PROJECT

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TITLE

Heavy Ion Transients in 2.5 Volt Precision Voltage Referens of Type 1009

EUROPEAN SPACE AGENCY
CONTRACT REPORT

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SUMMARY

This report presents the results from heavy ion irradiation on four types of 2.5 Volt precision voltage references from Linear Technology (two types), Intersil and Analog Devices.

The four types indicate similar SET behaviour with cross sections in the range of 1e-3 to 1e-4 cm2 depending on the pulse amplitude. The majority of the SET pulses are of small amplitude.
The typical SET pulses observed at small capacitance load are a drop in reference voltage of less than 1 volt for less than 1 microsecond. The device from Intersil indicates two groups of pulses, one small and short in time and one group with large amplitudes and long duration's.
For high capacitance load (33 nF and above) the pulse width tend to follow the re-charge value of the load capacitor.

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Issue	Date	Paragraphs affected	Change information
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1. INTRODUCTION

This report presents the results from heavy ion irradiation on four types of 2.5 Volt precision voltage references.

2. TEST SAMPLES

Table 1 below summarise the data known about the test samples used for heavy ion tests.

TABLE 1
Test sample data

Part Type	LT1009	RH1009	IS1009	REF043
Manufacturer	Linear Tech	Linear Tech	Intersil	Analog Devices
Date Code	9750A	9746	0111	
Package	TO-46	TO-46	TO-46	DIL-8
Sample Size	1	1	2	1
Part Number	M38510/148-02SXA	RH1009MH	IS2-1009RH/Proto	REF043-803Z
Quality Level	Class S	Class S	Mil Temp	Class S

3. TESTING TECHNIQUE

Single Event Transients (SET) were measured with an oscilloscope (Tektronix TDS3054, 500 MHz, 5GS/s). For each SET event the pulse length and the pulse height were registered on a PC-computer. The process time per SET event was less than 10 ms. The flux of the heavy ion beams were adjusted to avoid dead time in the system. The test software was developed by use of “Labview software” for the GPIB communication between the PC and the oscilloscope. All results were stored as common ”Excel-files”.

3.1 Bias Condition and Test Set-up

All four device types were tested in the same way biased at 5 VDC. In Fig 3.1 below a schematic drawing of the used test set-up is shown. SET data for five different loads were determined (15 pF, 3 nF, 30 nF, 100 nF, 1 µF).
The SET pulse amplitude is measured from the 2.5 Volt reference voltage as shown in Fig 3.2. In the off-line data analysis the SET probability and the associated pulse length could be determined for any value of the SET amplitude. In the present report, data are shown as a function of three regions of the SET amplitudes, e.g. SET’s larger than 0.2 Volt, SET’s larger than 0.5 Volt and SET’s larger than 1 Volt

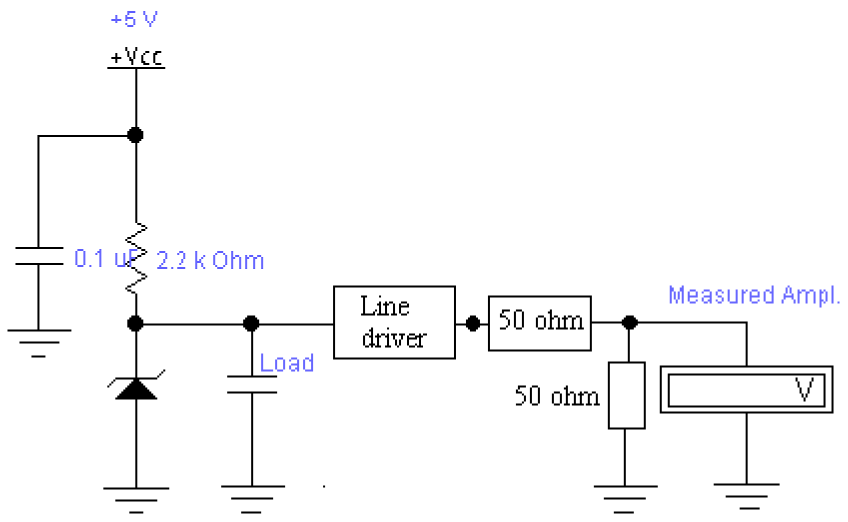

Fig 3.1 Schematic drawing of the test set-up. The box to the right represents the oscilloscope (Tektronix TDS3054, 500 MHz, 5GS/s). The load capacitance were varied for the values 15 pF, 3 nF, 30 nF, 100 nF, 1 μF.

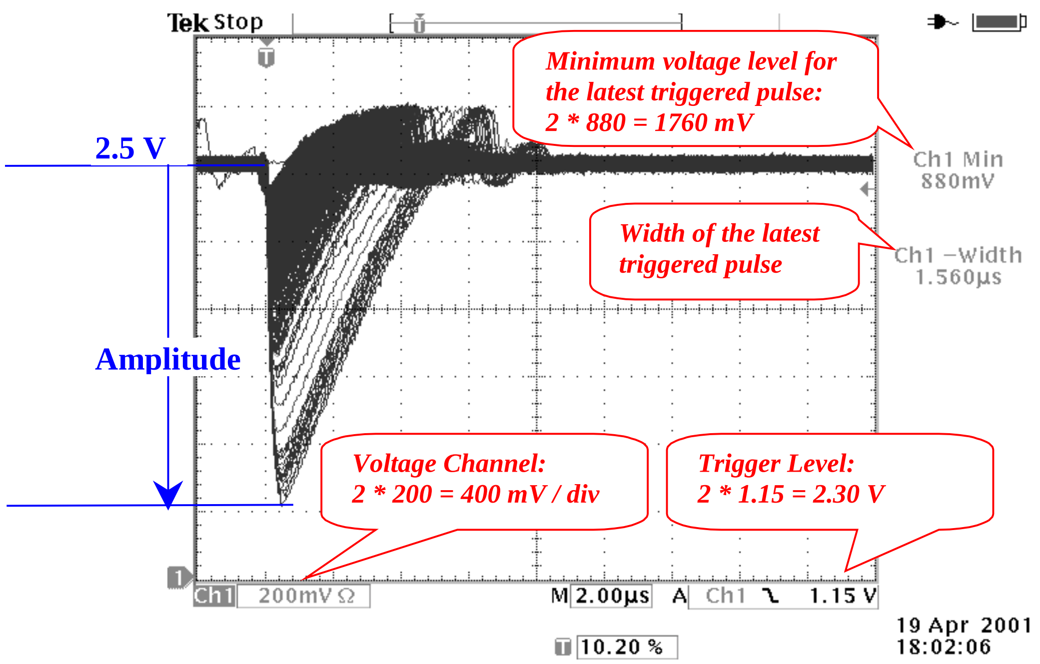

Fig 3.2 Definition of the amplitude of the SET pulse. An impedance match is connected after the linedriver (see fig. 3.1), therefore the measured amplitude will be half of the output from the zener diode.

4. HEAVY ION TEST FACILITY

Heavy ion tests were performed at the CYClotron of Louvain la Neuve (CYCLONE), Belgium. During the present experiments an ion "cocktail" composed of the ions given in Table 2 were used.

Data have been recorded for normal incident beam due to the difficulties to position the small devices correctly under tilted angle. Only at one data point (REF43, ^{15}N) one test was performed at tilted angle 60°.

TABLE 2

Heavy ions used in the present investigation

Element	**LET value** [$MeV \cdot cm^2/mg$]
15 N	3
40 Ar	14
78 Kr	34
131 Xe	56

5. RESULTS

The dominating SET pulses in the present set-ups are negative pulses, e.g. pulses going from the 2.5 V reference line towards the ground level. Positive SET pulses, e.g. pulses going to higher values than 2.5 Volt are less frequent and of much lower amplitude. No positive pulses higher than 0.5 volt above the reference voltage have been observed.

Test run data and information are given in Appendix A. Appendix-B to Appendix-E show obtained test data for the four device types. Cross section diagrams have been generated for three different pulse amplitudes;

- All SET pulses (pulses with amplitudes larger than 0.2 Volt , >0.2V),
- Pulses with amplitudes larger than 0.5 Volt (>0.5V) and
- Pulses with amplitudes larger than 1 Volt (>1 V).

Cross section diagrams are given for each individual capacitance load and device.
A selection of typical oscilloscope pictures of pulse widths has been given. Scattering diagrams of the pulse width as a function of the pulse height are given for representative LET values for each load.

5.1 LT1009 from Linear Technology

For low capacitance values SET pulses are shorter than 1µs with a majority of the SET pulses shorter than 0.5 µs. The cross sections for SET > 0.2 Volt (all amplitudes) are about 2e-3 cm2 and almost independent of capacitance load. The LET threshold is about 3 MeVcm2/mg for the low capacitance loads and is increasing up to above 10 MeV cm2/mg for 100 nF load. The cross section for no capacitance load (15 pF) are given in Fig 5.1.1 for three different pulse amplitudes. In Fig 5.1.2 a scatter diagram of pulse amplitude versus pulse length is shown.

For larger SET pulses with amplitude >0.5 V and particular for pulses with amplitudes > 1 volt, the LET thresholds are increasing strongly with increasing capacitance load, up to 30 MeVcm2/mg. For large pulses (> 1 V) the cross sections are reduced by a factor 10 compared to the small pulses, see Appendix B

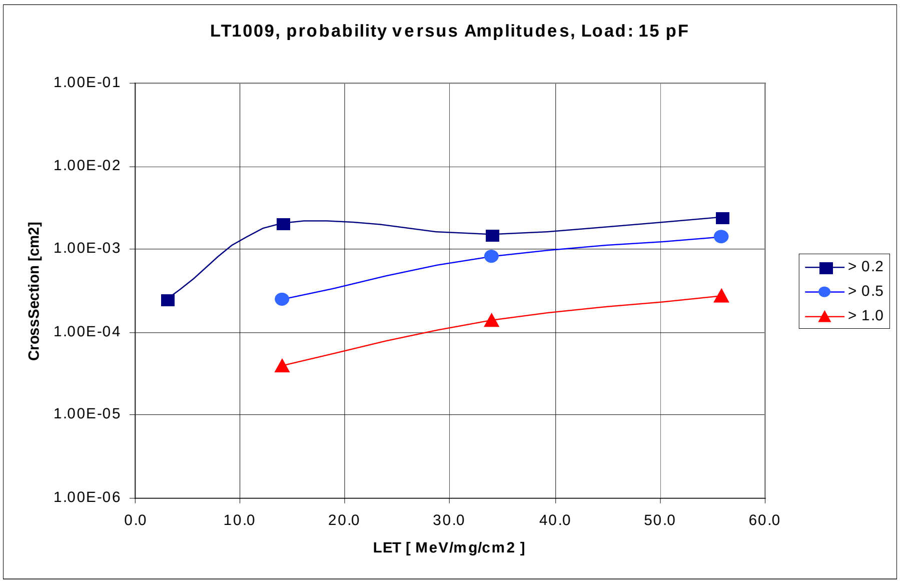

Fig 5.1.1 SET cross section versus LET-value for three different pulse amplitudes, capacitance load=15pF

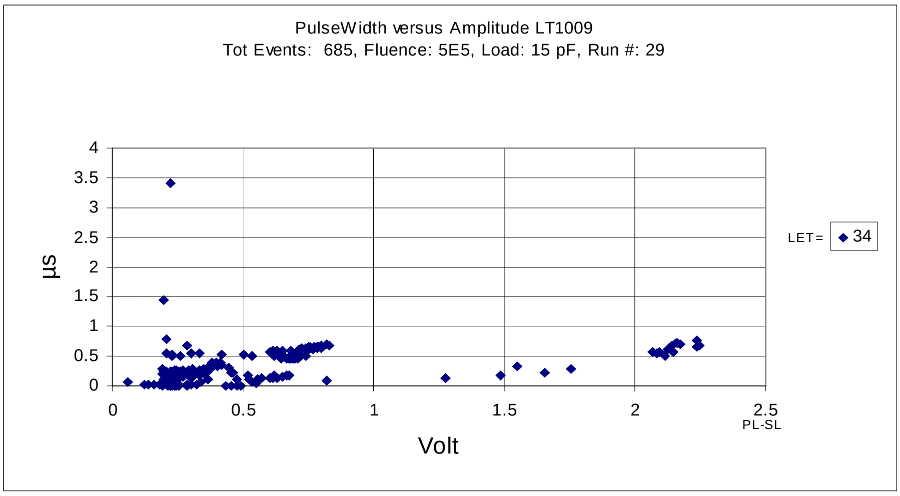

Fig 5.1.2 Scatter diagram showing pulse width in µs versus amplitude in Volt.

A summary of the maximum pulse width as a function of capacitance load is given in Table 3. For more detailed information, scatter diagrams showing pulse width versus pulse amplitude are given in appendix B.

TABLE 3

Summary of limits for detected pulse widths as a function of pulse amplitude and capacitance load for LT1009. The pulse width limits are given in µs. Detailed scatter graph information are included in appendix B

Pulse Amplitude [Volt]	**Capacitance Load** 15 pF [µs]	3.3 nF	33 nF	100 nF
< 0.5	< 1	< 1	< 0.5	< 2.5
0.5-1	< 1	< 1	< 0.5	< 2
> 1	< 1	< 1	< 1.5	< 3

5.2 RH1009 from Linear Technology

The RH1009 device is the Rad hard version of LT1009 from Linear Technology. This device was the first to be tested during this campaign using Kr ions LET=34 MeVcm2/mg. With the flux used during this test run the dead time in the sampling system accidentally became unacceptable high. This is reflected in the data points for LET=34 which are considerably lower than the surrounding points due to uncorrected dead time, see Fig 5.2.1.
SET wise this device resembles LT1009 but indicate up to a factor 5 lower cross sections for pulses >1 Volt and low capacitance load. With high capacitance load the number of errors for all pulse amplitudes are reduced with a factor 30 compared with LT1009. There is a striking difference in pulse widths particularly for higher capacitance load; RH1009 show much longer pulses compared to LT1009, all having very small amplitude.
A summary of the maximum pulse width as a function of capacitance load is given in Table 4.

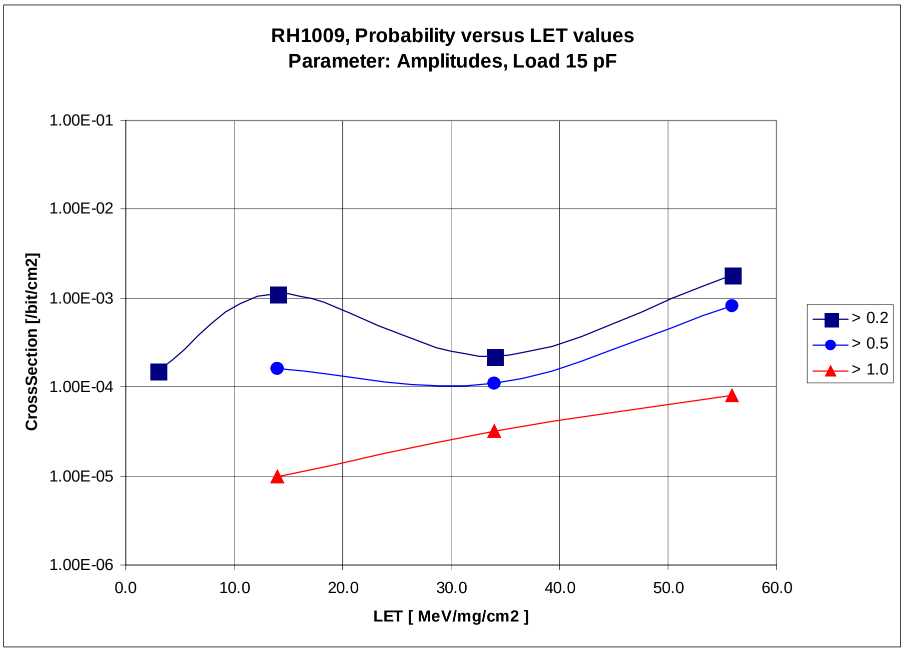

Fig 5.2.1 SET cross section versus LET-value for three different pulse amplitudes The drop in cross section for amplitudes >0.2 Volt at LET= 34 is due to uncontrolled dead time in the data recording system.

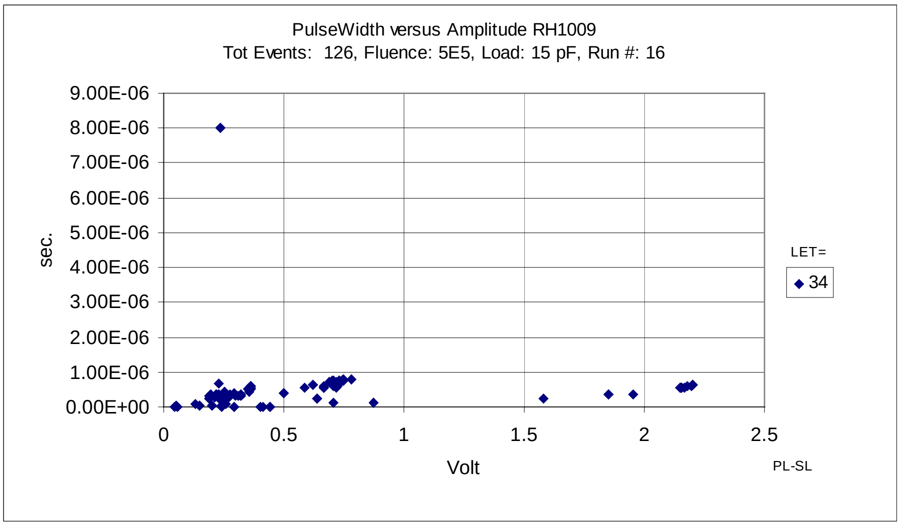

Fig 5.2.2 Scatter diagram showing pulse width in seconds versus amplitude in Volt. The shown data are from 84Kr, LET=34 MeVcm2/mg.

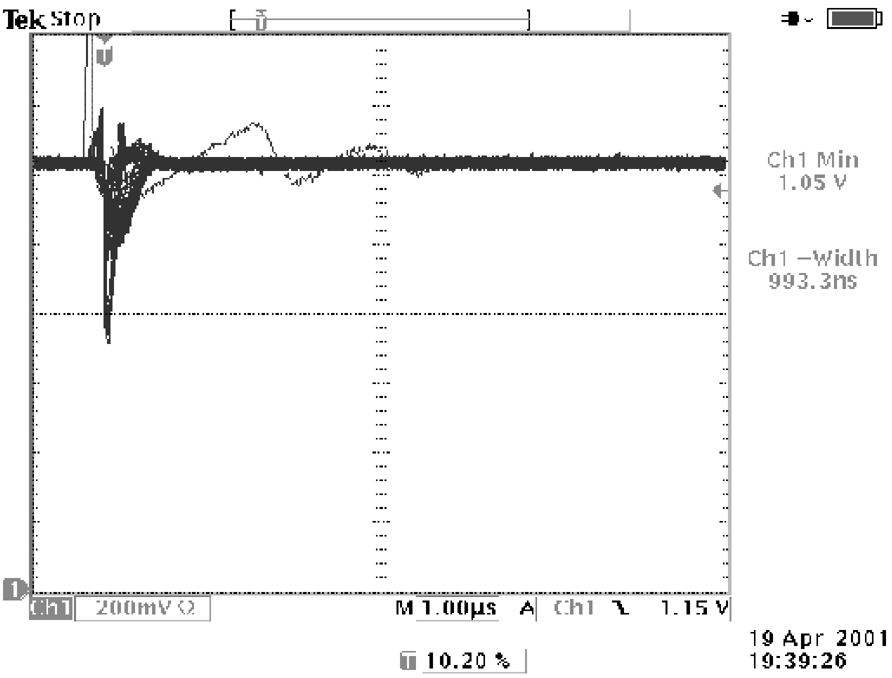

Fig 5.2.3 Oscilloscope picture generated by continuous sampling of SET Pulses , load= 15 pF, LET=14

A summary of the maximum pulse width as a function of capacitance load is given in Table 4. For more detailed information, scatter diagrams showing pulse width versus pulse amplitude are given in appendix C.

TABLE 4

Summary of limits for detected pulse widths as a function of pulse amplitude and capacitance load for RH1009. The pulse width limits are given in μs. Detailed scatter graph information are included in appendix C

Pulse Amplitude [Volt]	Capacitance Load 15 pF	3.3 nF	33 nF	100 nF
	[μs]			
< 0.5	< 1	< 1.5	< 8	< 17
0.5-1	< 1	< 2	< 8	-
> 1	< 1	< 3	-	-

5.3 IS1009 from Intersil

The rad hard voltage reference from Intersil, IS1009, shows the same general cross section and LET Thresholds for SET as LT1009 from Linear Technology. This device type differ in SET response in the fact that it show two groups of SET pulses clearly separated; one group of small pulses and one group of large pulses. This can be seen in Fig 5.3.3 which shows an oscilloscope picture of collected SET pulses. The cross sections as a function of LET values for no capacitance load (15 pF) are given in Fig 5.3.1. A scatter diagram for 84Kr (LET=34 MeVcm2/mg) is given in Fig 5.3.2.

A summary of the maximum pulse width as a function of capacitance load is given in Table 5. For more detailed information, scatter diagrams showing pulse width versus pulse amplitude are given in appendix D.

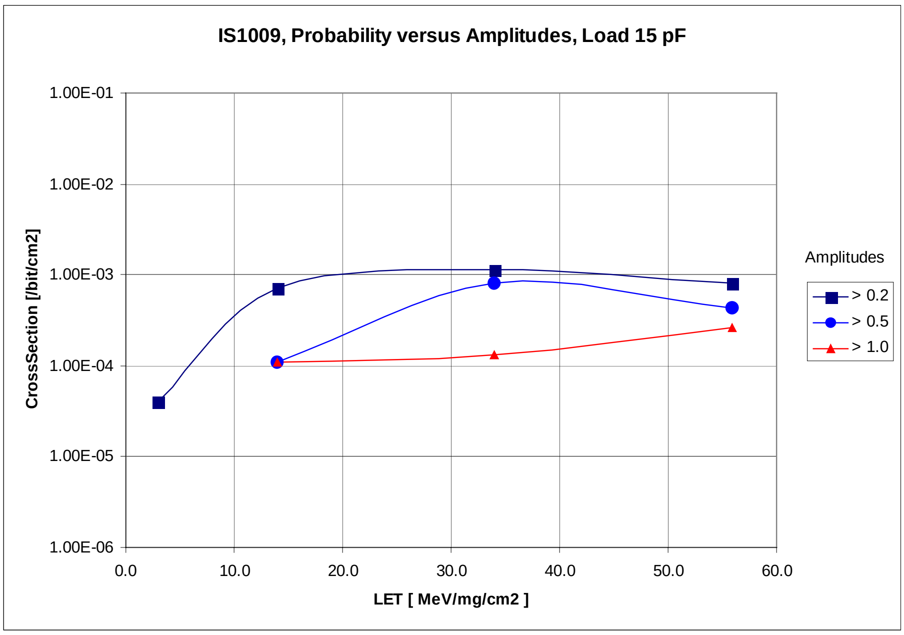

Fig 5.3.1 SET cross section versus LET-value for three different pulse amplitudes.

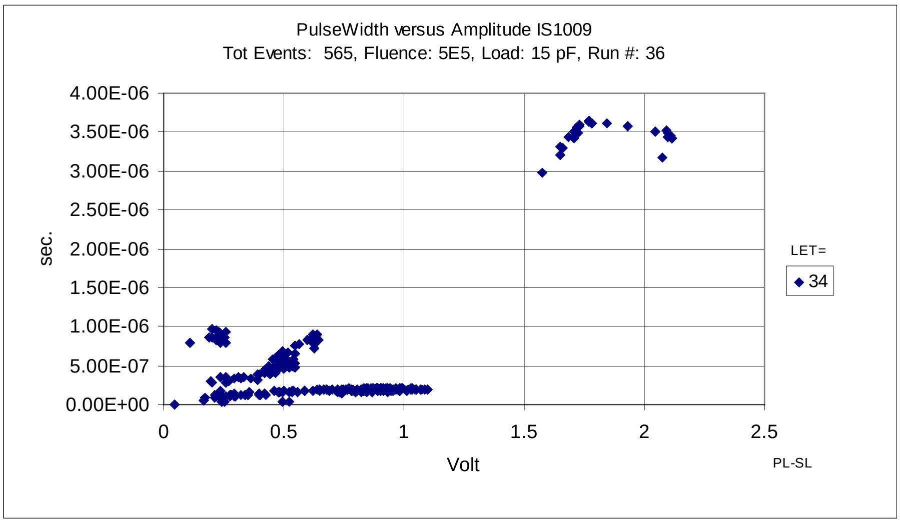

Fig 5.3.2 Scatter diagram showing pulse width in seconds versus amplitude in Volt.

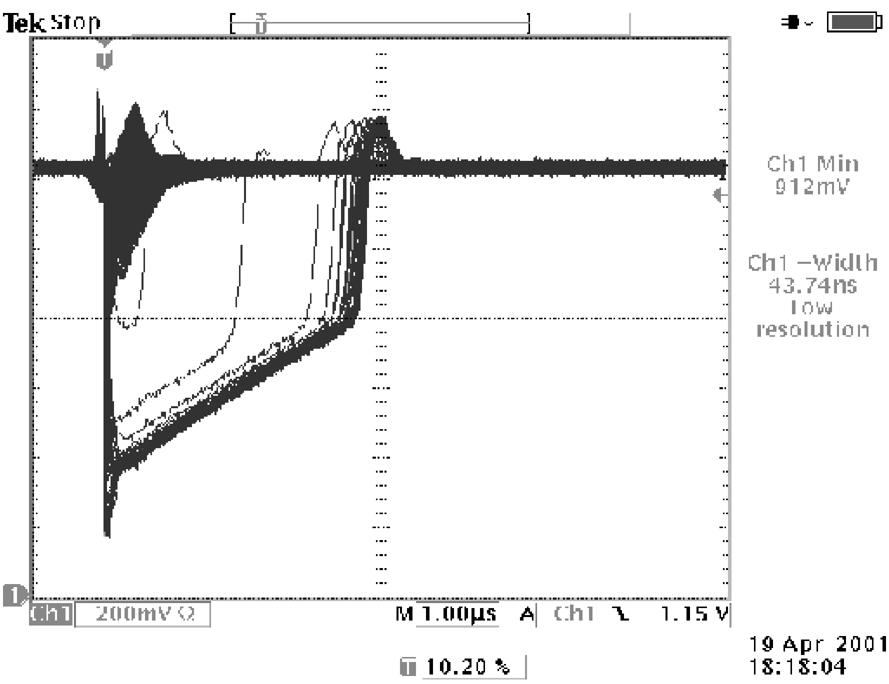

Fig 5.3.3 Oscilloscope picture, load= 15 pF, LET=34

TABLE 5

Summary of limits for detected pulse widths as a function of pulse amplitude and capacitance load for IS1009. The pulse width limits are given in µs. Detailed scatter graph information are included in appendix D.

Pulse Amplitude [Volt]	Capacitance Load [µs] 15 pF	3.3 nF	33 nF	100 nF
< 0.5	< 1	< 1	< 2	< 2.5
0.5-1	< 1	< 1	< 1	< 1.5
> 1	< 4	< 4	< 4	< 5

5.4 REF43 from Analog Devices

This device indicate about the same cross section than the other tested device types, but higher LET threshold. For no capacitance load (15 pF) there were only a few detected event with pulse amplitude > 1 V, see Figs 5.4.1 and 5.4.2 Adding capacitance load removed pulses larger than 0.5 V. The small amplitude SET pulses were, however, much longer in time than the for the other tested devices, see Table 6. For more detailed information, scatter diagrams showing pulse width versus pulse amplitude are given in appendix E.

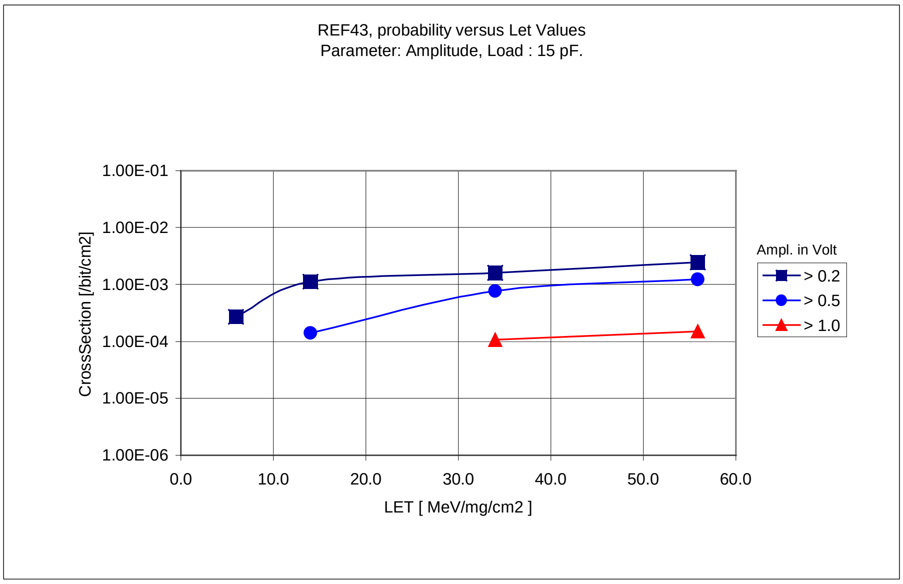

Fig 5.4.1 SET cross section versus LET-value for three different pulse amplitudes. No SET event was observed at LET=3 for a fluence of E+5 ions. Data at LET=6Mevcm2/mg are taken at 60° tilt angle

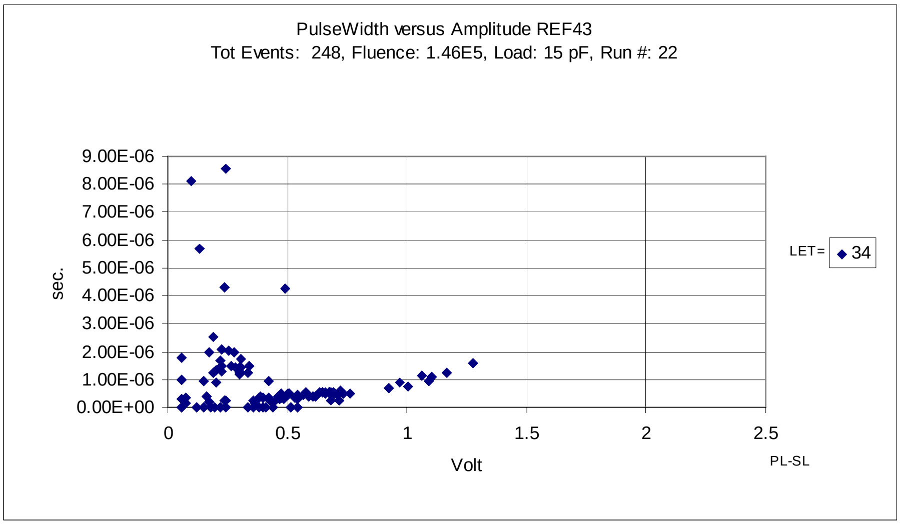

Fig 5.4.2 Scatter diagram showing pulse width in seconds versus amplitude in Volt.

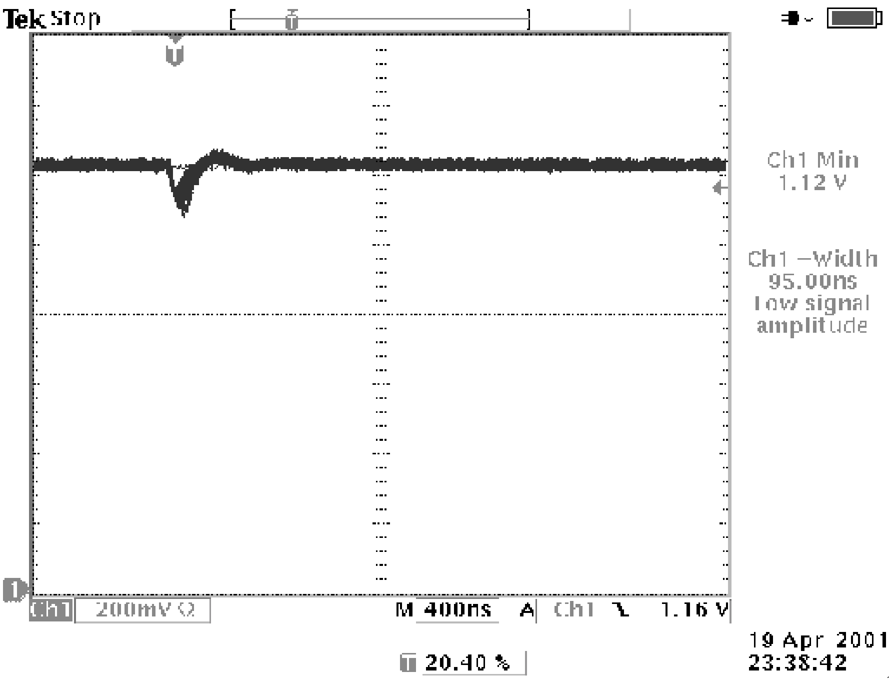

Fig 5.4.3 Oscilloscope picture, load= 15 pF, LET=6, (Tilt 60 deg of ^{15}N). No pulses were observed in 0° for ^{15}N.

TABLE 6

Summary of limits for detected pulse widths as a function of pulse amplitude and capacitance load for REF43. The pulse width limits are given in µs. Detailed scatter graph information are included in appendix E.

Pulse Amplitude [Volt]	Capacitance Load 15 pF [µs]	3.3 nF	33 nF	100 nF
< 0.5	< 10	< 8	< 10	< 1
0.5-1	< 1	-	-	-
> 1	< 2	-	-	-

6. CONCLUSION

The typical SET pulses observed are a drop in reference voltage of less than 1 volt for less than 1 microsecond. The SET pulse length and width varies between the devices. A comparison between the four devices indicate that the probability of SET are about the same, a cross section of about 1e-3 to 1e-4 cm2 depending on load conditions and a threshold somewhere between 5-15 MeVcm2/mg depending on pulse height. The majority of the SET pulses are of small amplitude. Long pulses are observed for the REF43 from Analog Devices and the hard device IS1009 from Intersil. This is best visualised in the scatter diagram.

7. APPENDIX A – Test Run Data

RUN#	ION	LET	FLUENCE	DEVICE	LOAD	ERRORS
16	Kr	34	5.0E+05	RH1009	15 pF	125
17	Kr	34	5.0E+05	RH1009	3,3 nF	78
18	Kr	34	5.0E+05	RH1009	33 nF	56
19	Kr	34	5.0E+05	RH1009	100 nF	31
20	Kr	34	5.0E+05	RH1009	1 uF	4
22	Kr	34	1.5E+05	REF43	15 pF	247
23	Kr	34	4.1E+05	REF43	15 pF	696
24	Kr	34	5.0E+05	REF43	3,3 nF	484
26	Kr	34	5.0E+05	REF43	33 nF	303
27	Kr	34	5.0E+05	REF43	100 nF	34
28	Kr	34	5.0E+05	REF43	1 uF	3
29	Kr	34	5.0E+05	LT1009	15 pF	684
30	Kr	34	5.0E+05	LT1009	15 pF	689
31	Kr	34	5.0E+05	LT1009	3,3 nF	700
32	Kr	34	5.0E+05	LT1009	33 nF	900
33	Kr	34	5.0E+05	LT1009	100 nF	897
35	Kr	34	5.0E+05	LT1009	1 uF	696
36	Kr	34	5.0E+05	IS1009	15 pF	564
37	Kr	34	5.0E+05	IS1009	3,3 nF	559
38	Kr	34	5.0E+05	IS1009	33 nF	545
39	Kr	34	5.0E+05	IS1009	100 nF	284
41	Kr	34	5.0E+05	IS1009	1 uF	257
43	Kr	34	1.0E+05	LT1009	15 pF	408
44	Kr	34	1.0E+05	LT1009	3,3 nF	365
45	Kr	34	1.0E+05	LT1009	33 nF	350
46	Kr	34	1.0E+05	LT1009	100 nF	311
47	Kr	34	1.0E+05	IS1009	15 pF	146
48	Kr	34	1.0E+05	IS1009	3,3 nF	134
49	Kr	34	1.0E+05	IS1009	33 nF	103
52	Ar	14	1.0E+05	RH1009	15 pF	117
53	Ar	14	1.0E+05	RH1009	3,3 nF	98
54	Ar	14	1.0E+05	RH1009	33 nF	56
55	Ar	14	1.0E+05	RH1009	100 nF	0
56	Ar	14	1.0E+05	RH1009	100 nF	1
57	Ar	14	1.0E+05	REF43	15 pF	120
58	Ar	14	1.0E+05	REF43	3,3 nF	15
59	Ar	14	1.0E+05	REF43	33 nF	9
60	Ar	14	1.0E+05	REF43	100 nF	0
61	Ar	14	1.0E+05	LT1009	15 pF	217
62	Ar	14	1.0E+05	LT1009	3,3 nF	231
63	Ar	14	1.0E+05	LT1009	33 nF	185
64	Ar	14	1.0E+05	LT1009	100 nF	134
65	Ar	14	1.0E+05	LT1009	1 uF	1
66	Ar	14	1.0E+05	IS1009	15 pF	73
67	Ar	14	1.0E+05	IS1009	3,3 nF	64
68	Ar	14	1.0E+05	IS1009	33 nF	32
69	Ar	14	1.0E+05	IS1009	100 nF	20
70	Ar	14	1.0E+05	IS1009	1 uF	14

RUN#	ION	LET	FLUENCE	DEVICE	LOAD	ERRORS
74	N	2.97	1.0E+05	RH1009	15 pF	14
75	N	2.97	1.0E+05	RH1009	3,3 nF	0
76	N	2.97	1.0E+05	RH1009	33 nF	0
77	N	2.97	1.0E+05	REF43	15 pF	2
78	N	2.97	1.0E+05	REF43	3,3 nF	0
81	N	2.97	1.0E+05	LT1009	15 pF	33
83	N	2.97	1.0E+05	LT1009	33 nF	106
84	N	2.97	1.0E+05	LT1009	15 pF	27
85	N	2.97	1.0E+05	LT1009	100 nF	0
87	N	2.97	1.0E+05	IS1009	15 pF	5
88	N	2.97	1.0E+05	IS1009	3,3 nF	6
89	N	2.97	1.0E+05	IS1009	33 nF	4
90	N	2.97	1.0E+05	LT1009	3,3 nF	71
92	N	5.96	1.0E+05	REF43	15 pF	40
94	Xe	55.9	1.0E+05	RH1009	15 pF	187
95	Xe	55.9	1.0E+05	RH1009	3,3 nF	105
96	Xe	55.9	1.0E+05	RH1009	33 nF	85
97	Xe	55.9	1.0E+05	RH1009	100 nF	75
98	Xe	55.9	1.0E+05	REF43	15 pF	272
99	Xe	55.9	1.0E+05	REF43	3,3 nF	189
100	Xe	55.9	1.0E+05	REF43	33 nF	102
101	Xe	55.9	1.0E+05	REF43	100 nF	41
102	Xe	55.9	1.0E+05	LT1009	15 pF	261
103	Xe	55.9	1.0E+05	LT1009	3,3 nF	267
104	Xe	55.9	1.0E+05	LT1009	33 nF	215
105	Xe	55.9	1.0E+05	LT1009	100 nF	162
106	Xe	55.9	1.0E+05	IS1009	15 pF	81
107	Xe	55.9	1.0E+05	IS1009	3,3 nF	71
108	Xe	55.9	1.0E+05	IS1009	33 nF	79
109	Xe	55.9	1.0E+05	IS1009	100 nF	55
110	Xe	55.9	1.0E+05	IS1009	1 uF	54

8. APPENDIX B - LT1009 form Linear Technology

8.1 Capacitance Load 15 pF: LT1009

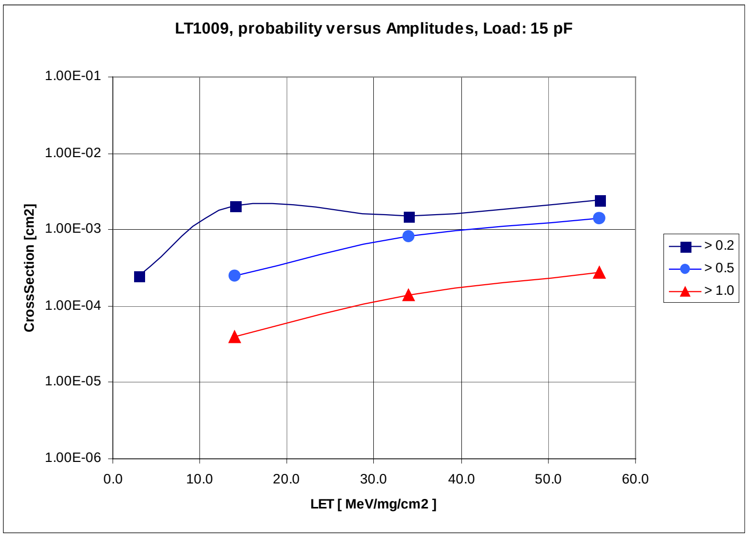

Fig 8.1.1 SET cross section versus LET-value for three different pulse amplitudes

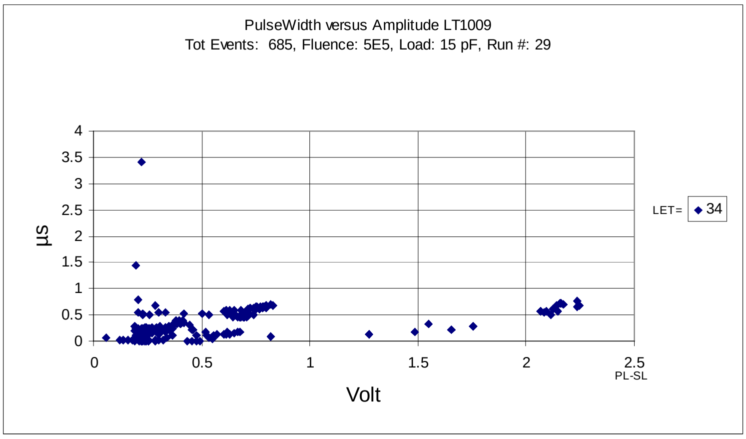

Fig 8.1.2 Scatter diagram showing pulse width in µs versus amplitude in Volt.

8.2 Capacitance Load 3.3 nF: LT1009

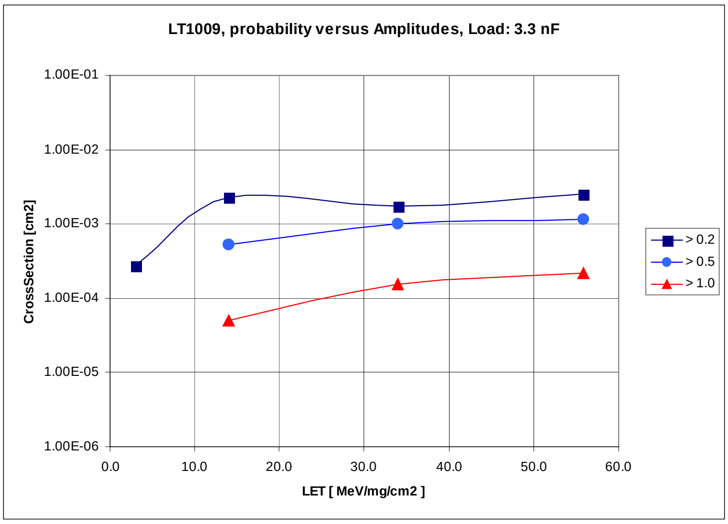

Fig 8.2.1 SET cross section versus LET-value for three different pulse amplitudes

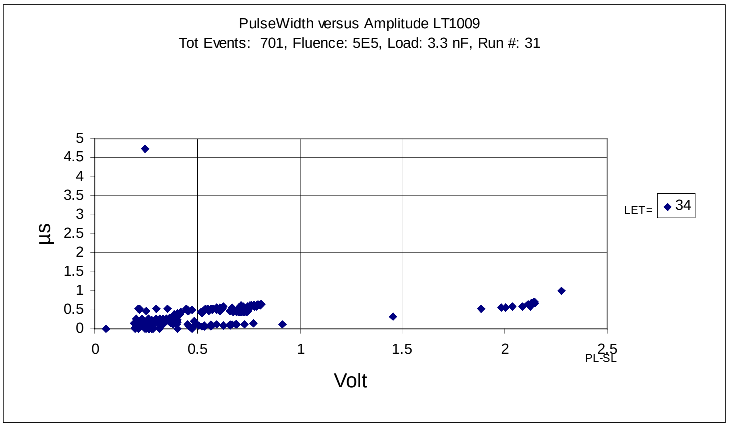

Fig 8.2.2 Scatter diagram showing pulse width in µs versus amplitude in Volt.

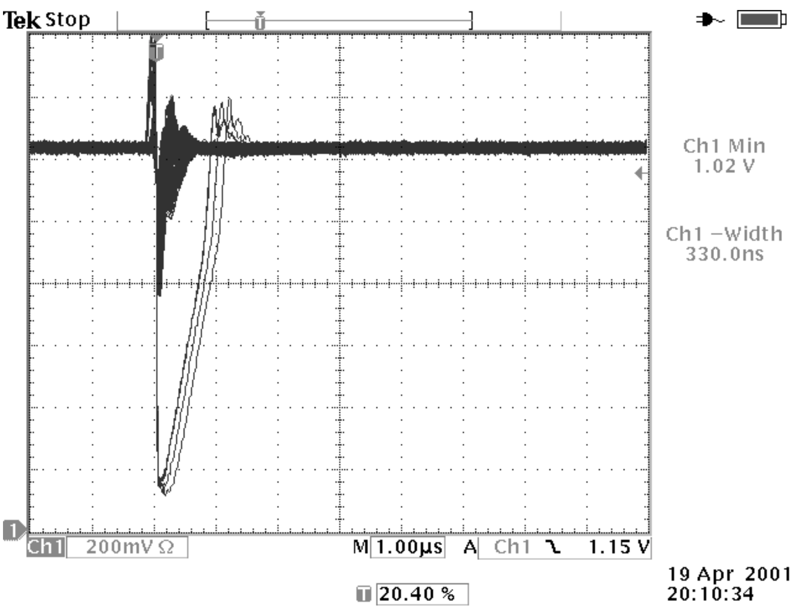

Fig 8.2.3 Oscilloscope picture, load= 3.3 nF, LET=14

8.3 Capacitance Load 33 nF: LT1009

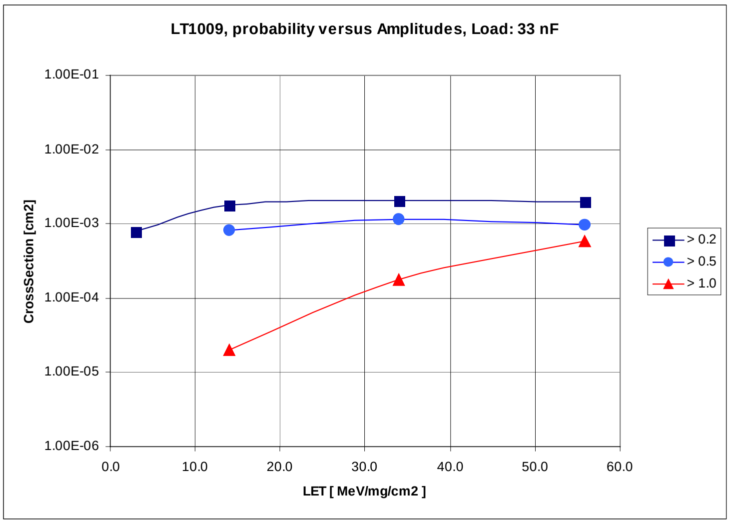

Fig 8.3.1 SET cross section versus LET-value for three different pulse amplitudes

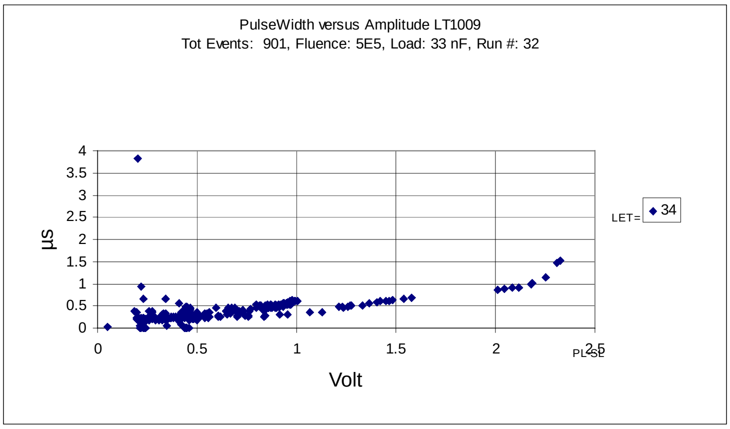

Fig 8.3.2 Scatter diagram showing pulse width in µs versus amplitude in Volt.

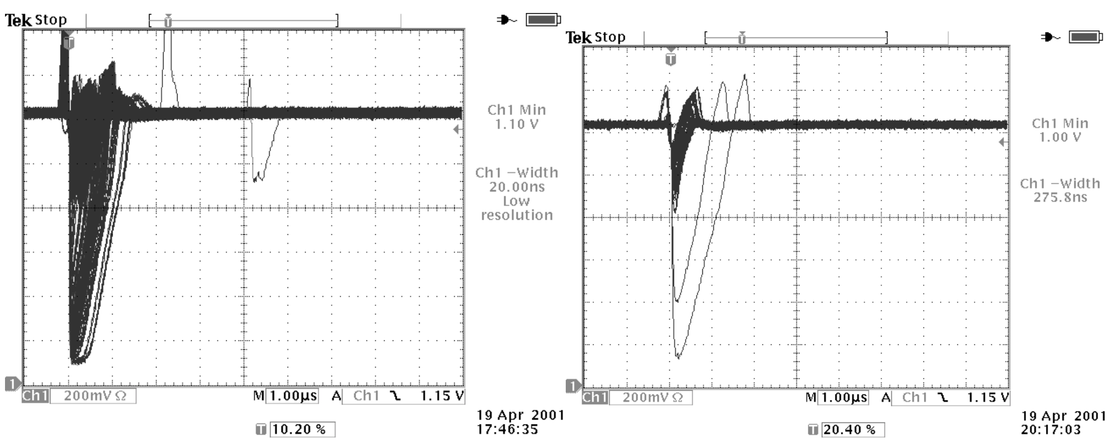

Fig 8.3.3 Oscilloscope picture, load=33 nF, LET=34 left and LET=14 right

8.4 Capacitance Load 100 nF: LT1009

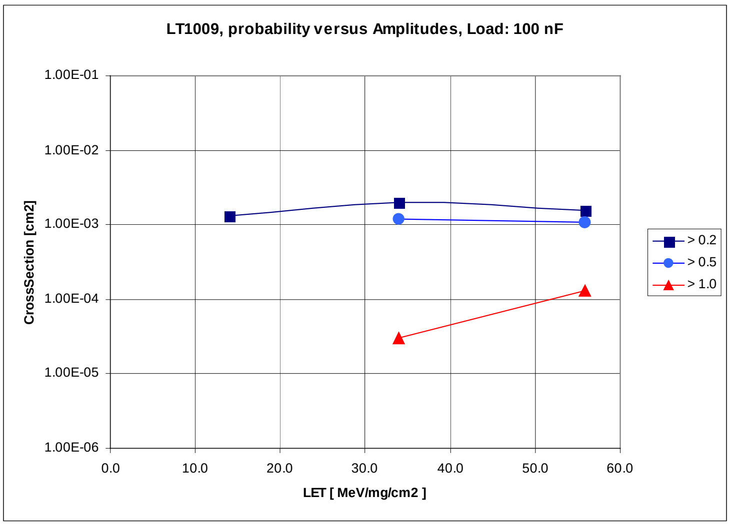

Fig 8.4.1 SET cross section versus LET-value for three different pulse amplitudes

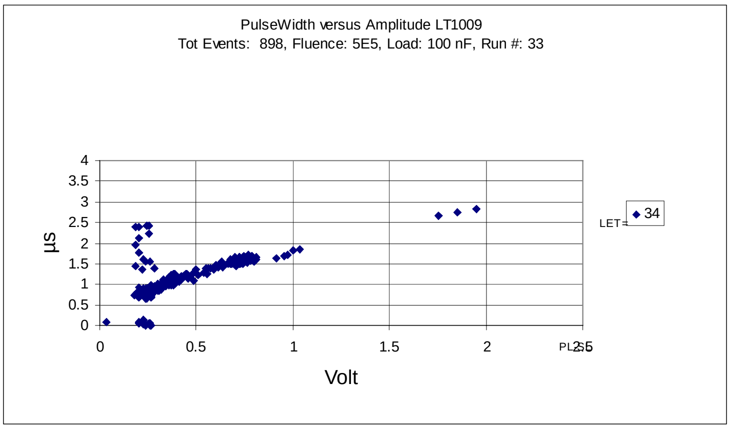

Fig 8.4.2 Scatter diagram showing pulse width in µs versus amplitude in Volt.

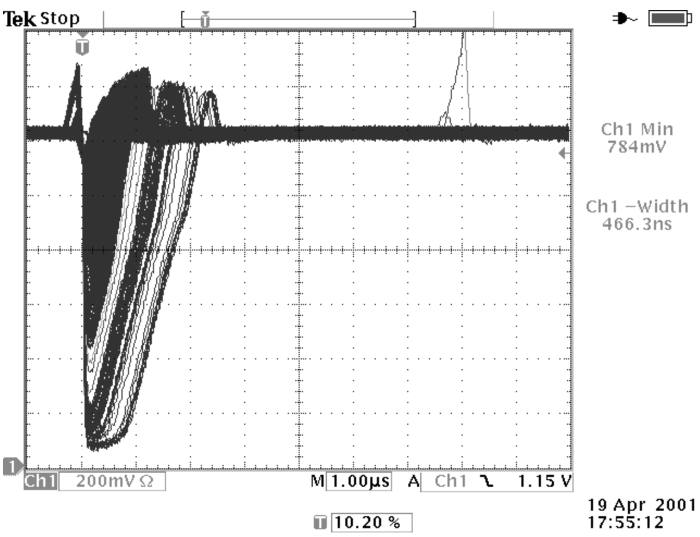

Fig 8.4.3 Oscilloscope picture, load=100 nF, LET=34

8.5 Capacitance Load 1µF: LT1009

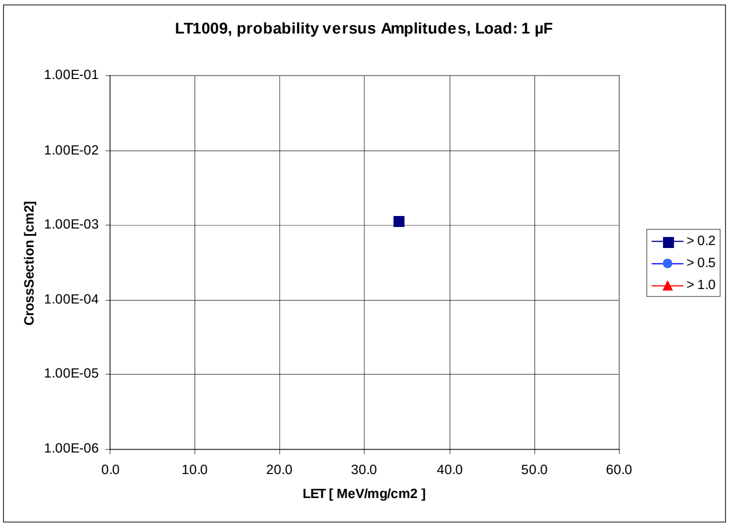

Fig 8.5.1 SET cross section versus LET-value.

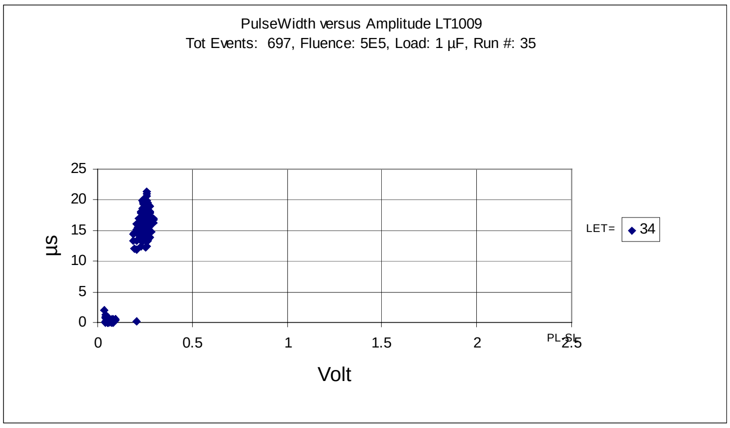

Fig 8.5.2 Scatter diagram showing pulse width in µs versus amplitude in Volt.

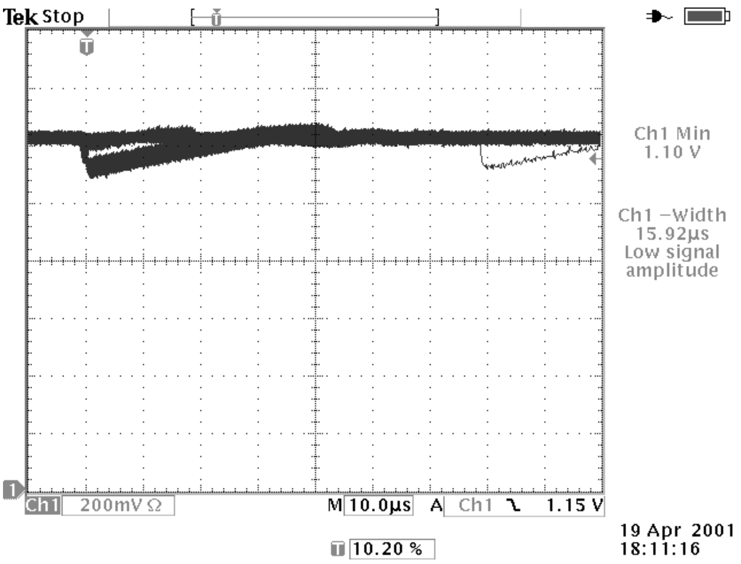

Fig 8.5.3 Oscilloscope picture, load=1µF, LET=34

9. APPENDIX C – RH1009 from Linear Technology

9.1 Capacitance Load 15 pF: RH1009

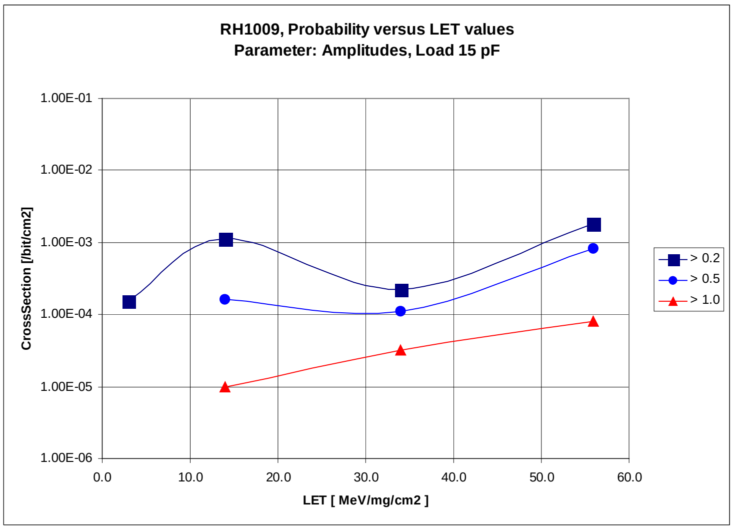

Fig 9.1.1 SET cross section versus LET-value for three different pulse amplitudes
The drop in cross section for amplitudes >0.2 Volt at LET= 34 is due to uncontrolled dead time in the data recording system.

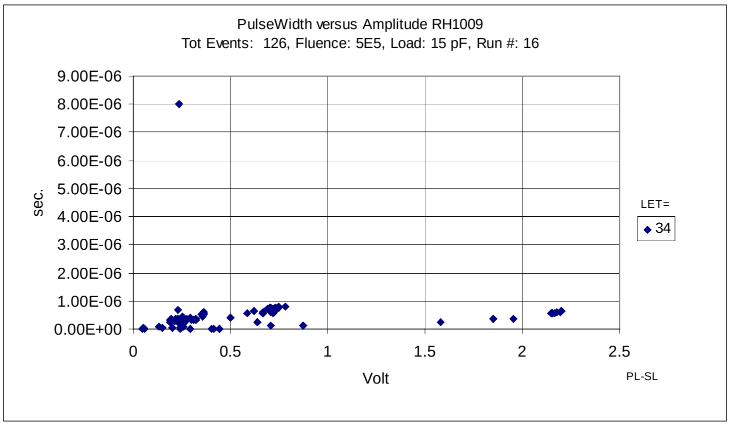

Fig 9.1.2 Scatter diagram showing pulse width in seconds versus amplitude in Volt.

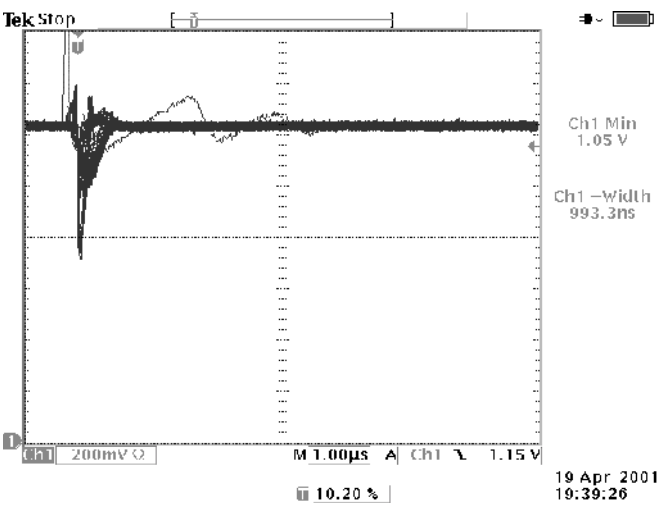

Fig 9.1.3 Oscilloscope picture, load= 15 pF, LET=14

9.2 Capacitance Load 3.3 nF: RH1009

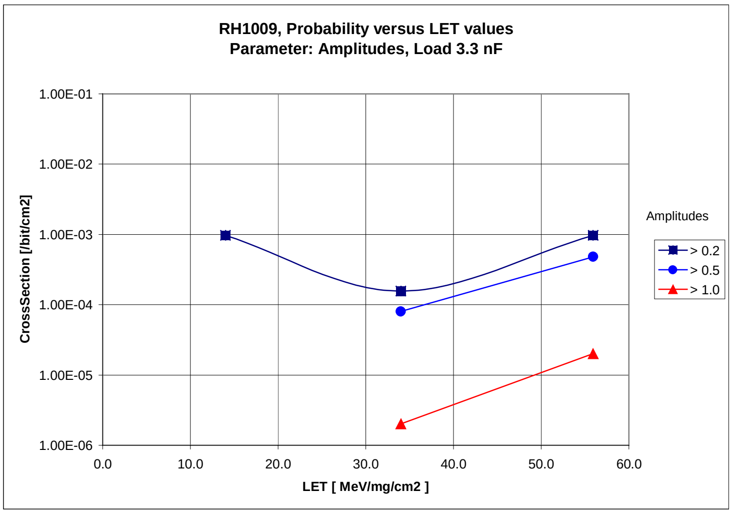

Fig 9.2.1 SET cross section versus LET-value for three different pulse amplitudes The drop in cross section for amplitudes >0.2 Volt at LET= 34 is due to uncontrolled dead time in the data recording system.

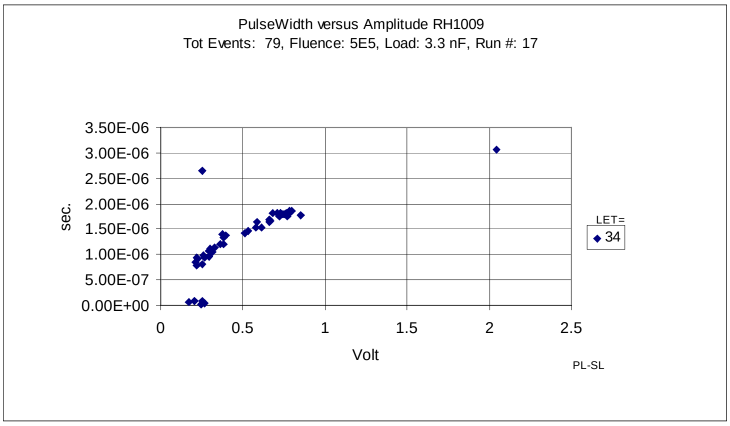

Fig 9.2.2 Scatter diagram showing pulse width in seconds versus amplitude in Volt.

9.3 Capacitance Load 33 nF: RH1009

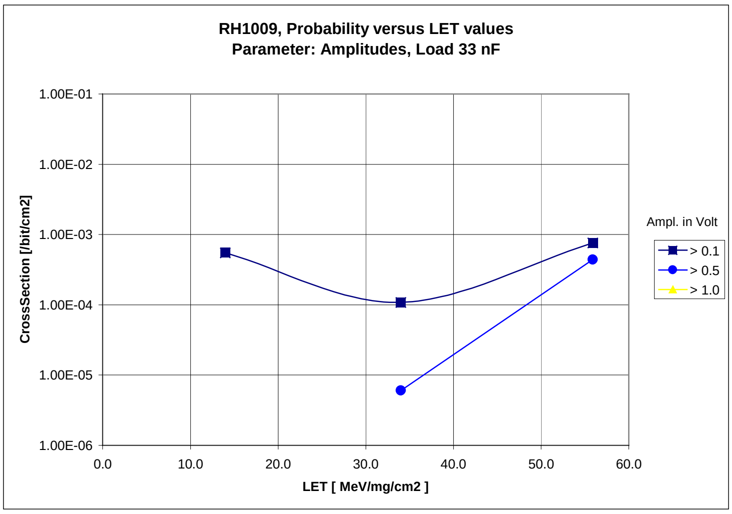

Fig 9.3.1 SET cross section versus LET-value for two different pulse amplitudes
The drop in cross section for amplitudes >0.2 Volt at LET= 34 is due to uncontrolled dead time in the data recording system. No SET pulse >1 V was observed.

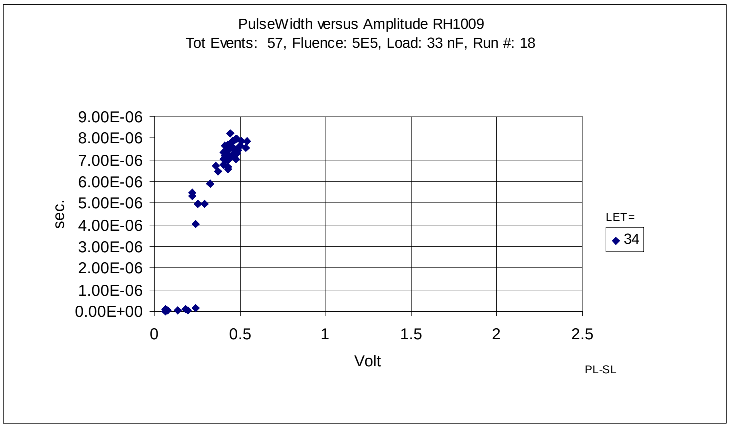

Fig 9.3.2 Scatter diagram showing pulse width in seconds versus amplitude in Volt.

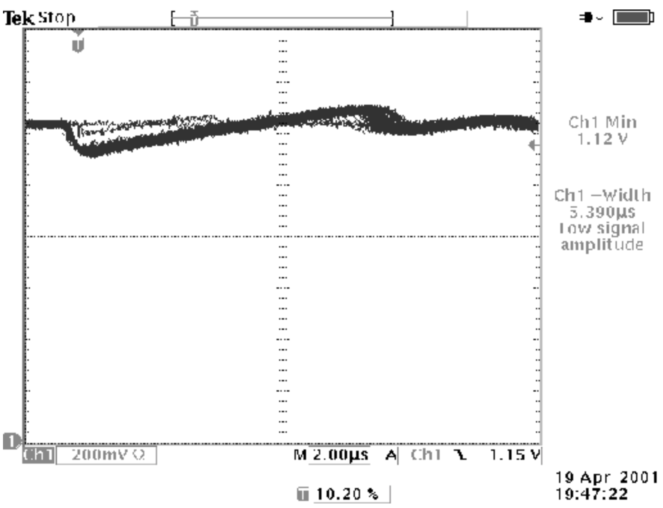

Fig 9.3.3 Oscilloscope picture, load= 15 pF, LET=14

9.4 Capacitance Load 100 nF: RH1009

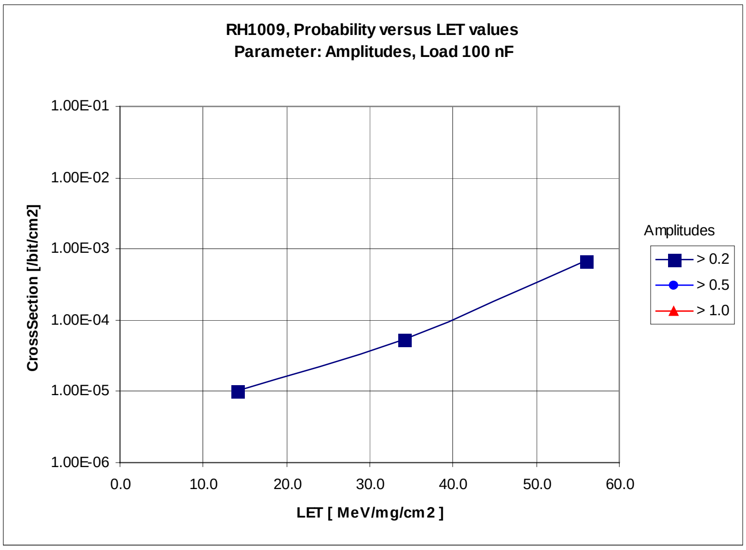

Fig 9.4.1 SET cross section versus LET-value. No SET pulse >0.5 V was observed.

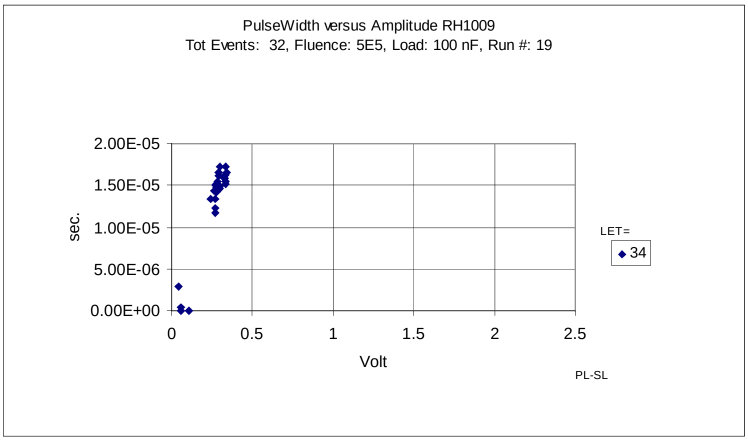

Fig 9.4.2 Scatter diagram showing pulse width in seconds versus amplitude in Volt.

10. APPENDIX D – IS1009 from Intersil

10.1 Capacitance Load 15 pF: IS1009

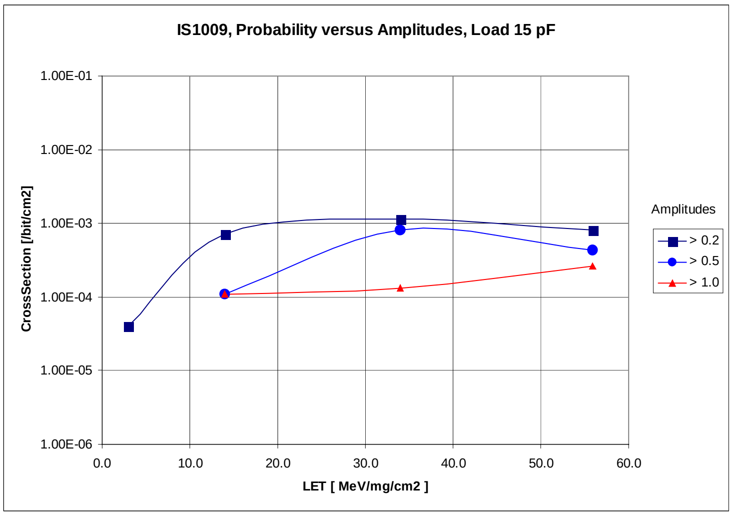

Fig 10.1.1 SET cross section versus LET-value for three different pulse amplitudes.

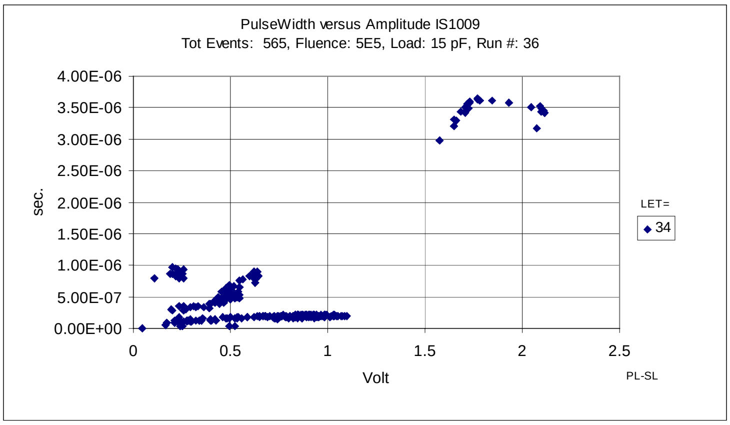

Fig 10.1.2 Scatter diagram showing pulse width in seconds versus amplitude in Volt.

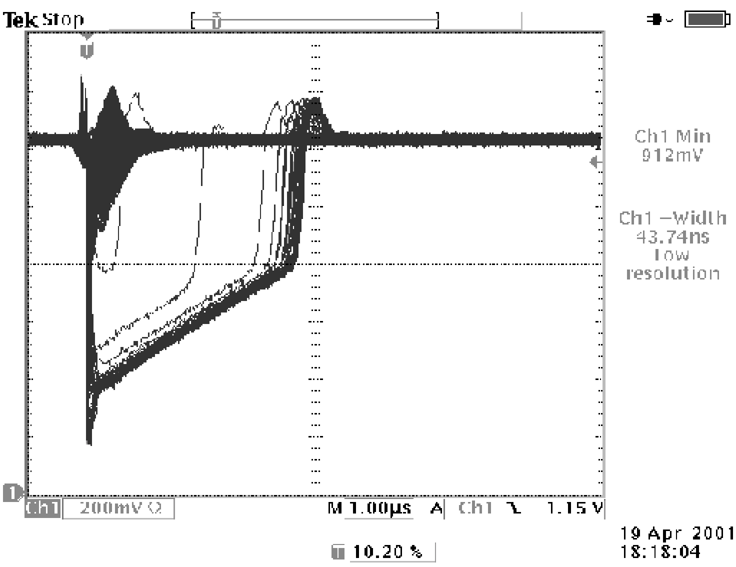

Fig 10.1.3 Oscilloscope picture, load= 15 pF, LET=34

10.2 Capacitance Load 3.3 nF: IS1009

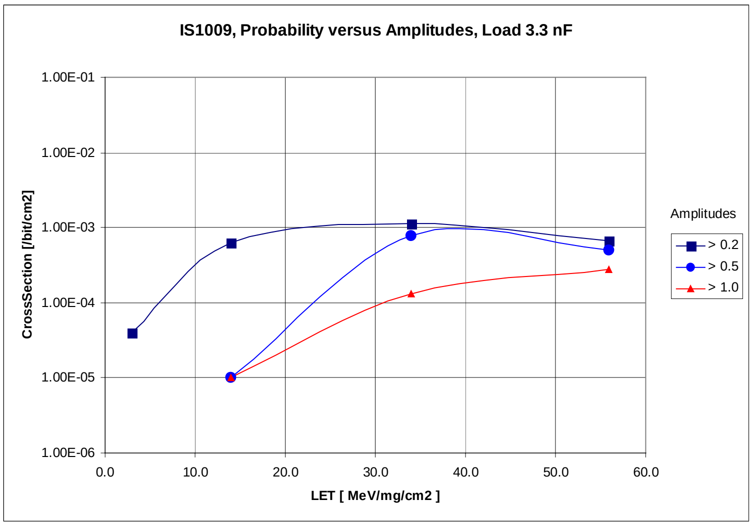

Fig 10.2.1 SET cross section versus LET-value for three different pulse amplitudes.

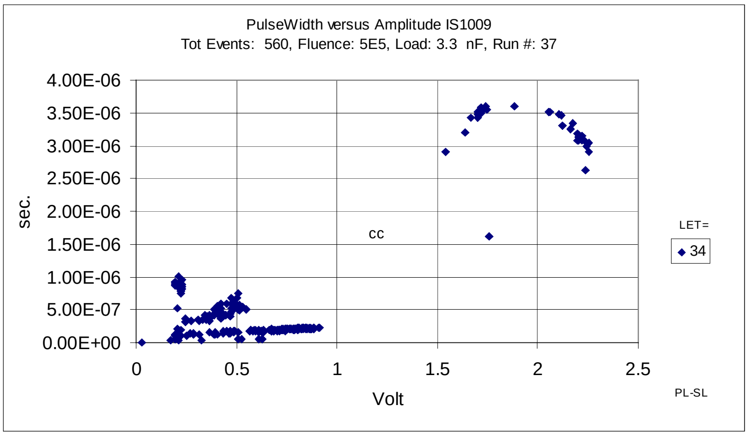

Fig 10.2.2 Scatter diagram showing pulse width in seconds versus amplitude in Volt.

10.3 Capacitance Load 33 nF: IS1009

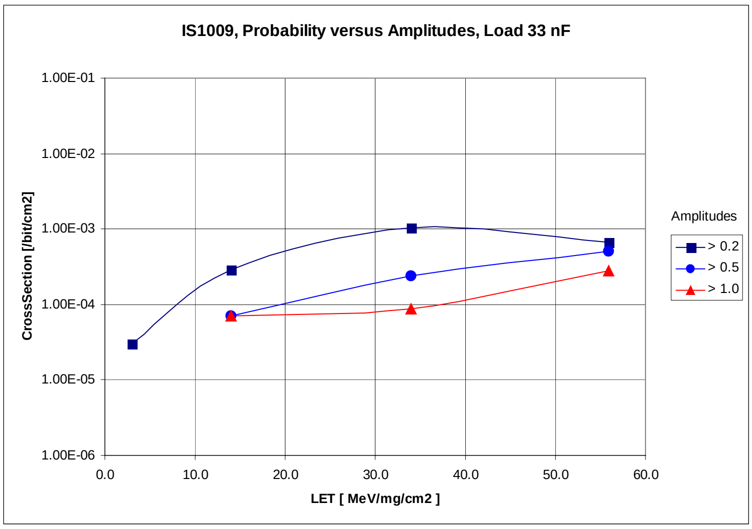

Fig 10.3.1 SET cross section versus LET-value for three different pulse amplitudes.

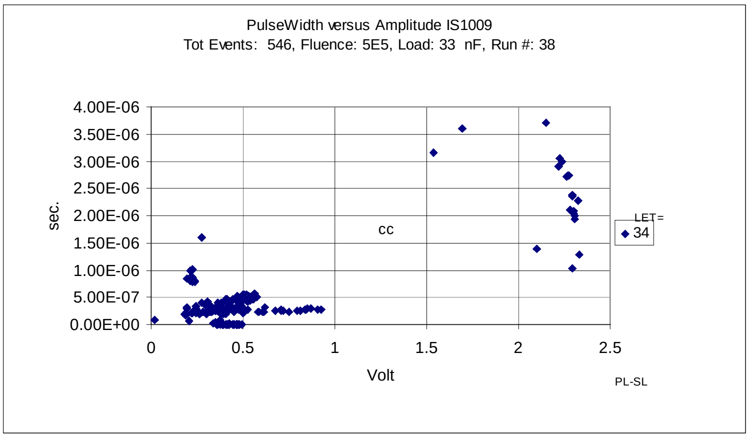

Fig 10.3.2 Scatter diagram showing pulse width in seconds versus amplitude in Volt.

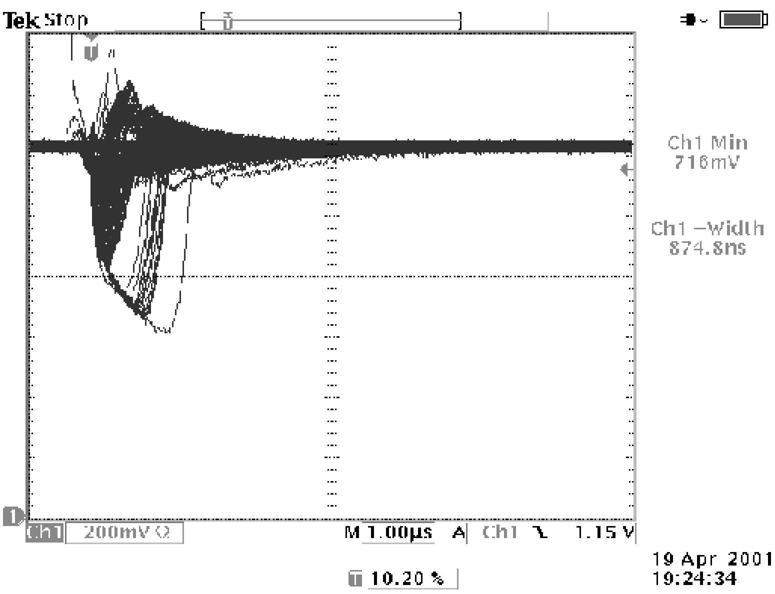

Fig 10.3.3 Oscilloscope picture, load= 33 nF, LET=34

10.4 Capacitance Load 100 nF: IS1009

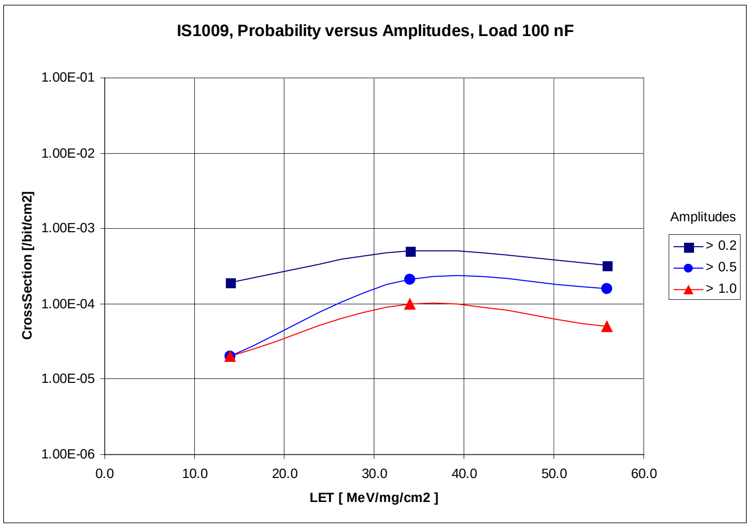

Fig 10.4.1 SET cross section versus LET-value for three different pulse amplitudes.

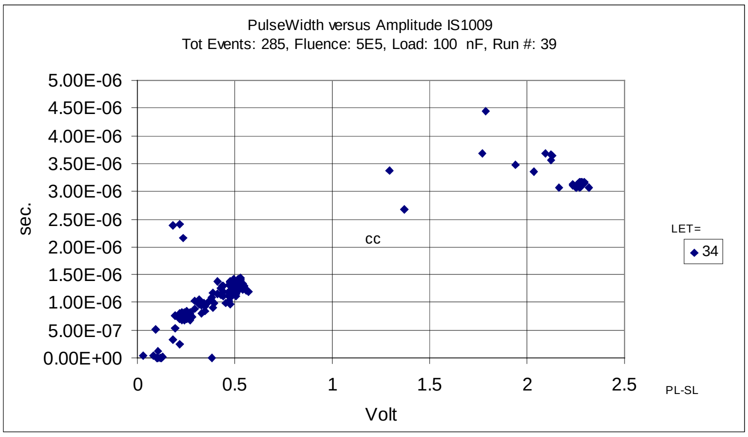

Fig 10.4.2 Scatter diagram showing pulse width in seconds versus amplitude in Volt.

10.5 Capacitance Load 1 µF: IS1009

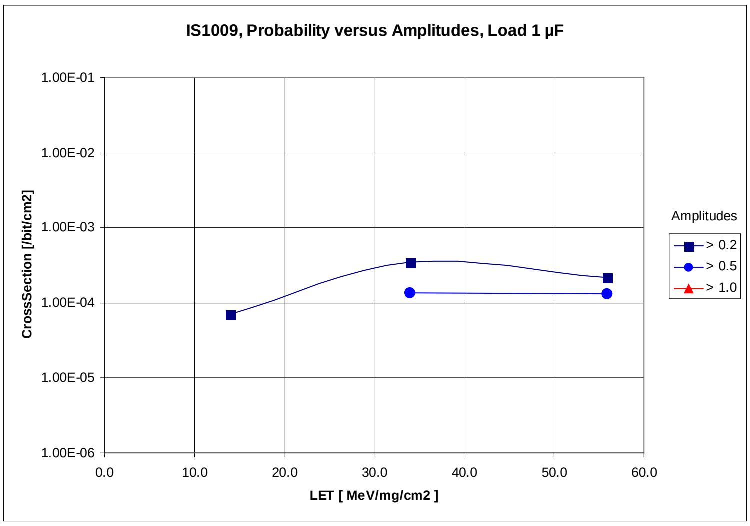

Fig 10.5.1 SET cross section versus LET-value for two different pulse amplitudes.

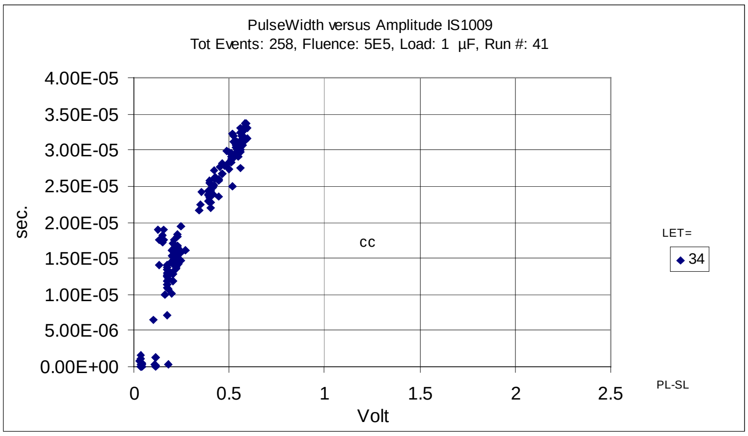

Fig 10.5.2 Scatter diagram showing pulse width in seconds versus amplitude in Volt.

11. APPENDIX E – REF43 from Analog Devices

11.1 Capacitance Load 15 pF: REF43

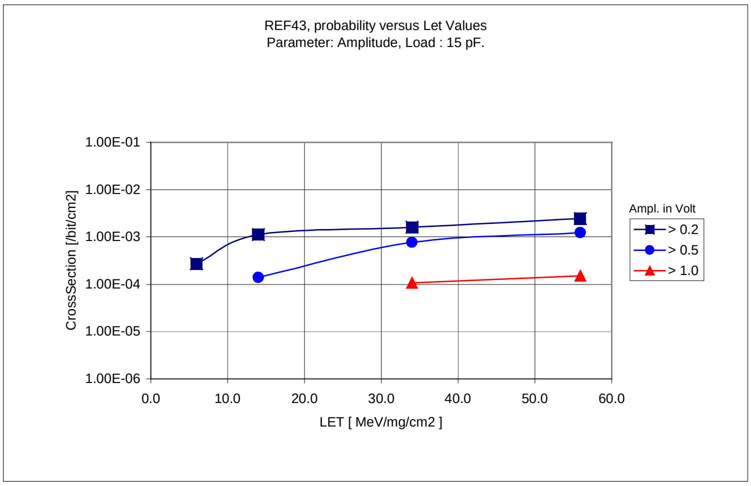

Fig 11.1.1 SET cross section versus LET-value for three different pulse amplitudes.
No SET event was observed at LET=3 for a fluence of E+5 ions.
Data at LET=6Mevcm2/mg are taken at 60° tilt angle

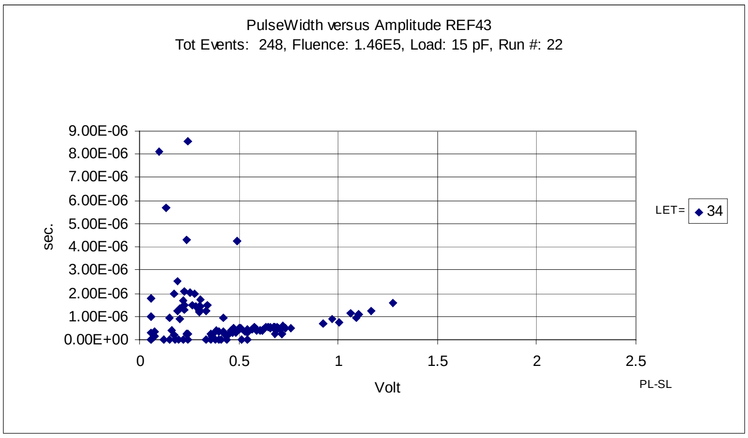

Fig 11.1.2 Scatter diagram showing pulse width in seconds versus amplitude in Volt.

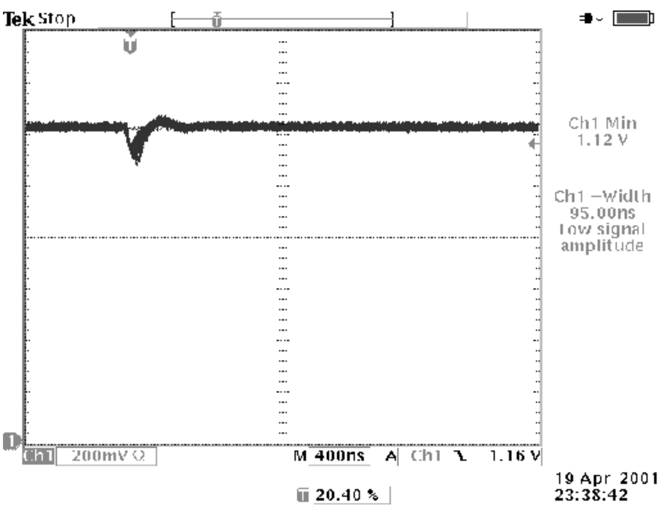

Fig 11.1.3 Oscilloscope picture, load= 15 pF, LET=6, (Tilt 60 deg of ^{15}N).

No pulses were observed in 0° for ^{15}N.

11.2 Capacitance Load 3.3 nF: REF43

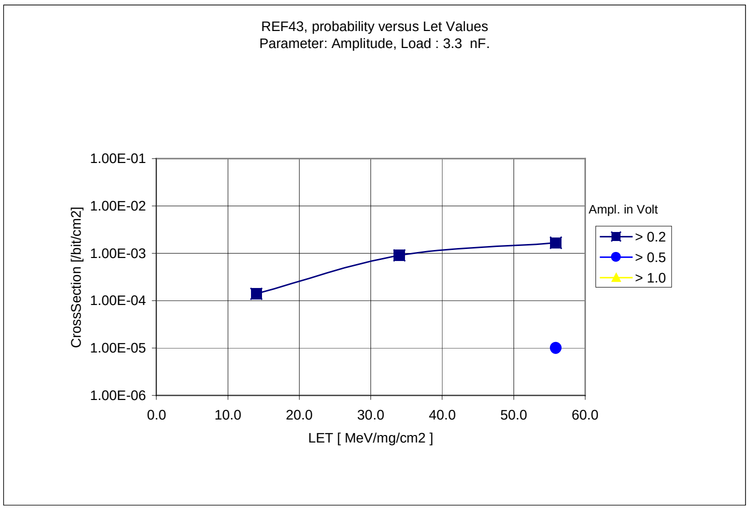

Fig 11.2.1 SET cross section versus LET-value for two different pulse amplitudes. No large amplitude data was observed

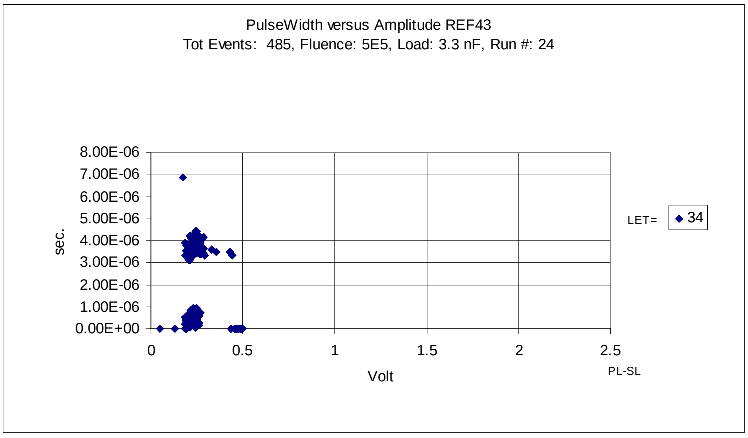

Fig 11.2.2 Scatter diagram showing pulse width in seconds versus amplitude in Volt.

11.3 Capacitance Load 33 nF: REF43

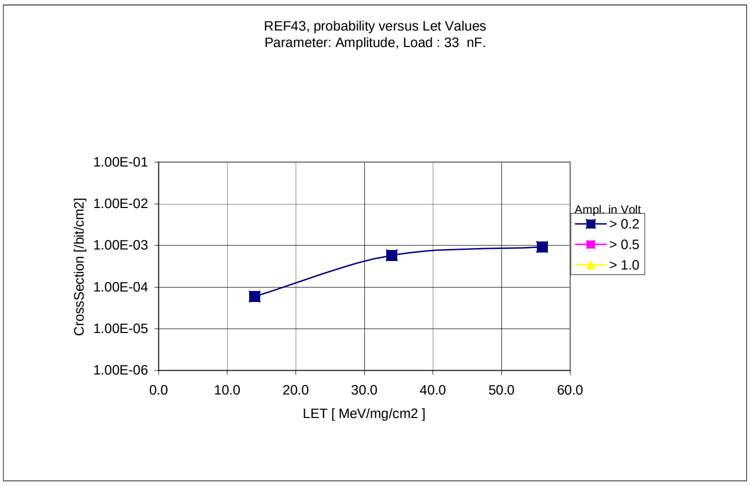

Fig 11.3.1 SET cross section versus LET-value.
No SET with large amplitude was observed

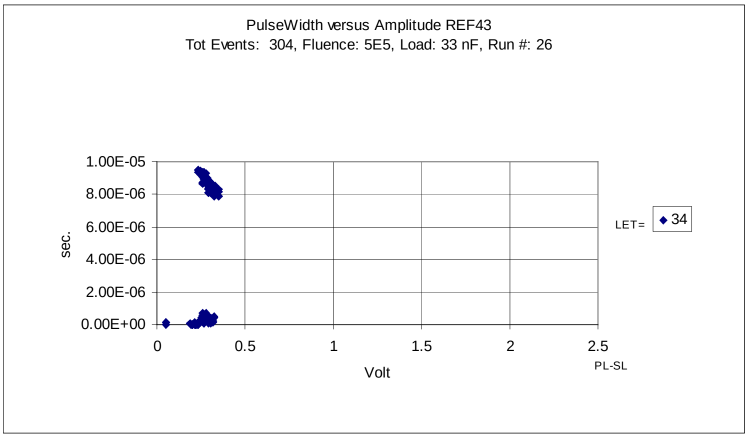

Fig 11.3.2 Scatter diagram showing pulse width in seconds versus amplitude in Volt.

11.4 Capacitance Load 100 nF: REF43

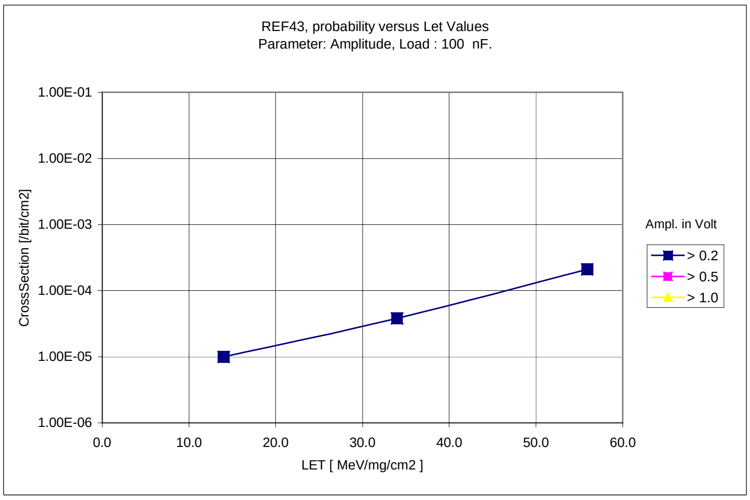

Fig 11.4.1 SET cross section versus LET-value.
No large amplitude data was observed

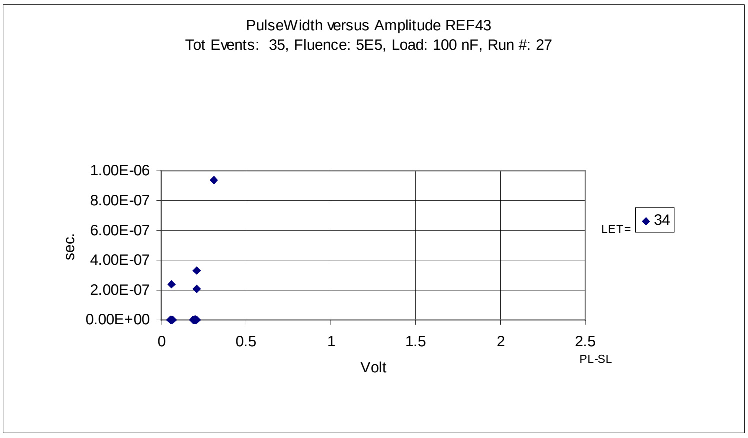

Fig 11.4.2 Scatter diagram showing pulse width in seconds versus amplitude in Volt.