**SINGLE EVENT EFFECTS TEST REPORT**

| | |
|---|---|
| PRODUCT: | AD8229 |
| DIE TYPE: | 8YK90 |
| DATE CODE: | 1132 |
| CASE TEMPERATURE: | SEL: 125°C<br>SET: 25°C |
| EFFECTIVE LET: | SEL: (3.5 – 91.5) MeV-cm$^2$/mg<br>SET: (3.5 – 58.8) MeV-cm$^2$/mg |
| TOTAL EFFECTIVE FLUENCE: | SEL: 1e7 Ions/cm$^2$<br>SET: (3.87E4 – 1E6) ion/cm$^2$ |
| FACILITIES: | Lawrence Berkeley National Laboratories |
| TESTED: | November, 2012 |

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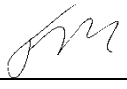
**SINGLE EVENT EFFECTS**
**TEST REPORT**

| | |
|---|---|
| Test Type: | Heavy Ion |
| Test facility: | LBNL / BASE |
| Test Date: | November 2012 |
| Part Type: | AD8229 |
| Part Description: | 1 nV/√Hz Low Noise<br>210°C Instrumentation Amplifier |
| Part Manufacturer: | Analog Devices |

**Analog Devices Purchase Order No 45399090 dated 9/25/2012**

| | | | | |
|---|---|---|---|---|
| **Hirex reference :** | HRX/SEE/0430 | Issue : 01 | Date : | June 19, 2013 |
| **Written by :** | M. Kaddour | Design Engineer |  | |
| **Authorized by:** | F.X. Guerre | Study Manager |  | |

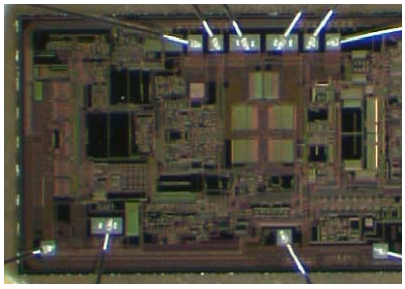
**RESULTS SUMMARY**

**Facility** LBNL / BASE

**Test date** November 2012

**Device description**

Part type: AD8229
Description: 1 nV/√Hz Low Noise 210°C Instrumentation Amplifier
Package: SBDIP-8 leads
Die dimensions: 1.692 mm x 2.801 mm



**SEE Results**

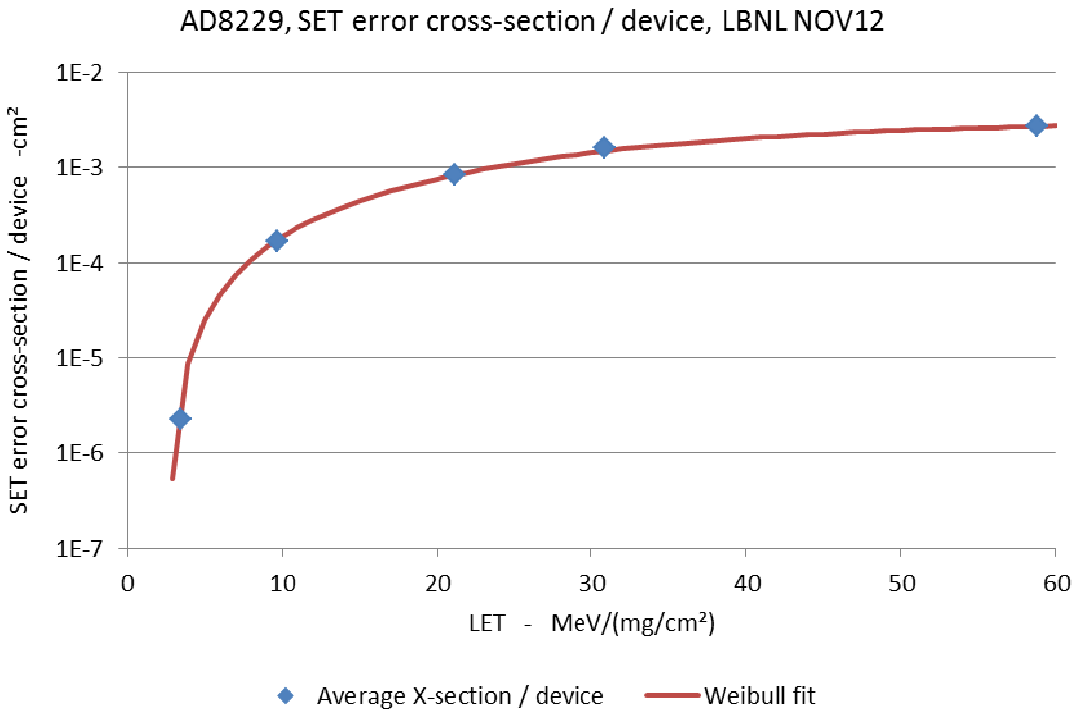
Four samples have been exposed over a LET range from 3.5 to 58.8 MeV/(mg/cm²) at room temperature for SET and at 125°C for SEL characterizations.

**SEL Results**

Device is not sensitive to SEL up to a LET of 91.5 MeV/(mg/cm2) with V =+/-17V bias conditions and at 125°C.

**SET Results**

SET events were detected at any tested LET.
Asymptotic SET cross-section / channel is about 3 $10^{-03}$ $cm^2$ while LET threshold is below 3.5 MeV/(mg/cm2)
Worst case amplitude with Xenon (Let=58.8) is about 13.1V while worst case duration is around 2.6µs.



| | |
|---|---|
| W | 35 |
| xo | 2.75 |
| A | 3.00E-03 |
| s | 1.75 |

(see 6 for Weibull parameter definition)

**DOCUMENTATION CHANGE NOTICE**

| Issue | Date | Page | Change Item | |
|---|---|---|---|---|
| 01 | 19/06/2013 | All | | |

Contributors to this work:

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| Laetitia Barrau | Hirex Engineering |
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# SEE TEST REPORT

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# 1 Introduction

This report presents the results of Heavy Ion test program carried out on Analog Devices 1 nV/√Hz Low Noise 210°C Instrumentation Amplifier AD8229.

Four parts were heavy ion tested at LBNL / BASE, Berkeley, USA in November 2012.

This work was performed for Analog Devices Purchase Order No 45399090, dated 09/25/2012.

# 2 Applicable and Reference Documents

## 2.1 Applicable Documents

AD-1. 1 nV/√Hz Low Noise
AD-2. 210°C Instrumentation Amplifier AD8229 datasheet; 2002 Revision B 2/12
AD-3. Hirex proposal HRX/PRO/4032 Issue 02, dated September 14, 2012

## 2.2 Reference Documents

RD-1. Single Event Effects Test method and Guidelines ESA/SCC basic specification No 25100
RD-2. The Berkeley Accelerator Space Effects (BASE) Facility, Proceedings of the Space Nuclear Conference 2005, San Diego, California, June 5-9, 2005

# 3 DEVICE INFORMATION

## 3.1 Device description

The AD8229 is a 1 nV/√Hz Low Noise
210°C Instrumentation Amplifier in a SBDIP ceramic package.

Part Type: AD8229
Manufacturer: Analog Devices
Package: SBDIP-8 leads
Tested samples: HRX s/n #01, #02, #03, #4
Top Marking: logo AD8229HDZ #1132 E194959
Die dimensions: 1.692 mm x 2.801 mm
Manufacturer lot # AG62661.9

## 3.2 Sample identification

Analog Devices has delivered 10 AD8229 samples.
Eight of them were prepared for heavy ions testing.


Photo 1 - Top Marking (AD8229)


Photo 2 – Bottom marking (AD8229)

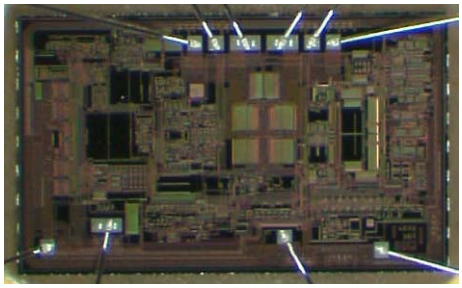

Photo 3 – Die full view (AD8229)

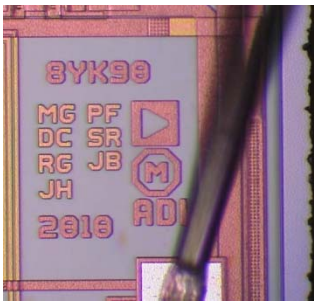


Photo 4 – Die marking 1 (AD8229)

**Figure 1: Device identification for the AD8229 part**

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# 4 Test Set-up

Figure 4 shows the principle of the Heavy Ion test system.

The test system is based on a Virtex5 FPGA (Xilinx). It runs at 50MHz. 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 16 independent channels.

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

Hirex 4-Channel digitizer allows monitoring the DUT outputs. The events are captured and stored. Recorded data provide information on SET amplitude (high level, low level) and width distribution (shape).

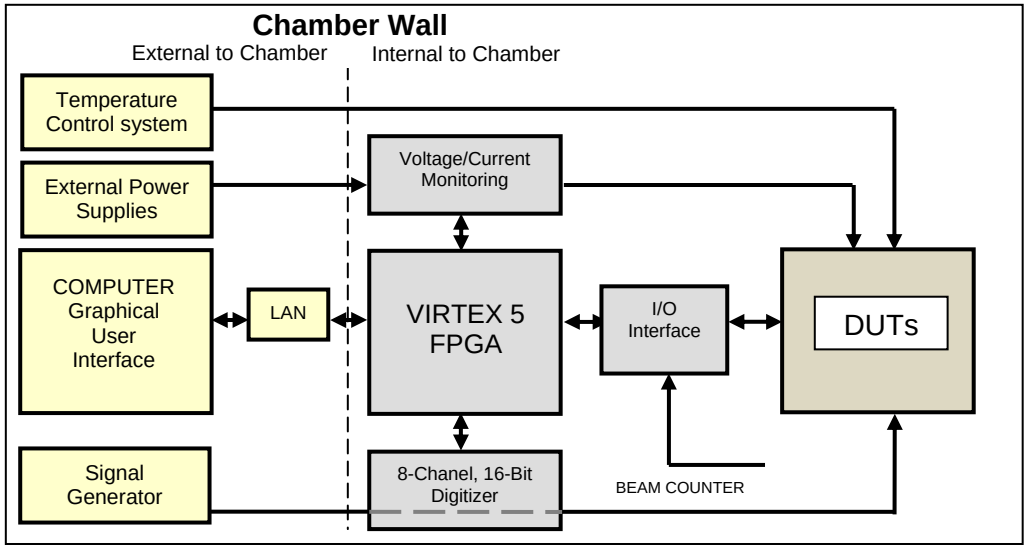



**Figure 4: Heavy Ion test set-up**

SET

A dynamic signal, i.e. a sine wave -1v/+1V at 100kHz v is applied at DUT input.
A subtraction operation is executed between each output sample from the present period and equivalent sample from the previous period. If the result of subtraction exceeds 12 LSB (detection threshold), then an error is detected and output recording is triggered. (1 LSB =36mV)

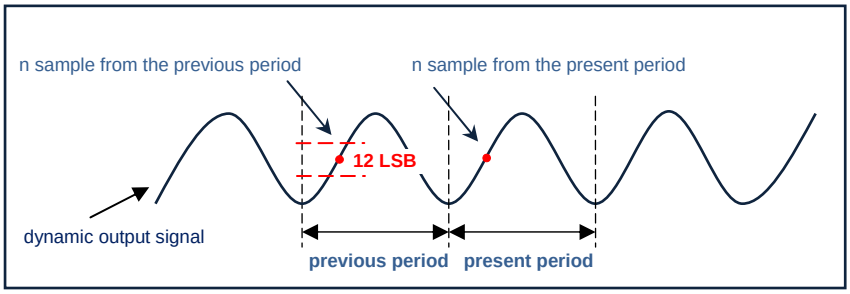



**Figure 5: SET detection for the dynamic input**

SEL

SEL detection is performed by monitoring the DUT supply currents. When a SEL occurs (typically over 100mA during at least 2 milliseconds), then device is switched off during 1 second, and the SEL event is registered in the log file. Input signal is also put in tri-state to avoid feeding the eventual SEL via the input.
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 as well as inputs currents of each DUT are monitored.

### 4.1 Device configuration

The device configuration is as follows:

- Input: Sine wave -1v/+1V at 100 KHz
- Supply voltage for SET: ±15V
- Supply voltage for SEL: ±17V at 85°C and 125°C
- Gain = 2
- Resistance load = 10k Ohm

Due to the feedback resistor of 10kOhm, the overall gain value is 2/3.

Device schematic is presented in Figure 6.

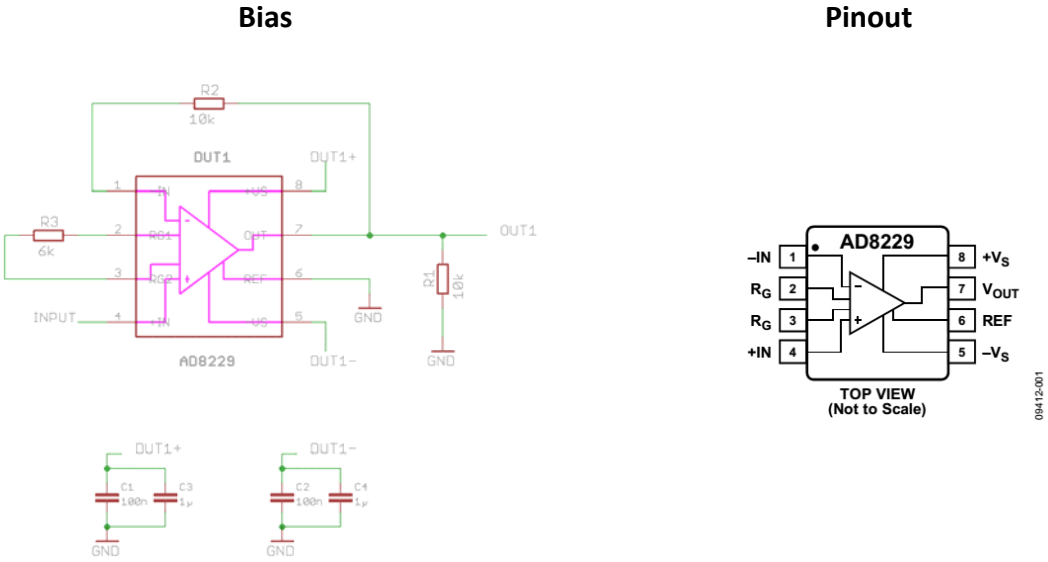



**Figure 6: The AD8229 configuration**

4 samples are mounted on a daughter board so that the 4 DUTs can be exposed and tested at the same time (see Figure 7). 2 boards were prepared for the test campaign.

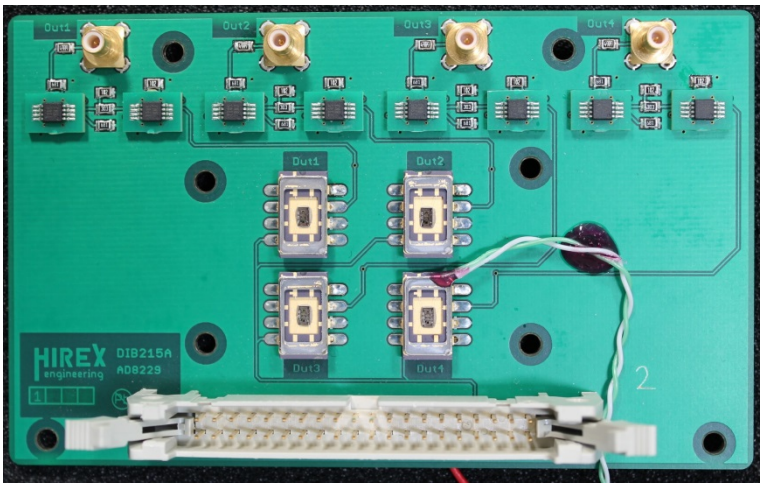


**Figure 7 – Photo of daughter board with 4 samples prepared for testing**

## 4.2 LBNL

A complete description of the facility (BASE) is given in RD-2.

### 4.2.1 Beam

10 MeV/amu cocktail was used for this experiment. Runs were performed with selected following ions, Ne, Ar, Cu, Kr and Xe. All tests were done at room temperature for SET and at 125°C for SEL testing.

### 4.2.2 Dosimetry

The current BASE dosimetry system and procedures were used.
Record of the beam count with Hirex hardware was not possible.

### 4.2.3 Used ions

The LBNL ions used are listed in the table below (10MeV/nucleon cocktail, see Figure 8).

| Ion | Energy | LET at DUT surface | Range |
|---|---|---|---|
| Ne | 216.28 | 3.49 | 174.6 |
| Ar | 400 | 9.74 | 130.1 |
| Cu | 659.19 | 21.17 | 108 |
| Kr | 906.45 | 30.23 | 113.1 |
| Xe | 1232.55 | 58.78 | 90 |

**Table 1: LBNL ions and features thereof**

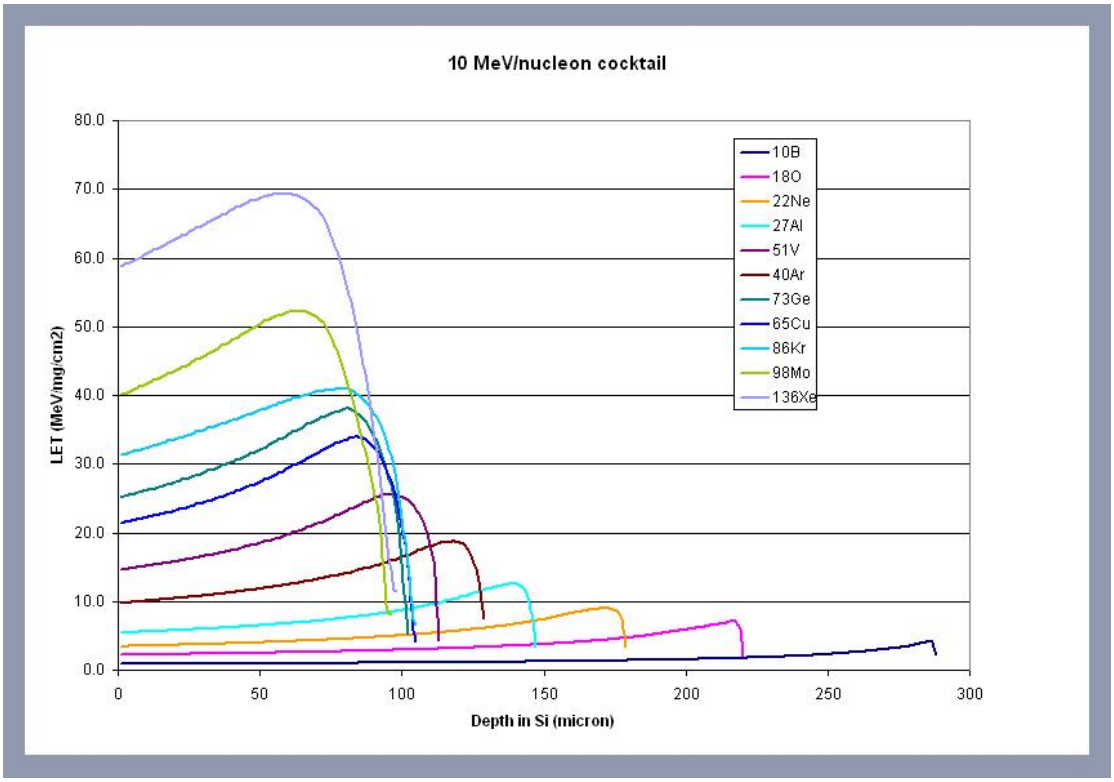



**Figure 8 – LBNL, 88 inches cyclotron, 10MeV/nucleon cocktail**

# 5 SEE Test Results

Four samples have been exposed at the same time over a LET range from 3.49 to 58.7 MeV/(mg/cm²) at room temperature for SET and at 125°C for SEL characterization.
Detailed results per run are presented in **Table 2**.

## 5.1 SET

SET events were detected at any tested LET.

The corresponding SET cross-section per output channel is shown in **Figure 9**.

Weibull fit is shown in **Figure 10** as well as Weibull fit parameters.

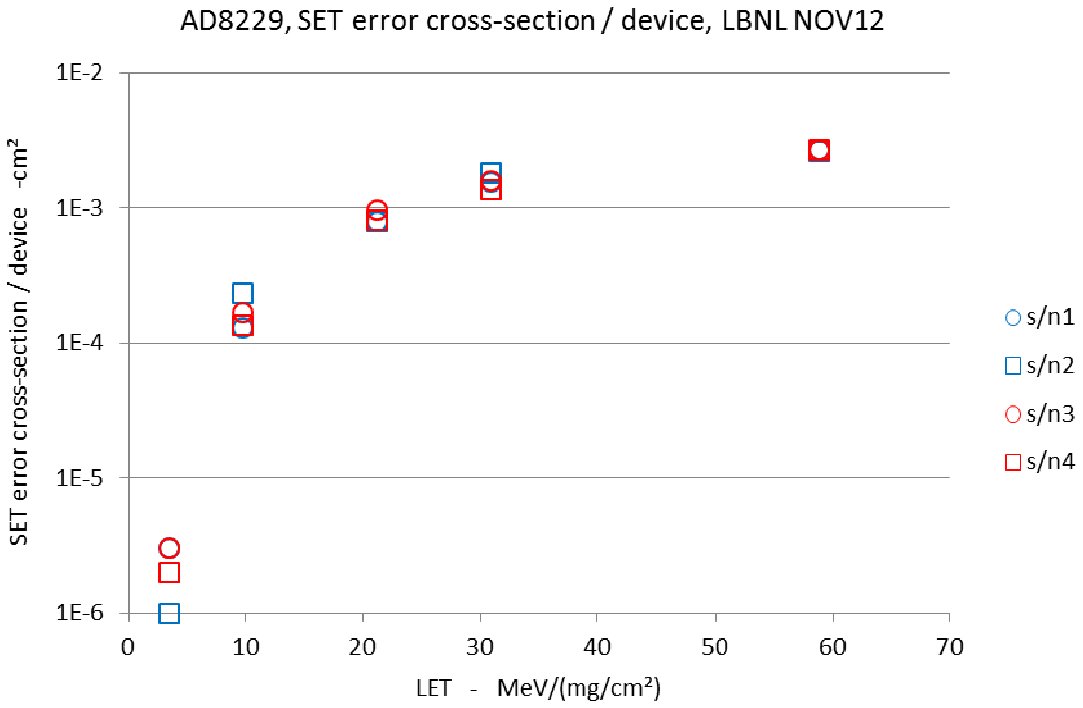
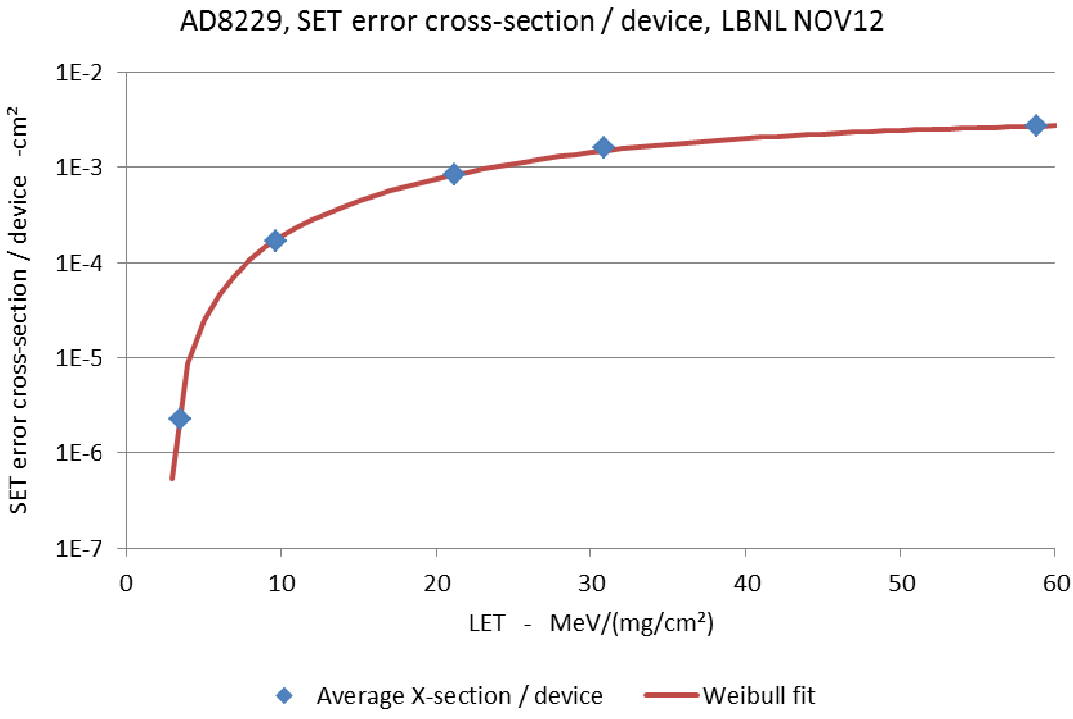



**Figure 9: SET X-section / dut for the AD8229 part; LBNL, NOV12**

| run # | Vcc (V) | Vccin (V) | Sine wave (Hz) | Temp (°C) | ion | LET | tilt | Eff. LET | Fluence | Duration | average flux | SEL | ch1 | ch2 | ch3 | ch4 | Total | X-section DUT1 | X-section /DUT2 | X-section /DUT3 | X-section /DUT4 | X-section /DUT |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| run007 | +/-15 | +/-1 | 1.00E+05 | Room | Ne | 3.49 | 0 | 3.49 | 1.00E+06 | 467 | 2141 | 0 | 3 | 1 | 3 | 2 | 9 | 3.00E-06 | 1.00E-06 | 3.00E-06 | 2.00E-06 | 2.25E-06 |
| run006 | +/-15 | +/-1 | 1.00E+05 | Room | Ar | 9.74 | 0 | 9.74 | 5.93E+05 | 3117 | 190 | 0 | 76 | 139 | 100 | 80 | 395 | 1.28E-04 | 2.34E-04 | 1.69E-04 | 1.35E-04 | 1.67E-04 |
| run005 | +/-15 | +/-1 | 1.00E+05 | Room | Cu | 21.2 | 0 | 21.2 | 1.54E+05 | 337 | 457 | 0 | 123 | 122 | 147 | 124 | 516 | 7.99E-04 | 7.92E-04 | 9.55E-04 | 8.05E-04 | 8.38E-04 |
| run008 | +/-15 | +/-1 | 1.00E+05 | Room | Kr | 30.9 | 0 | 30.9 | 6.30E+04 | 402 | 157 | 0 | 99 | 115 | 101 | 87 | 402 | 1.57E-03 | 1.83E-03 | 1.60E-03 | 1.38E-03 | 1.60E-03 |
| run010 | +/-15 | +/-1 | 1.00E+05 | Room | Xe | 58.8 | 0 | 58.8 | 3.87E+04 | 960 | 40 | 0 | 104 | 101 | 104 | 105 | 414 | 2.69E-03 | 2.61E-03 | 2.69E-03 | 2.71E-03 | 2.67E-03 |
| run011 | +/-17 | +/-1 | 1.00E+05 | 125 | Xe | 58.8 | 0 | 58.8 | 1.00E+07 | 1103 | 9066 | 0 | - | - | - | - | - | - | - | - | - | - |
| run012 | +/-17 | +/-1 | 1.00E+05 | 125 | Xe | 58.8 | 50 | 91.5 | 1.00E+07 | 413 | 24213 | 0 | - | - | - | - | - | - | - | - | - | - |

**Table 2: SET run details for the AD8229 part; LBNL, NOV 2012**




| | |
|---|---|
| W | 35 |
| xo | 2.75 |
| A | 3.00E-03 |
| s | 1.75 |

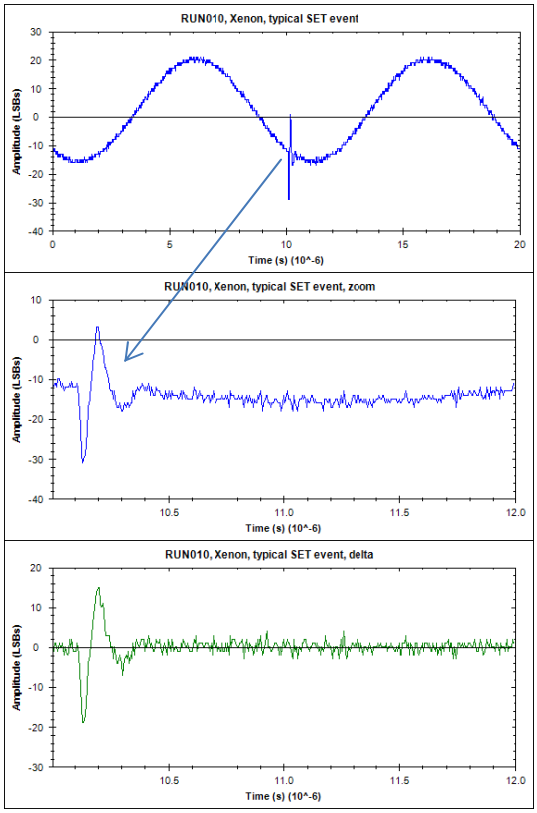
(see 6 for Weibull parameter definition)

**Figure 10: SET X-section/device, Weibull fit for the AD8229 part; LBNL, NOV12**

## 5.2 SEL

No SEL has been detected at a LET of 58.8 and 91.5 MeV/(mg/cm²) and a fluence of 1 10+07ions / cm² at a DUT temperature of 125°C.

Figure 11 present the way an SET is processed.
Amplitude is given in LSBs. 1 LSB is 36mV.
Figure 12 presents the SET envelop with Xenon (58 MeV/mg/cm²) for the 4 DUTs exposed at the same time as well as the worst cases in amplitude and duration.
Worst case amplitude is about 364 LSBs that corresponds to amplitude of 13.1V and worst case duration is around 2.6µs.

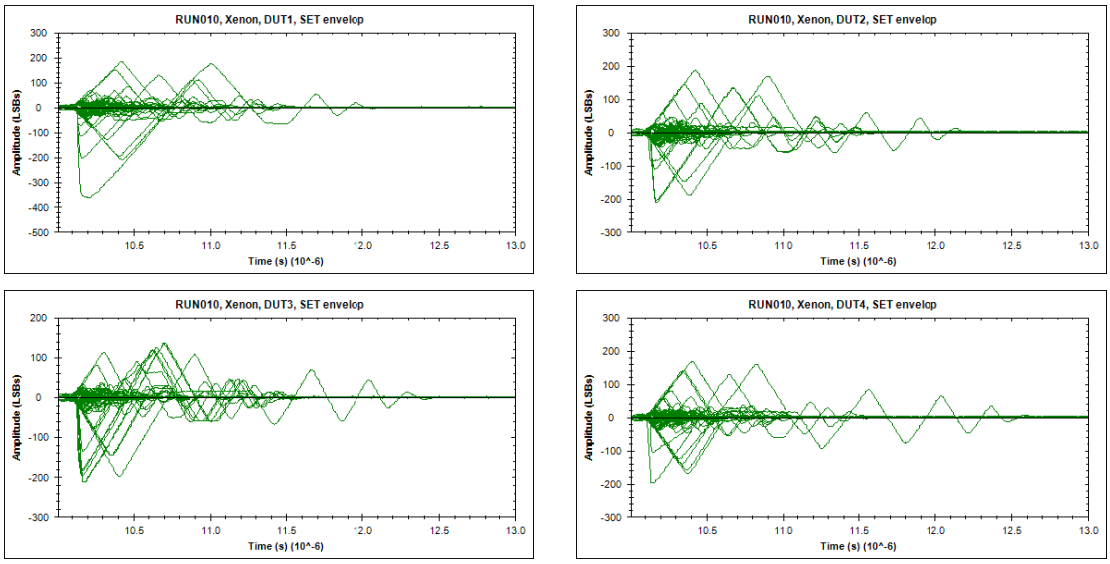



SET record (triggered by delta amplitude higher or equal to 12 LSB)

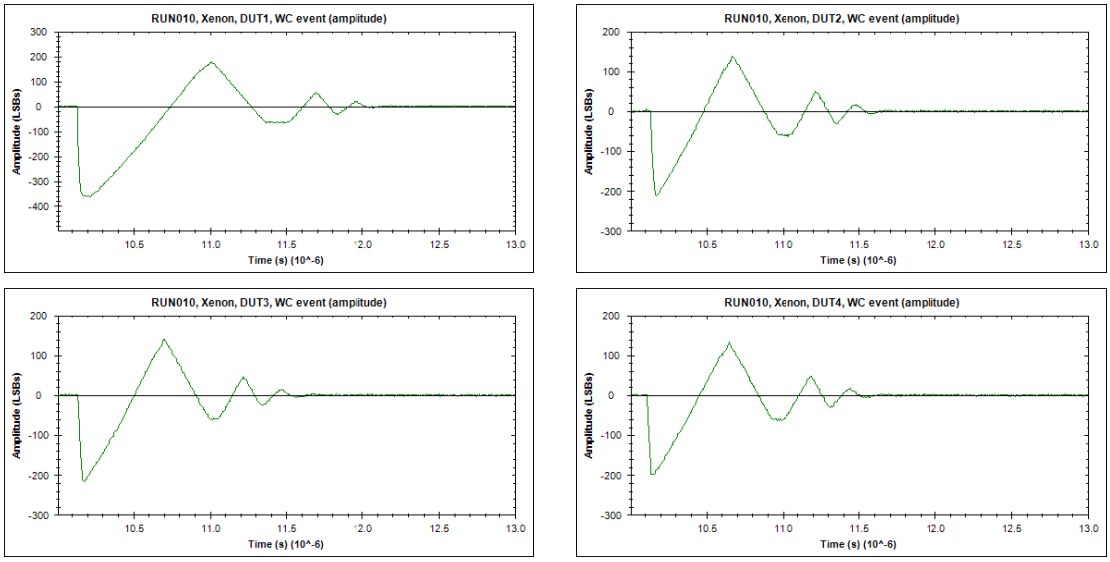
Zoom

Event delta (comparison of the input current period with the previous one)

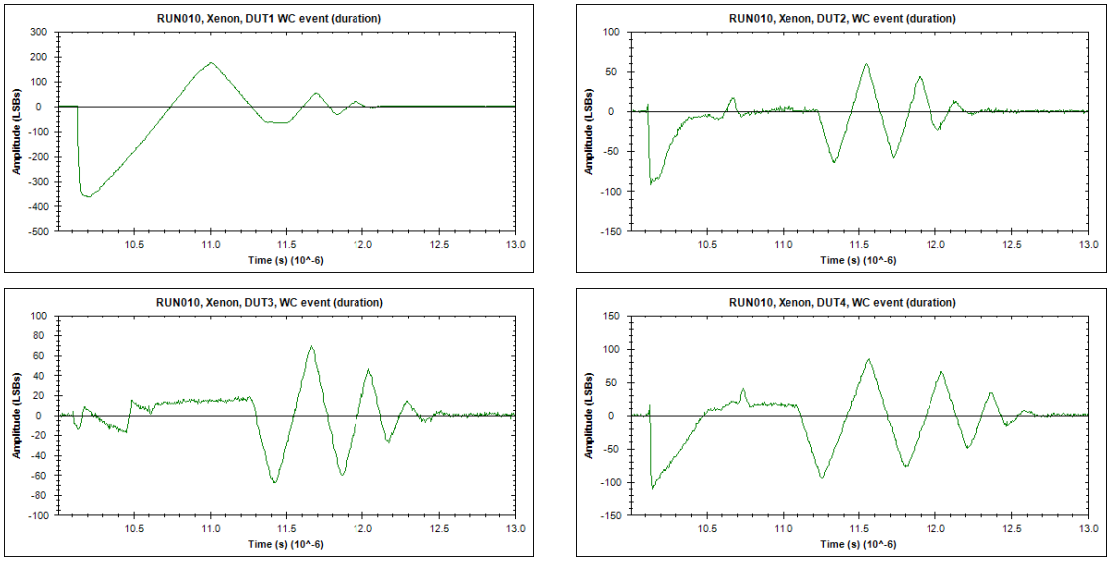
**Figure 11:** RUN010, Xenon, process of a typical SET event record




RUN010, Xenon, SET envelop for DUT1 to DUT4




RUN010, Xenon, SET WC (amplitude) for DUT1 to DUT4




RUN010, Xenon, SET WC (duration) for DUT1 to DUT4

**Figure 12 – Xenon, SET envelop and worst cases (amplitude and duration) for DUT1 to DUT4**

# 6 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 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.