2.00E+06	58.78	113.200	113.200	0	189	9.45E-05
11	all off/10V	Xe	58.78	0.00	2.00E+06	58.78	0.000	0.000	0	85	4.25E-05
12	out2/100mA/50V	Xe	58.78	0.00	2.00E+06	58.78	97.300	97.500	0	165	8.25E-05
13	all off 50V	Cu	21.17	0.00	2.00E+06	21.17	0.000	0.000	0	58	2.90E-05
14	out1/630ma/50	Cu	21.17	0.00	2.00E+06	21.17	628.800	628.800	0	6	3.00E-06
15	out1/110ma/10V	Cu	21.17	0.00	2.00E+06	21.17	113.500	113.400	0	76	3.80E-05
16	all off/10V	Cu	21.17	0.00	2.00E+06	21.17	0.000	0.000	0	64	3.20E-05
17	out2/100mA/50V	Cu	21.17	0.00	2.00E+06	21.17	97.400	97.400	0	75	3.75E-05
18	all off 50V	Cu	21.17	58.00	2.00E+06	39.95	0.000	0.000	0	80	4.00E-05
19	out1/630ma/50	Cu	21.17	58.00	2.00E+06	39.95	628.700	628.700	0	23	1.15E-05
20	out1/110ma/10V	Cu	21.17	58.00	2.00E+06	39.95	113.100	113.100	0	138	6.90E-05
21	all off/10V	Cu	21.17	58.00	2.00E+06	39.95	0.000	0.000	0	92	4.60E-05
22	out2/100mA/50V	Cu	21.17	58.00	2.00E+06	39.95	97.200	97.400	0	104	5.20E-05
23	all off 50V	Si	6.09	58.00	2.00E+06	11.49	0.000	0.000	0	2	1.00E-06
24	out1/630ma/50	Si	6.09	58.00	2.00E+06	11.49	628.300	628.300	0	0	0.00E+00
22	out1/110ma/10V	Si	6.09	58.00	2.00E+06	11.49	113.500	113.300	0	1	5.00E-07
23	all off/10V	Si	6.09	58.00	4.00E+06	11.49	0.000	0.000	0	3	7.50E-07
24	out2/100mA/50V	Si	6.09	58.00	5.00E+06	11.49	97.400	97.400	0	7	1.40E-06
25	all off 50V	Ar	9.74	58.00	2.00E+06	18.38	0.000	0.000	0	23	1.15E-05
26	out1/630ma/50	Ar	9.74	58.00	2.00E+06	18.38	628.000	628.000	0	0	0.00E+00
27	out1/110ma/10V	Ar	9.74	58.00	2.00E+06	18.38	113.200	113.200	0	29	1.45E-05
28	all off/10V	Ar	9.74	58.00	2.00E+06	18.38	0.000	0.000	0	19	9.50E-06
29	out2/100mA/50V	Ar	9.74	58.00	2.00E+06	18.38	97.200	97.200	0	47	2.35E-05

Figure 6. Run Log

3.2 Scope Captures of Transients

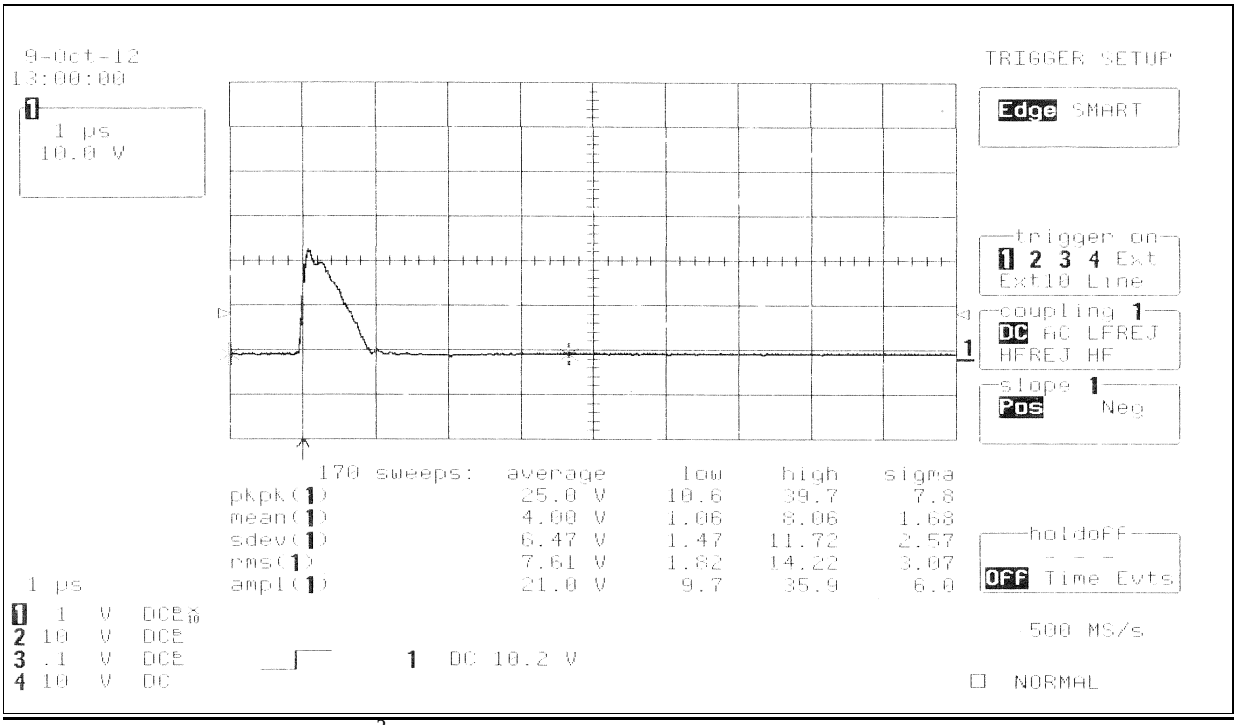

Figure 7. LET 117.56 MeV-cm^2/mg all channels off Vs=50V, CH1, ~1uS transient

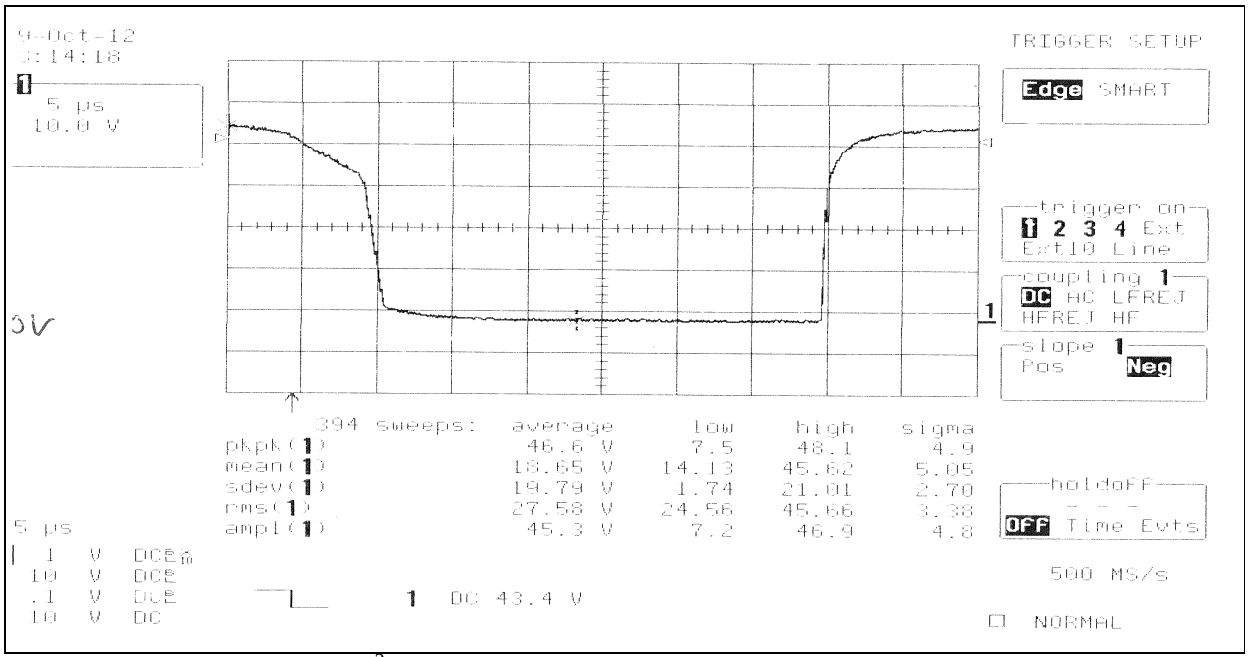

Figure 8. LET 117.5 MeV-cm^2/mg, CH1 On 70Ohm load, Vs=50V, ~35uS transient

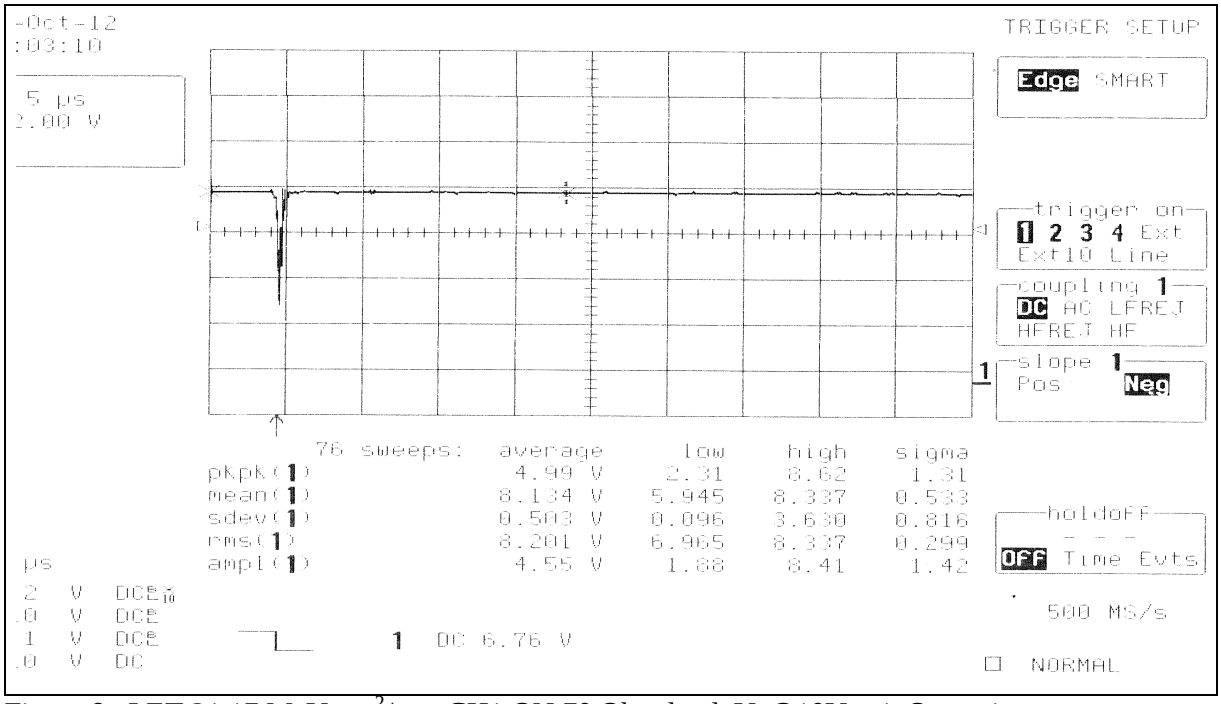

Figure 9. LET 21.17 MeV-cm^2/mg, CH1 ON 70 Ohm load, Vs@10V, ~1uS transient

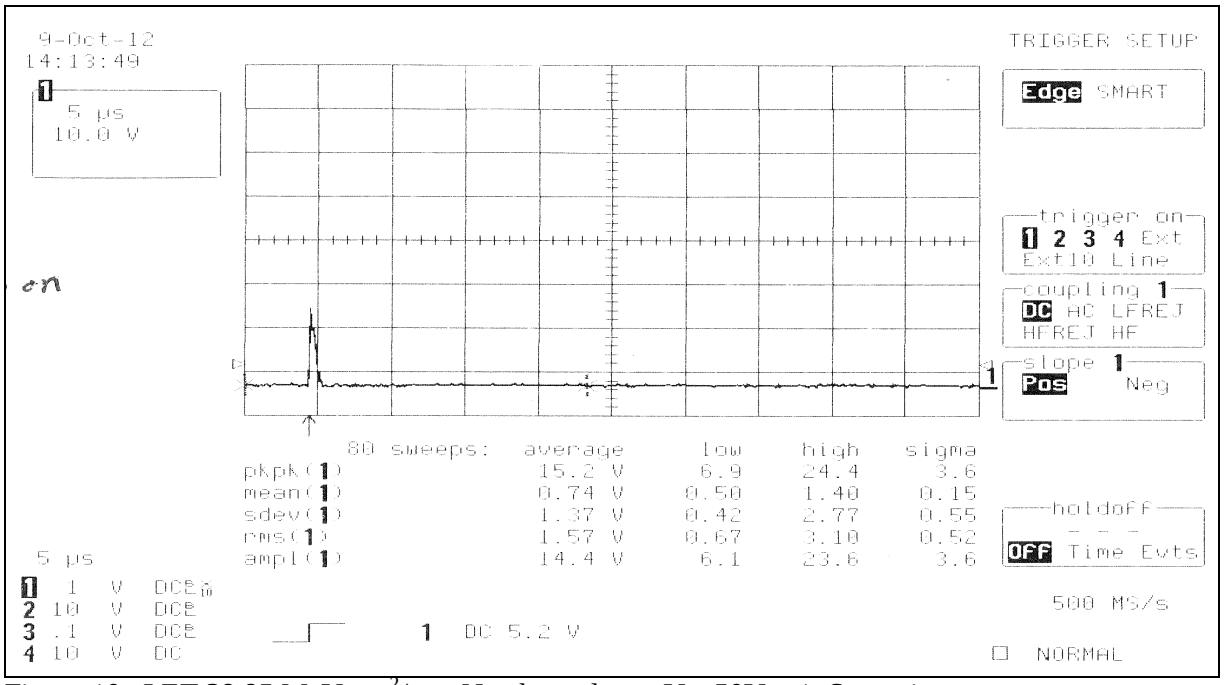

Figure 10. LET 39.95 MeV-cm^2/mg, No channels on, Vs=50V, ~1uS transient

4) Test data analysis

4.1) SEL / SEGR / SEB

No evidence of SEL, SEGR or SEB was seen on the parts we tested. The parts were fully functional after being exposed to LET's up to 117 MeV-cm^2/mg. SEL was not seen as verified by the lack of significant supply current increases. Full functionality of parts post SEE testing verified that no SEGR or SEB were present.

4.2) SET

The distribution of SET events increased with increasing LET and was consistent with the predicted Weibull fit of LET versus cross section (cm^2). The five Weibull fits are shown in Figures 11-15. OMERE Ver. 3.1 (based on CRÈME 86) was used to calculate these Weibull fits. This software was also used to calculate the expected number of transients per year in the space environment, specifically in the GEO orbit (35870km). This orbit was used because it acts as the worst-case orbit in terms of SEE events/year.

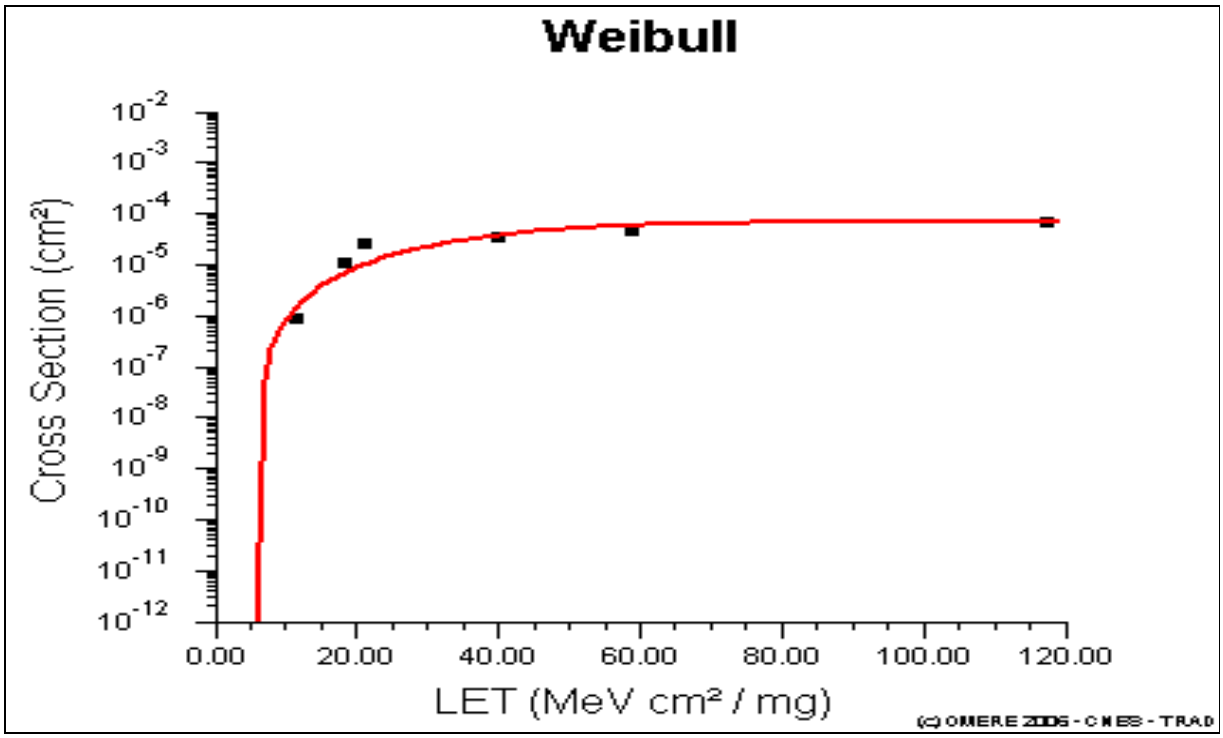

Figure 11. Weibull Fit for test#1, No channels On, Vs=50V, Trigger on CH1 turning

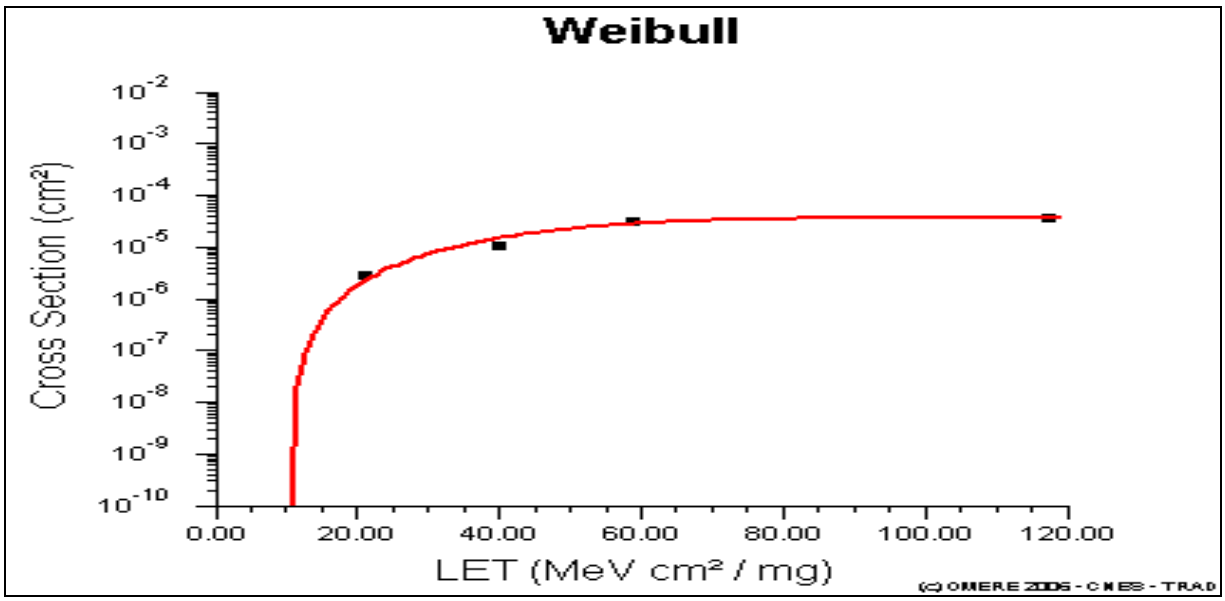

Figure 12. Weibull fit for test #2, CH1 On, 70Ohm load, 630mA current, Vs=50V, Trigger on CH1 being turned off

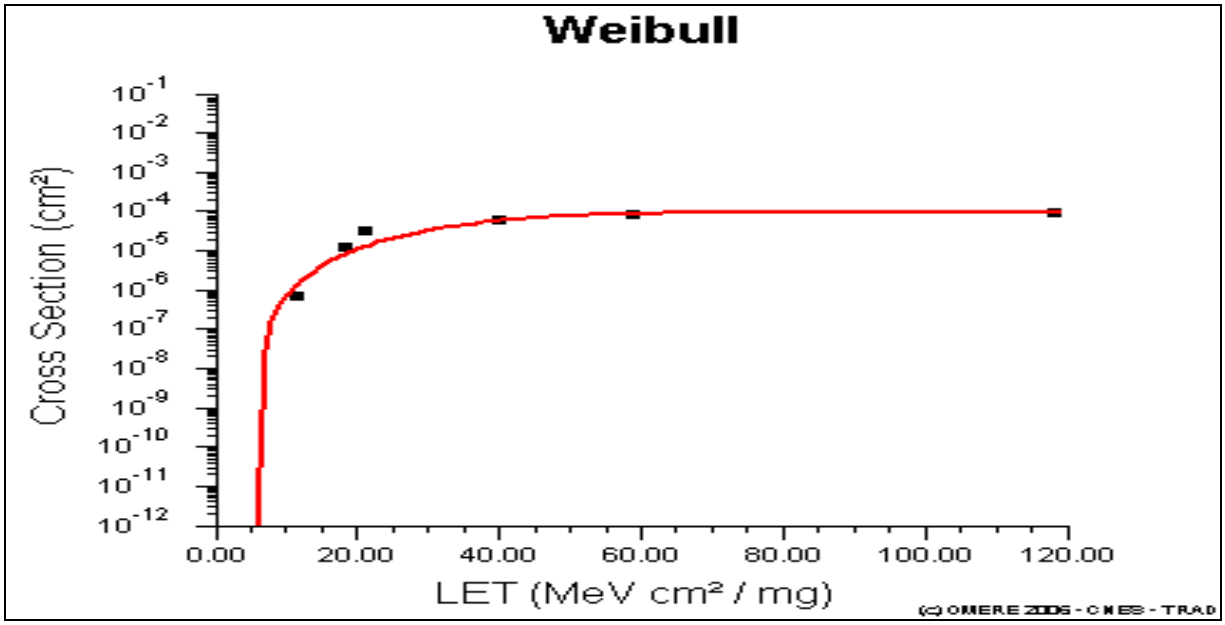

Figure 13. Weibull fit for test #3, CH1 On, 70Ohm load, 110mA current, Vs=10V, Trigger on CH1 being turned off

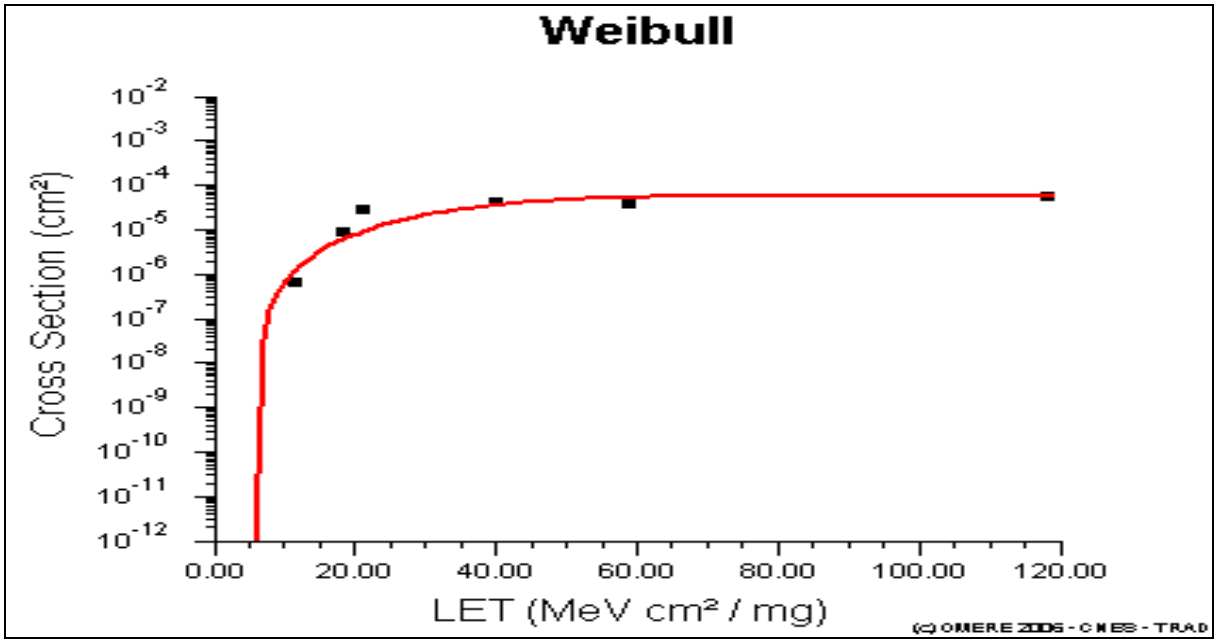

Figure 14. Weibull fit for test #4, No channels On, Vs=10V, Trigger on CH1 being turned on

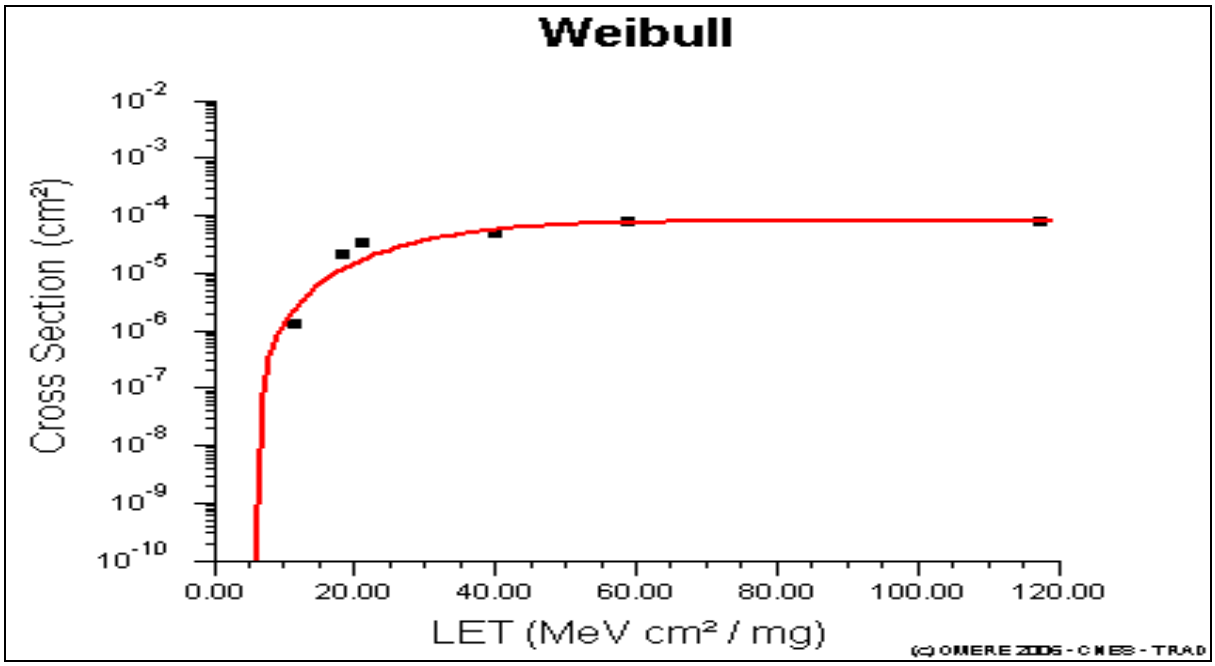

Figure 15. Weibull fit for test #5, CH2 On, 500Ohm load, 100mA current, Vs=50V, Trigger on CH2 being turned off

5) SET Error Rate

Error rate (calculated by OMERE)

Condition	SET/day	SET/year	Years till SET on a Channel	Years till SET on device [8 CH]	LET THRESHOLD MeV-cm^2/mg
50V all off	7.02E-05	2.56E-02	39.03	4.88	5.69
out1/700ma/50	1.92E-05	7.01E-03	142.69	17.84	10.49
out1/110ma/10	7.71E-05	2.81E-02	35.53	4.44	5.69
all off 10V	6.16E-05	2.25E-02	44.48	5.56	5.69
out2/100mA/50V	1.05E-04	3.83E-02	26.09	3.26	5.69

Figure 16. Error rate

6) Conclusion

- No SEL, SEB or SEGR events were seen at LET's up to 117 Mev-cm^2/mg.
- SET threshold LET's were calculated to be between 5.69-10.49 Mev-cm^2/mg depending on channel configuration.
- In Geosynchronous orbit SET's can be expected every 3.26-17.84 years per device depending on channel configuration
- All SET's were less than 35us is pulse duration.
- SET's when channels were on initially had longer transients than when channels were initially off
- With appropriate added capacitance on the outputs these transients can be filtered out.