SINGLE EVENT EFFECTS TEST REPORT

PRODUCT:	ADL5501
DIE TYPE:	ADL5501 Rev A
DATE CODE:	1138
CASE TEMPERATURE:	SEL: 125°C SET: 25°C
EFFECTIVE LET:	SEL: 84.85 MeV-cm^2/mg SET: (3.63 – 60) MeV-cm^2/mg
TOTAL EFFECTIVE FLUENCE:	1e7 Ions/cm^2
FACILITIES:	RADEF, University of Jyväskylä
TESTED:	February, 2013

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ANALOG DEVICES

SINGLE EVENT EFFECTS
TEST REPORT

Test Type:	Heavy ion
Test facility:	RADEF, University of Jyväskylä, Jyväskylä, Finland
Test Date:	February 2013
Part Type:	ADL5501
Part Description:	50 MHz to 6 GHz TruPwr Detector
Part Manufacturer:	Analog Devices

Analog Devices contract n° 45399090

Hirex reference :	HRX/SEE/0437	Issue : 01	Date :	June 21, 2013
Written by :	Mehdi Kaddour	Design Engineer		
Authorized by:	F.X. Guerre	Study Manager		

RESULTS SUMMARY

Facility

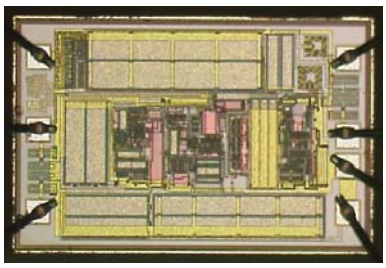
RADEF, University of Jyväskylä, Jyväskylä, Finland

Test date

February 2013

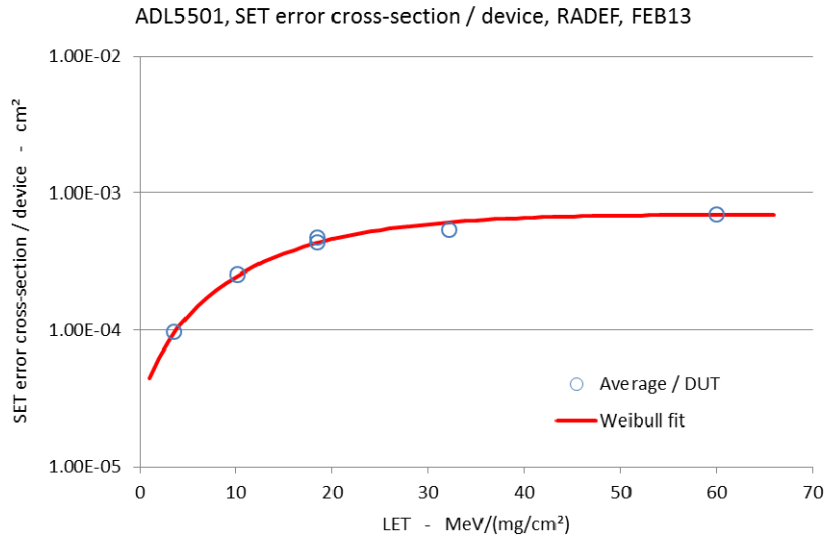
Device description

Part type:	ADL5501
Manufacturer:	Analog Devices
Package:	FP-10
Top marking:	ADL5501AX1 1138 serial
Bottom marking:	
Date code:	1138
Die dimensions:	1.64 mm X 1.36 mm



SET Results

Bias voltage was set to +5 V and room temperature with sine wave 9dBm at 50MHz signal at the input.
Four samples have been exposed over a LET range from 3.63 to 60 MeV/(mg/cm²) for SET testing.
SET events were detected at any tested LET.
Asymptotic SET cross-section / channel is about 7 10-4 cm2 while LET threshold is below 3.5 MeV/(mg/cm2).



W	22
xo	1
A	7.00E-04
s	1.6

see paragraph 7 for Weibull parameters definition

SEL Results

No SEL was detected with Vd =+5.5V and with a DUT temperature of 125°C at a LET of 85MeV/(mg/cm²) and a fluence of 1 10+07 ions/ cm².

DOCUMENTATION CHANGE NOTICE

Issue	Date	Page	Change Item	
01	21-Jun-13	All	Original issue	

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1 Introduction

This report presents the results of Heavy Ions test program carried out on a 50 MHz to 6 GHz TruPwr Detector ADL5501. During February 2013, four samples were used for heavy ions testing at RADEF, University of Jyväskylä, Jyväskylä, Finland.
This work was performed for Analog Devices under contract n° 45399090.

2 Applicable and Reference Documents

2.1 Applicable Documents

AD-1. ADL5501: 50 MHz to 6 GHz TruPwr Detector Data Sheet (Rev B).

AD-2. Hirex proposal PRO/4032 Issue 02.

2.2 Reference Documents

RD-1. Single Event Effects Test method and Guidelines ESA/SCC basic specification No 25100

3 DEVICE INFORMATION

3.1 Device description

The ADL5501 is a 50 MHz to 6 GHz TruPwr Detector.

Part type:	ADL5501
Manufacturer:	Analog Devices
Package:	FP-10
Top marking:	ADL5501AX1 1138 serial
Bottom marking:	-
Date code:	1138
Die dimensions:	1.64 mm X 1.36 mm

3.2 Sample identification

ADL5501 parts were delivered by Analog Devices. 10 samples were prepared and delidded to be tested to heavy ions. 8 samples were verified fully functional before the test campaign, and 4 were tested under irradiation.

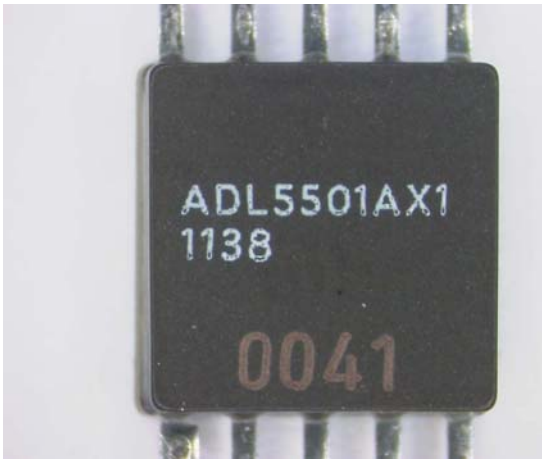


Photo 1 – Device top view

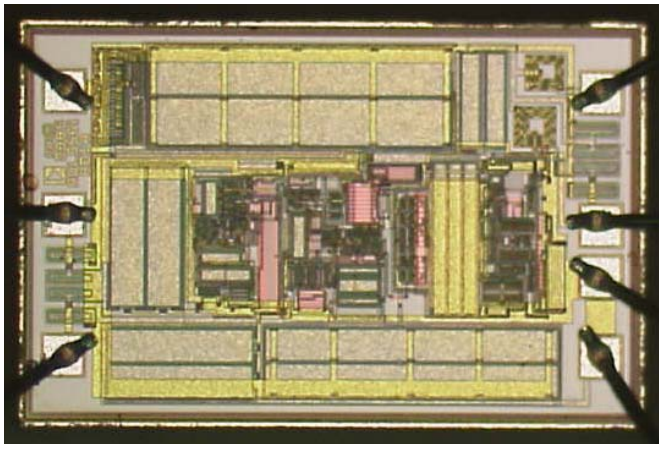


Photo 2 – Device delidded

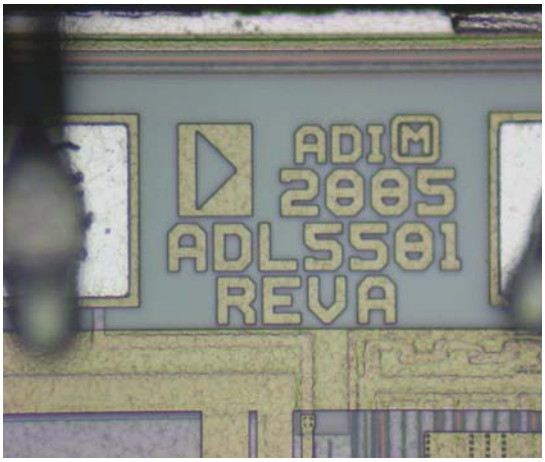


Photo 3 – Die marking

Figure 1: ADL5501 device identification

The assembly is equipped with a standard mounting fixture. The adapters required to accommodate the special board configurations and the vacuum feed-through can also be made in the laboratory's workshops. The chamber has an entrance door, which allows rapid changing of the circuit board or individual components.

A CCD camera with a magnifying telescope is located at the other end of the beam line to determine accurate positioning of the components. The coordinates are stored in the computer's memory allowing fast positioning of various targets during the test.

4.2 Beam quality control

For measuring beam uniformity at low intensity, a CsI(Tl) scintillator with a PIN-type photodiode readout is fixed in the mounting fixture. The uniformity is measured automatically before component irradiation and the results can be plotted immediately for more detailed analysis. A set of four collimated PIN-CsI(Tl) detectors is located in front of the beam entrance. The detectors are operated with step motors and are located at 90 degrees with respect to each other. During the irradiation and uniformity scan they are set to the outer edge of the beam in order to monitor the stability of the homogeneity and flux.

4.3 Dosimetry

The flux and intensity dosimeter system contains a Faraday cup, several collimators, a scintillation counter and four PIN-CsI(Tl) detectors. Three collimators of different sizes and shapes are placed 25 cm in front of the device under test. They can be used to limit the beam to the active area to be studied.

At low fluxes a plastic scintillator with a photomultiplier tube is used as an absolute particle counter. It is located behind the vacuum chamber and is used before the irradiation to normalize the count rates of the four PIN-CsI(Tl) detectors.

4.4 Used ions

The following Table 1 summarizes the used ions during the test campaign.

Ion	Beam energy (MeV)	Range (Si) (µm)	LET* (MeV.cm^2/mg)
20 Ne+6	186	146	3.63
40 Ar+12	372	118	10.2
56 Fe+15	523	97	18.5
82 Kr+22	768	94	32.2
131 Xe+35	1217	89	60.0

*: LET at surface SRIM2006

Table 1: Used ions

5 Test Set-up

Test system Figure 3 shows the principle of the Heavy Ion test system.

The test system is based on a Virtex5 FPGA (Xilinx). It runs at 50 MHz. The test board has 168 I/Os which can be configured using several I/O standards.

The test board includes the voltage/current monitoring and the latch-up management of the DUT power supplies up to 24 independent channels.

The communication between the test chamber and the controlling computer is effectively done by a 100Mbit/s Ethernet link which safely enables high speed data transfer.

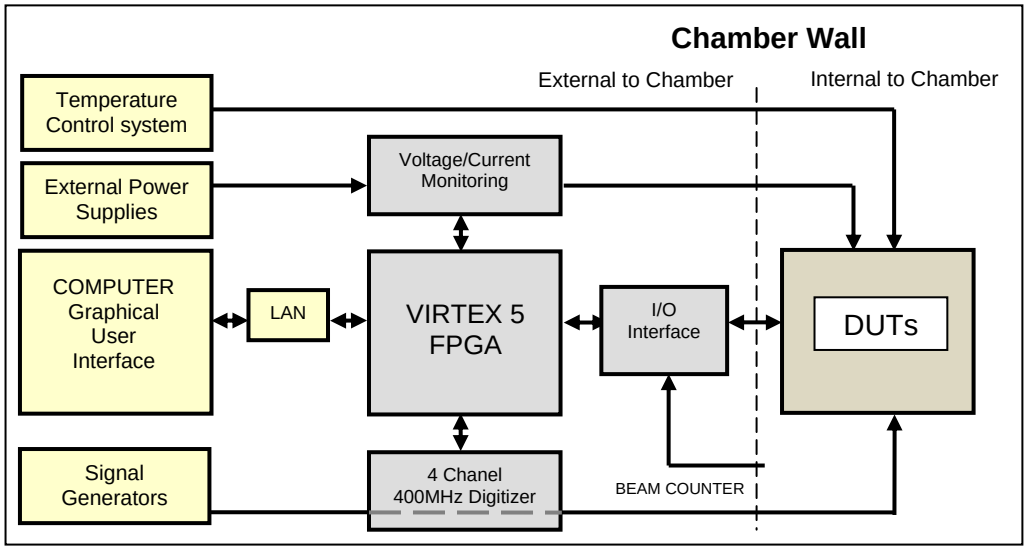


Figure 3: Heavy ion test set-up

5.1 SET

All along the test Sine wave 9dBm at 50MHz signal was applied to the 4 ADL5501inputs.
Then, DUT output is a constant voltage signal of about 2.8V.
Upper and lower thresholds of +/130mV are applied to detect the SETs.

5.2 SEL

SEL detection is performed by monitoring the DUT supply currents. When a SEL occurs (typically over 50mA during at least 2 milliseconds), then device is switched off during 1 second, and the SEL event is registered in the log file.

The SEL threshold can be adjusted during the test, but in general it is adjusted before starting the test. During all irradiation time, the supply currents of each DUT are monitored and recorded.

5.3 ADL5501 test principle and conditions

Figure 4 shows the test configuration.
In order to test the ADL5501 50 MHz to 6 GHz TruPwr Detector, one daughter board was designed. Four DUTs were soldered on the boards (see Figure 5)
The four samples on each board were irradiated in the same time.

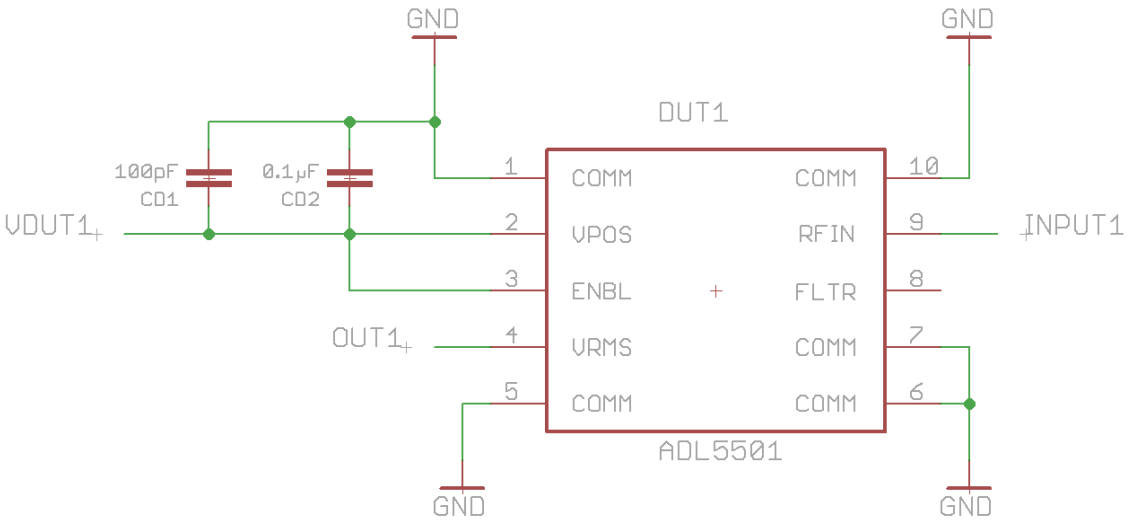


Figure 4: ADL5501 test configuration

Supply Voltages
Input: Sine wave 9dBm at 50MHz
Supply voltage for SET: +5V
Supply voltage for SEL: +5.5V at 85°C and 125°C

Consumptions
Dut 1: 5 mA
Dut 2: 5 mA
Dut 3: 5 mA
Dut 4: 5 mA

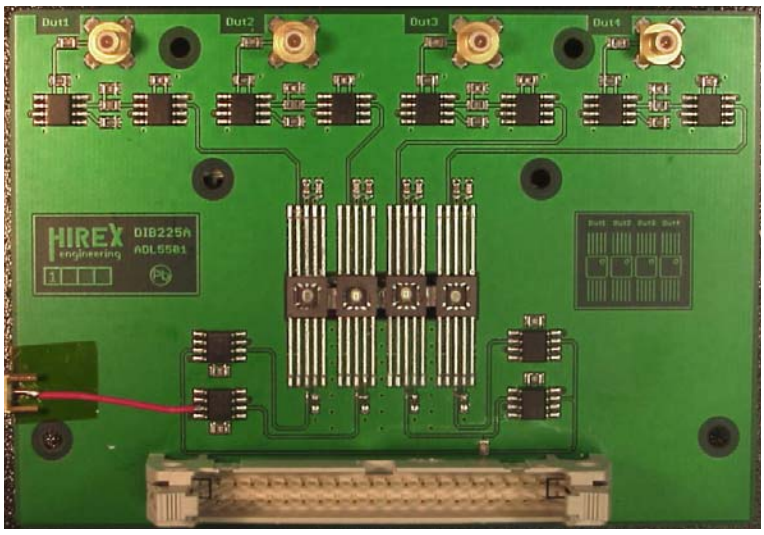


Figure 5 – ADL5501, photo of the daughter board

6 SEE Test Results

Four samples were exposed to 5 different LETs into a range from 3.63 MeV.cm²/mg up to 60 MeV.cm²/mg at ambient temperature for SET characterization and at 85°C and 125 °C for SEL characterization.
The detailed results table is presented in Table 2.

RUN HRX	Ion	LET	Tilt	Eff. LET	Fluence	Time	Mean Flux	Board	SNs	Temp	Vcc	SEL	SET	SET_CH1	SET_CH2	SET_CH3	SET_CH4	Comment		SET X-section DUT1	SET X-section DUT2	SET X-section DUT3	SET X-section DUT4	total	SET X-section / DUT
1	Ar	10.2	0	10.20	6.51E+05	461	1410	1	1 to 4	Room	5	0	1320	156	176	199	129		10.2	2.40E-04	2.70E-04	3.06E-04	1.98E-04	660	2.53E-04
2	Ne	3.63	0	3.63	1.00E+06	479	2090	1	1 to 4	Room	5	0	784	95	120	94	79		3.63	9.50E-05	1.20E-04	9.40E-05	7.90E-05	388	9.70E-05
3	Fe	18.5	0	18.50	2.00E+05	137	1460	2	5 to 8	Room	5	0	790	79	107	120	72		18.5	3.95E-04	5.35E-04	6.00E-04	3.60E-04	378	4.73E-04
4	Fe	18.5	0	18.50	5.00E+05	625	800	2	5 to 8	Room	5	0	1804	193	262	245	178		18.5	3.86E-04	5.24E-04	4.90E-04	3.56E-04	878	4.39E-04
5	Kr	32.2	0	32.20	5.00E+05	841	595	2	5 to 8	Room	5	0	2216	248	308	303	225		32.2	4.96E-04	6.16E-04	6.06E-04	4.50E-04	1084	5.42E-04
6	Xe	60	0	60.00	5.00E+05	636	786	2	5 to 8	Room	5	0	2870	358	387	369	281		60	7.16E-04	7.74E-04	7.38E-04	5.62E-04	1395	6.98E-04
7	Xe	60	45	84.85	1.00E+07	2754	3630	2	5 to 8	85	5.5	0	-					set n/a	60						
8	Xe	60	45	84.85	1.00E+07	2567	3900	2	5 to 8	125	5.5	0	-					set n/a	60						

Table 2 – RADEF, FEB 2013, ADL5501 runs details

6.1 SEL

No SEL has been observed with the following ions Ne, Ar, Fe, Kr and Xe. With Xenon additional specific SEL tests were performed with supply voltage at 5.5V and DUT temperature at 85°C and 125°C. No SEL has been detected at a LET of 85MeV/(mg/cm²) with fluences up to 1 10+07 ions/cm².

6.2 SET

First event was observed with Neon at LET = 3.63 MeV.cm²/mg. 1 LSB is for 13mV.
Figure 6 presents for Xenon the worst case events while Figure 9 show the events envelop for each ion and for the fou DUTs exposed at the same time.
With Xenon (LET= 60), worst case can extend up to about 10µs, and worst case amplitude can go up to saturation (5Volts) for positive events with a voltage output at about 2.8V and can attain 0.7V for negative transients.

SET cross-section per device is shown in Figure 7 and Weibull fit in Figure 8.

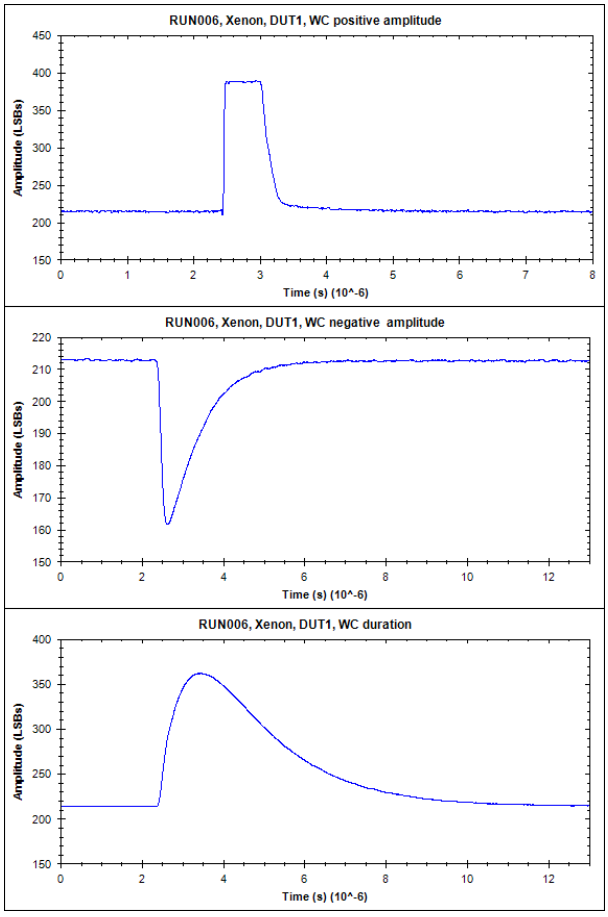


Figure 6 – DUT1, Worst case events with Xenon, RADEF, FEB13

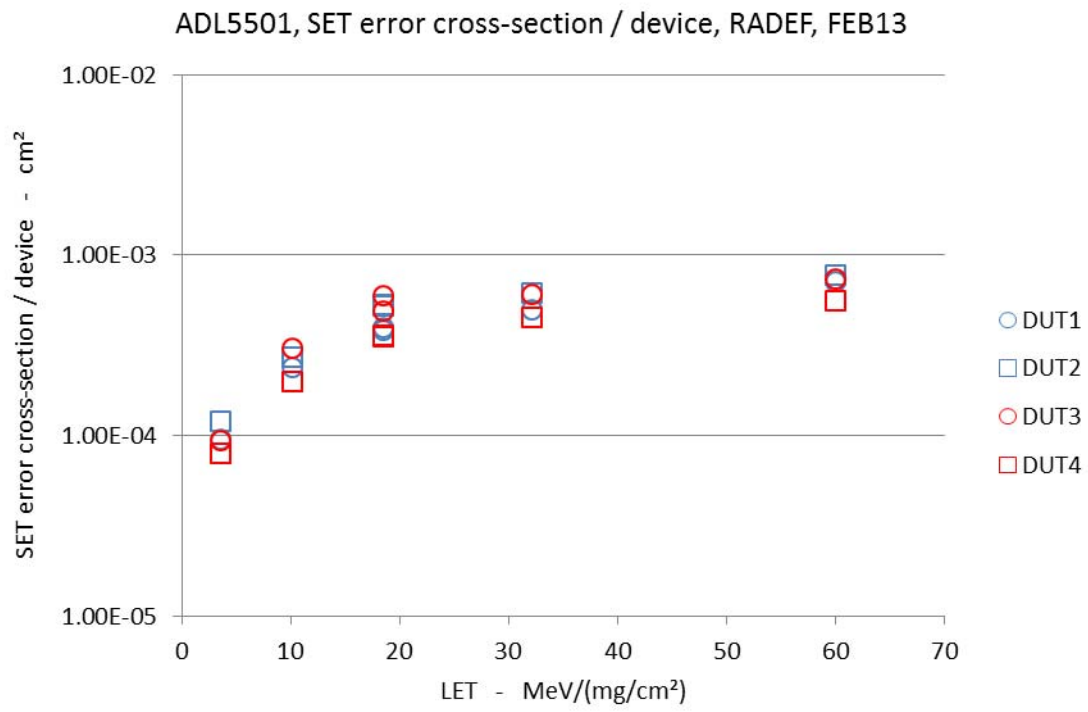
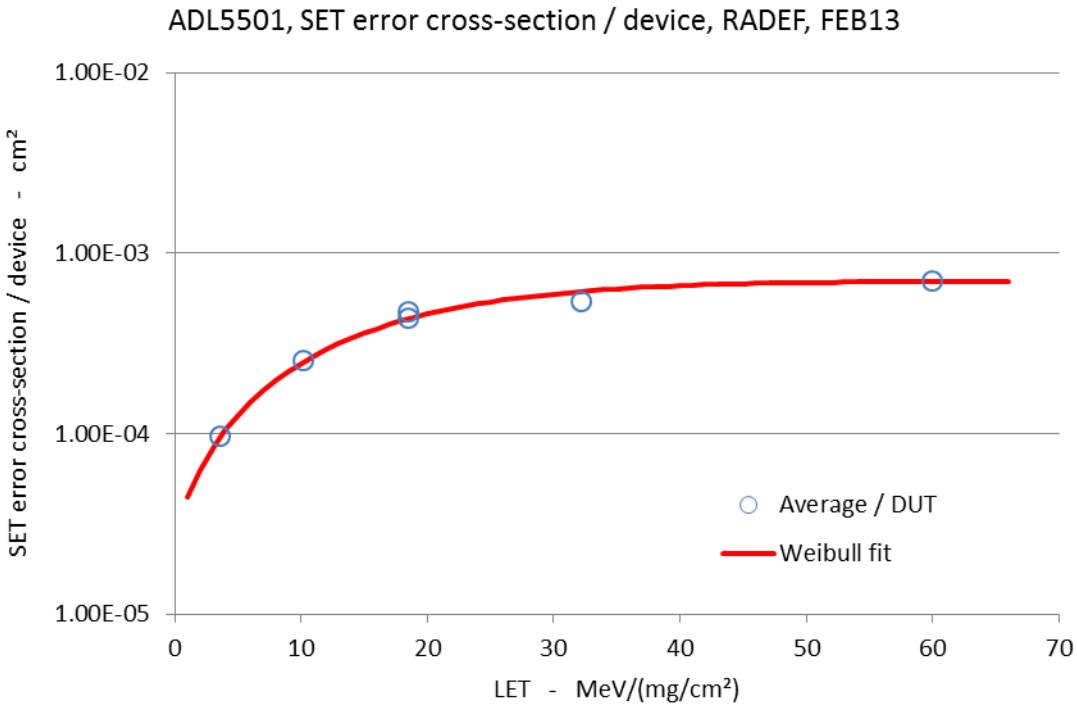


Figure 7: SET Cross-section / DUT



W	22
xo	1
A	7.00E-04
s	1.6

see paragraph 7 for Weibull parameters definition

Figure 8: Average SET Cross-section / DUT, Weibull fit

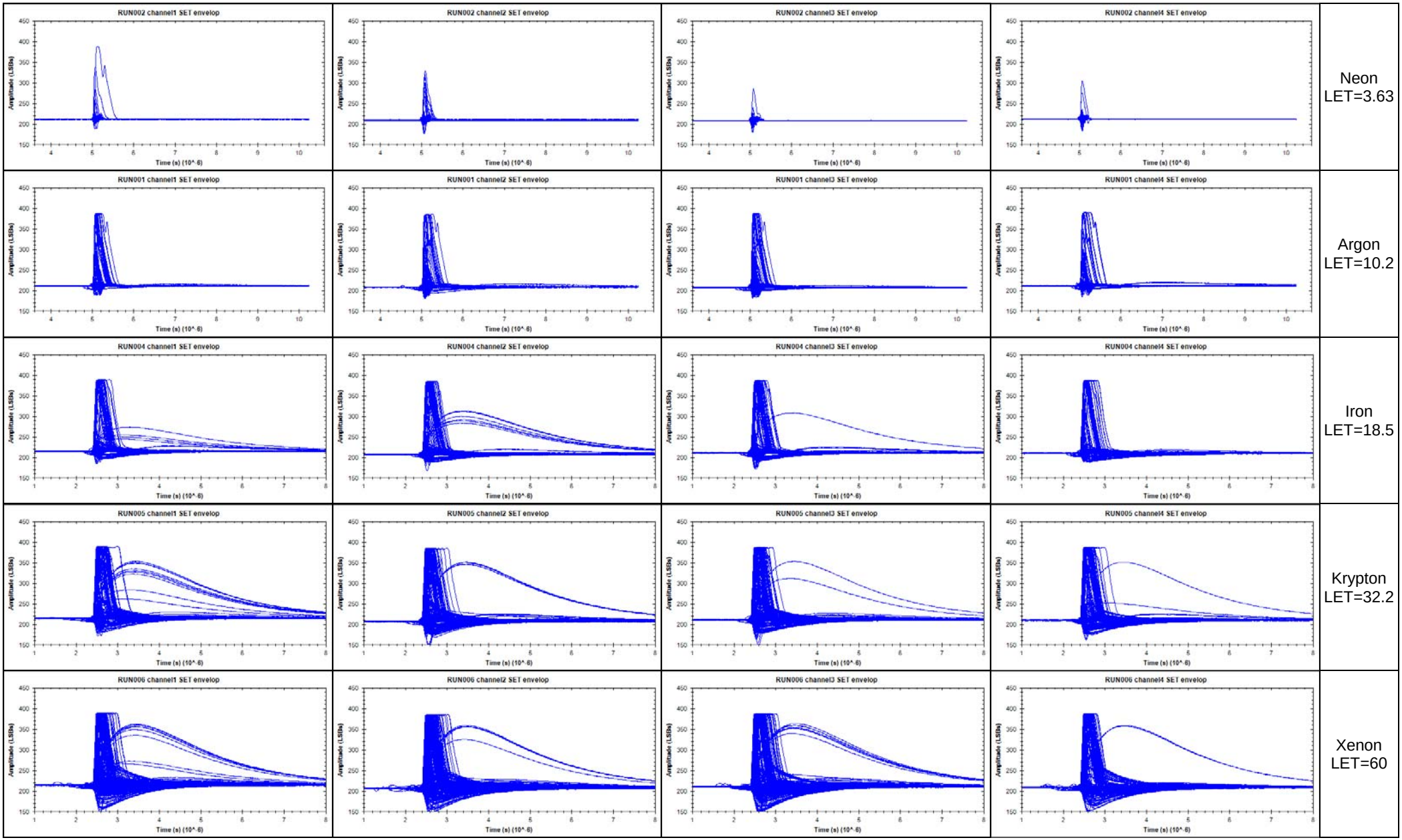


Figure 9 – SET envelop for the 4 DUTs exposed at the same time, with the different ions, RADEF, FEB13

7 Glossary

Most of the definitions here below are from JEDEC standard JESD89A

DUT: Device under test.

Fluence (of particle radiation incident on a surface): The total amount of particle radiant energy incident on a surface in a given period of time, divided by the area of the surface.
In this document, Fluence is expressed in ions per cm2.

Flux: The time rate of flow of particle radiant energy incident on a surface, divided by the area of that surface.
In this document, Flux is expressed in ions per cm2*s.

Single-Event Effect (SEE): Any measurable or observable change in state or performance of a microelectronic device, component, subsystem, or system (digital or analog) resulting from a single energetic particle strike.
Single-event effects include single-event upset (SEU), multiple-bit upset (MBU), multiple-cell upset (MCU), single-event functional interrupt (SEFI), single-event latch-up (SEL.

Single-Event Transient (SET): A soft error caused by the transient signal induced by a single energetic particle strike.

Single-Event Latch-up (SEL): An abnormal high-current state in a device caused by the passage of a single energetic particle through sensitive regions of the device structure and resulting in the loss of device functionality.
SEL may cause permanent damage to the device. If the device is not permanently damaged, power cycling of the device (off and back on) is necessary to restore normal operation.
An example of SEL in a CMOS device is when the passage of a single particle induces the creation of parasitic bipolar (p-n-p-n) shorting of power to ground.
Single-Event Latch-up (SEL) cross-section: the number of events per unit fluence. For chip SEL cross-section, the dimensions are cm2 per chip.

Error cross-section: the number of errors per unit fluence. For device error cross-section, the dimensions are cm2 per device. For bit error cross-section, the dimensions are cm2 per bit.

Tilt angle: tilt angle, rotation axis of the DUT board is perpendicular to the beam axis; roll angle, board rotation axis is parallel to the beam axis

Weibull Function: $F(x) = A\ (1- \exp\{-[(x-x0)/W]s\})$

x = effective LET in MeV-cm2 /milligram;
F(x) = SEE cross-section in square-cm2/bit;
A = limiting or plateau cross-section;
x0 = onset parameter, such that F(x) = 0 for x < x0;
W = width parameter;
s = a dimensionless exponent.