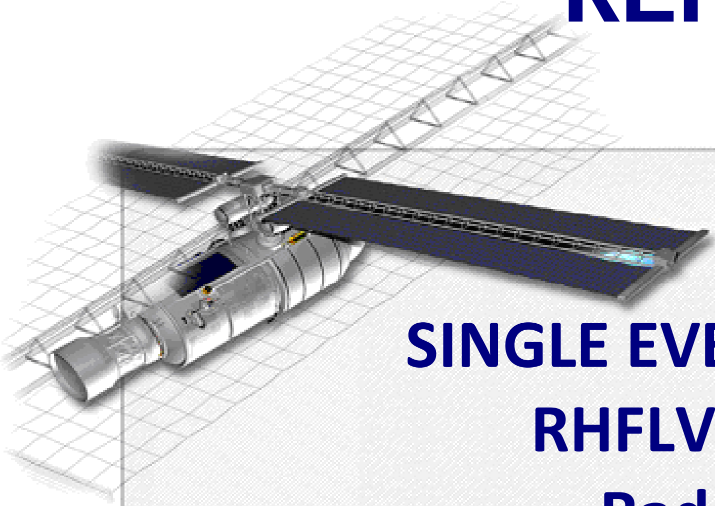
# HEAVY IONS TEST REPORT



## SINGLE EVENT EFFECTS
## RHFLVDS228A
## Rad-Hard
## Dual 4x4 Crosspoint Switch LVDS
## From
## ST Microelectronics

| TRAD/TI/RHFLVDS228A/XXX1/STM/LS/1307 | | Labège, September 03rd, 2013 |
|---|---|---|
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| Revision: 0 | | |
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# 1. Introduction

This report includes the test results of the heavy ions Single Event Effects (SEEs) test sequence carried out on the RHFLVDS228A, a Rad-Hard Dual 4x4 Crosspoint Switch LVDS from ST Microelectronics.

This test was performed for ST Microelectronics on the RHFLVDS228A susceptible to show Single Event Latch-ups (SELs) and Single Event Transients (SETs) induced by heavy ions.

# 2. Documents

## 2.1. Applicable documents

Technical Proposal: TRAD/P/STM/4xLVDS/ER/310513 Rev.1
SEE Test Plan: RNS/GC/13-141-02 ce Rev2 of 11/06/2013.
Mail from Mr Croisat, dated august 2nd, 2013, subject “RE: [SEE] RHFLVDS R2D2 - RHFLVDS228A”.
Mail from Mrs Rousseau, dated september 10th, 2013, subject “Fwd: Manip IOL semaine 35. LVDS”.

# 3. Organization of Activities

The relevant company has performed the following tasks during this evaluation:

| | | |
|---|---|---|
| 1 | Procurement of Test Samples | STM |
| 2 | Preparation of Test Samples (delidding) | STM |
| 3 | Preparation of Test Hardware and Test Program | TRAD |
| 4 | Samples Check out | TRAD |
| 5 | Accelerator Test | TRAD |
| 6 | Heavy Ion Test Report | TRAD |

**Table 1: Organization of activities**

# 4. Parts information

## 4.1. Device description

The LVDS-MUX8 is 8-channel 4x4 crosspoint switch base on Low Voltage Differential Signaling (LVDS) for low power and high speed communications. The two 4x4 MUX allows connection of any of the four inputs to any of the four outputs.

## 4.2. Identification

| | |
|---|---|
| Type: | RHFLVDS228A |
| Manufacturer: | ST Microelectronics |
| Function: | Rad-Hard Dual 4x4 Crosspoint Switch LVDS |

## 4.3. Procurement information

| | |
|---|---|
| Packaging: | FP-64 |
| Sample size: | 6 parts provided by STMicroelectronics. |

## 4.4. Sample Preparation

All parts were delidded by ST Microelectronics.
A functional test sequence was performed on delidded samples. It appears that 1 part provided by STMicroelectronics was non-functional.

## 4.5. Sample pictures

### 4.5.1. External view

No marking at the bottom of the package was observed.


**Figure 1: Package marking (Top View)**

### 4.5.2. Internal view

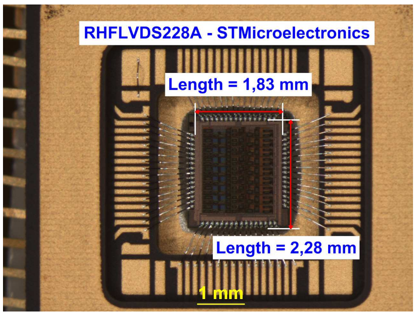



**Figure 2: Internal overall view**

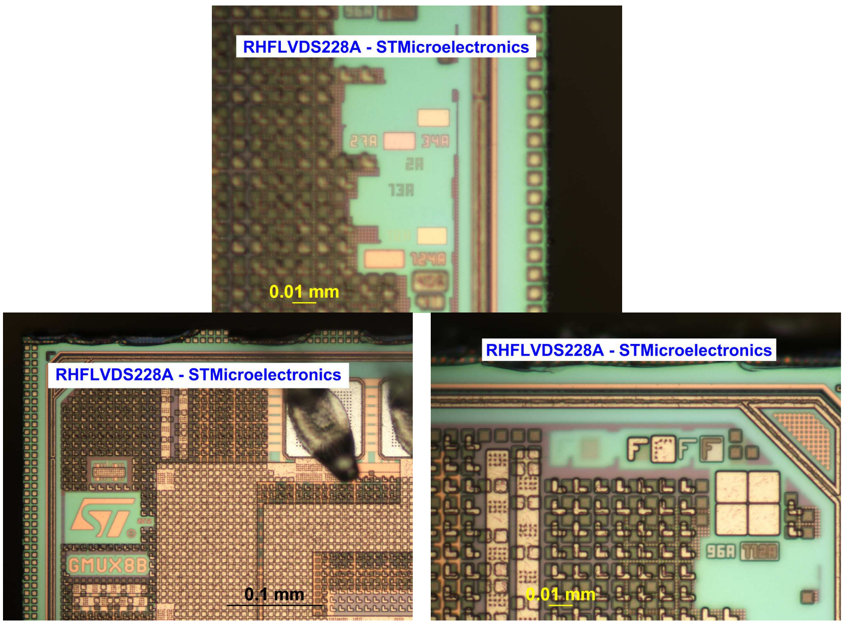


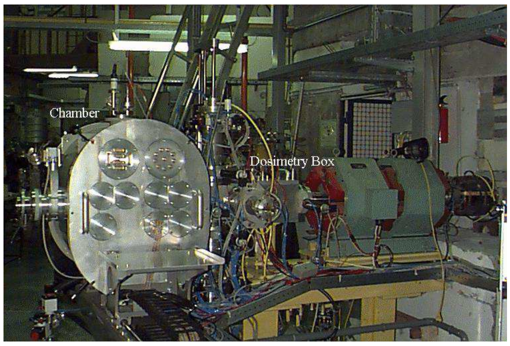

**Figure 3: Die marking**

# 5. Dosimetry and Irradiation Facilities

The test was performed at U.C.L (Université Catholique de Louvain) on August 26th and 30th and on October 07th and 08th, 2013. 4 delidded samples were irradiated.

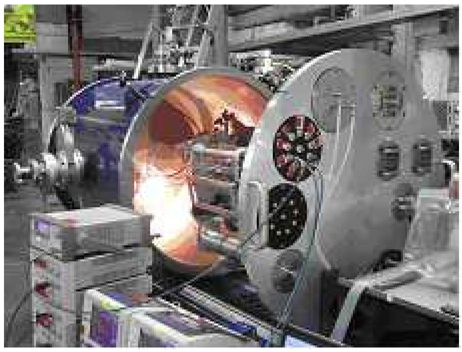
## 5.1. UCL Heavy Ion Test Facility (Université Catholique de Louvain - Belgique)

The CYClotron of LOuvain la NEuve (CYCLONE) is a multi-particle, variable energy, cyclotron capable of accelerating protons (up to 85 MeV), alpha particles and heavy ions.
For heavy ions, the covered LET range is between 1.2 MeV.cm².mg$^{-1}$ and 67.7 MeV.cm².mg$^{-1}$. Heavy ions available are separated in two "Ion Cocktails" named M/Q=5 and M/Q=3.3.




One of the main advantages of the UCL Heavy Ion Test Facility is the fast changing of ion species. Within the same cocktail, it takes only a few minutes to change from one ion to another.

The chamber has the shape of a barrel stretched vertically; its internal dimensions are 71 cm in height, 54 cm in width and 76 cm in depth. One side flange is used to support the board frame (25 X 25 cm) and user connectors.
The chamber is equipped with a vacuum system.



## 5.2. Dosimetry

To control and monitor the beam parameters, a dosimetry box is placed in front of the chamber. It contains a faraday cup, 2 Parallel Plate Avalanche Counters (PPAC).
Two additional surface barrier detectors are placed in the test chamber.
The faraday cup is used during beam preparation at high intensity.
A beam uniformity measurement is performed with a collimated surface barrier detector. This detector is placed on a X and Y movement. The final profile is drawn and the ± 10 % width is calculated. The Homogeneity is ± 10 % on a 25 mm diameter.
During the irradiation, the flux is integrated in order to give the delivered total fluence (particule.cm$^{-2}$) on the device.

### 5.3. Beam characteristics

The beam flux is variable between a few particles $s^{-1}cm^{-2}$ and $1.8\cdot10^4 s^{-1}cm^{-2}$ depending on the device sensitivity.

Heavy ion characteristics are listed in the following tables:

| Ion | Energie (MeV) | Range (µm(Si)) | LET (MeV.cm².mg$^{-1}$) |
|---|---|---|---|
| $^{15}N^{3+}$ | 60 | 59 | 3.3 |
| $^{20}Ne^{4+}$ | 78 | 45 | 6.4 |
| $^{40}Ar^{8+}$ | 151 | 40 | 15.9 |
| $^{84}Kr^{17+}$ | 305 | 39 | 40.4 |
| $^{124}Xe^{25+}$ | 420 | 37 | 67.7 |

**Table 2 : UCL cocktail M/Q=5**

| Ion | Energie (MeV) | Range (µm(Si)) | LET (MeV.cm².mg$^{-1}$) |
|---|---|---|---|
| $^{13}C^{4+}$ | 131 | 292 | 1.1 |
| $^{22}Ne^{7+}$ | 235 | 216 | 3 |
| $^{40}Ar^{12+}$ | 372 | 117 | 10.2 |
| $^{58}Ni^{18+}$ | 567 | 100 | 20.4 |
| $^{83}Kr^{25+}$ | 756 | 92 | 32.6 |

**Table 3 : UCL cocktail M/Q=3.3**

The highlighted ion species in the table above were used to perform this SEE test.

# 6. Test Procedure and Setup

## 6.1. Test procedure

### 6.1.1. Description of the test method

The test was divided in two parts, with respect to reference or applicable documents:

- Runs were performed up to a fluence of $1.10^7$ $cm^{-2}$ with only SEL monitoring. This configuration allowed us to verify the latchup sensitivity of the device.
- Runs were performed up to a fluence of $1.10^7$ $cm^{-2}$ for the SET detection. A latchup monitoring was used during these tests in order to protect the component. This configuration allowed us to verify the SET sensitivity.

The test was terminated when the maximum fluence was reached or when we got about a hundred events.

### 6.1.2. SEL Test Principle

The test was performed at maximum operating voltage and temperature.
TRAD has developed a fully integrated test bench to perform Single Event Latchup tests (SEL). The GUARD system (Graphical Universal Autorange Delatcher) allows the user to easily protect his device under test and perform SEL characterization.
The power supply is applied to the device under test through the GUARD system.
The threshold current of the GUARD system is set according to the nominal current. If the nominal current exceeds the threshold current, the GUARD system is triggered and the event is counted as an SEL. Then, the GUARD system sends a trigger command to the oscilloscope, maintains the power supply during a defined 'Time hold' and cut off during a defined 'Time cut'. Then, the power supply is restarted with the nominal current expected consumption.
At the end of each run, the test program reads the oscilloscope's "Local Scope Counter" which represents the total event count and downloads the records currents waveforms to store them.

Figure 4 shows an example of the SEL detection.

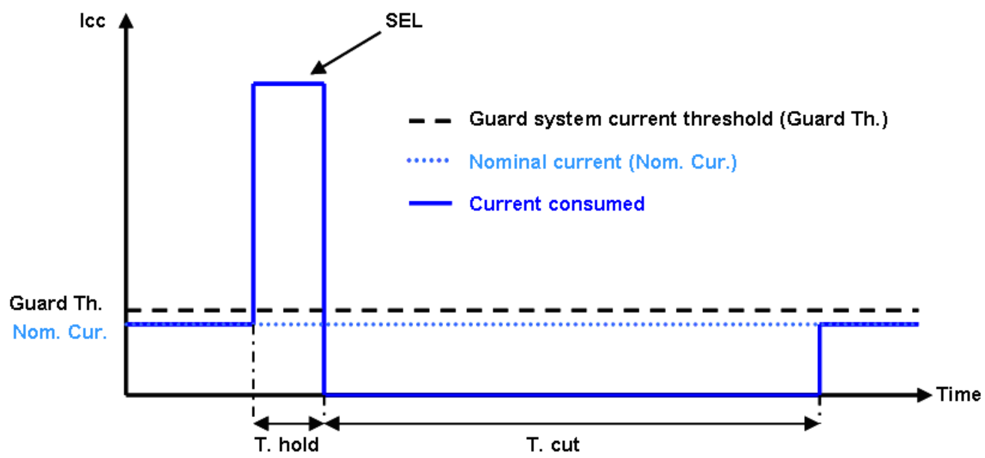



**Figure 4 : Common SEL characteristic.**

### 6.1.3. SET Test Principle

The GUARD system is always used on the component's power supply to detect SEL and to prevent the destruction of the device under test.
Single Event Transient is an event described by a voltage amplitude and a timing parameter.
To detect these events, the component's output voltage is monitored.
Two configurations were tested:

- High level out of range:

Pulse width modifications are detected. If the high level time ($T_H$) is not comprised between $T_H$ min threshold and $T_H$ max threshold, an increment of the oscilloscope internal counter occurs and the trace is stored.

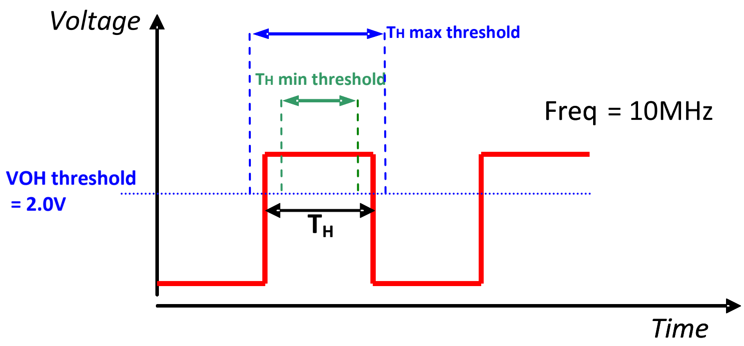



Figure 5: Output signal monitoring in High level configuration.

- Low level out of range:

Same as the High level configuration except we monitor the low level time.

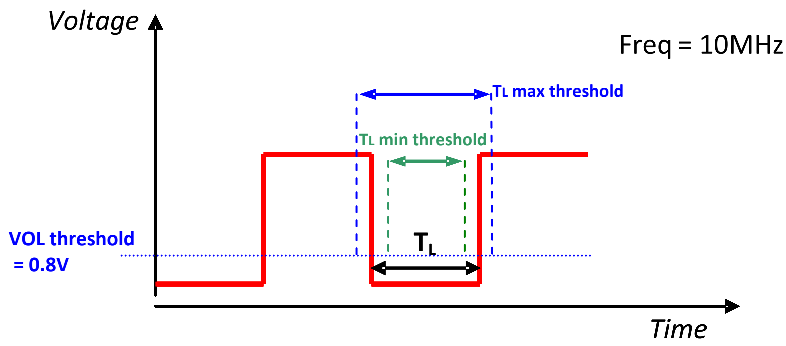



Figure 6: Output signal monitoring in Low level configuration.

At the end of each run, the test program reads the oscilloscope's "Local Scope Counter" which represents the total event count and downloads the records currents waveforms to store them.

## 6.2. Test bench description

### 6.2.1. Preparation of test hardware and program

TRAD has developed a specific test program and a specific motherboard to feed power supply to components.
The different outputs of the DUT are visualized using two oscilloscopes and curves are saved when an event occurs.
The test system is driven by a personal computer through a standard IEEE488 communication interface.
All signals are delivered and monitored by this equipment and SEE curves are saved in its memory.
At the end of each test run, data is transferred to the hard disk for storage. An overall description of the test system is given in Figure 7.

### 6.2.2. Test equipment identification

The tests were carried out with evaluation test boards developed by TRAD.

| | |
|---|---|
| COMPUTER | PO-TE-096 |
| REF. TEST BOARD | TRAD/CT1/I/RHFLVDS228A/FP64/LS/1307<br>TRAD/CT2/I/RHFLVDS228A/FP64/LS/1307<br>TRAD/CT3/I/RHFLVDS228A/FP64/LS/1307<br>TRAD/CT4/I/RHFLVDS228A/FP64/LS/1307 |
| EQUIPMENT | MI-52; MI-60; ME-44; ME-71; ME-79 |
| TEST PROGRAM | RHFLVDS228A_TI_XXX1_BI_V10 |

### 6.2.3. Test Bench description

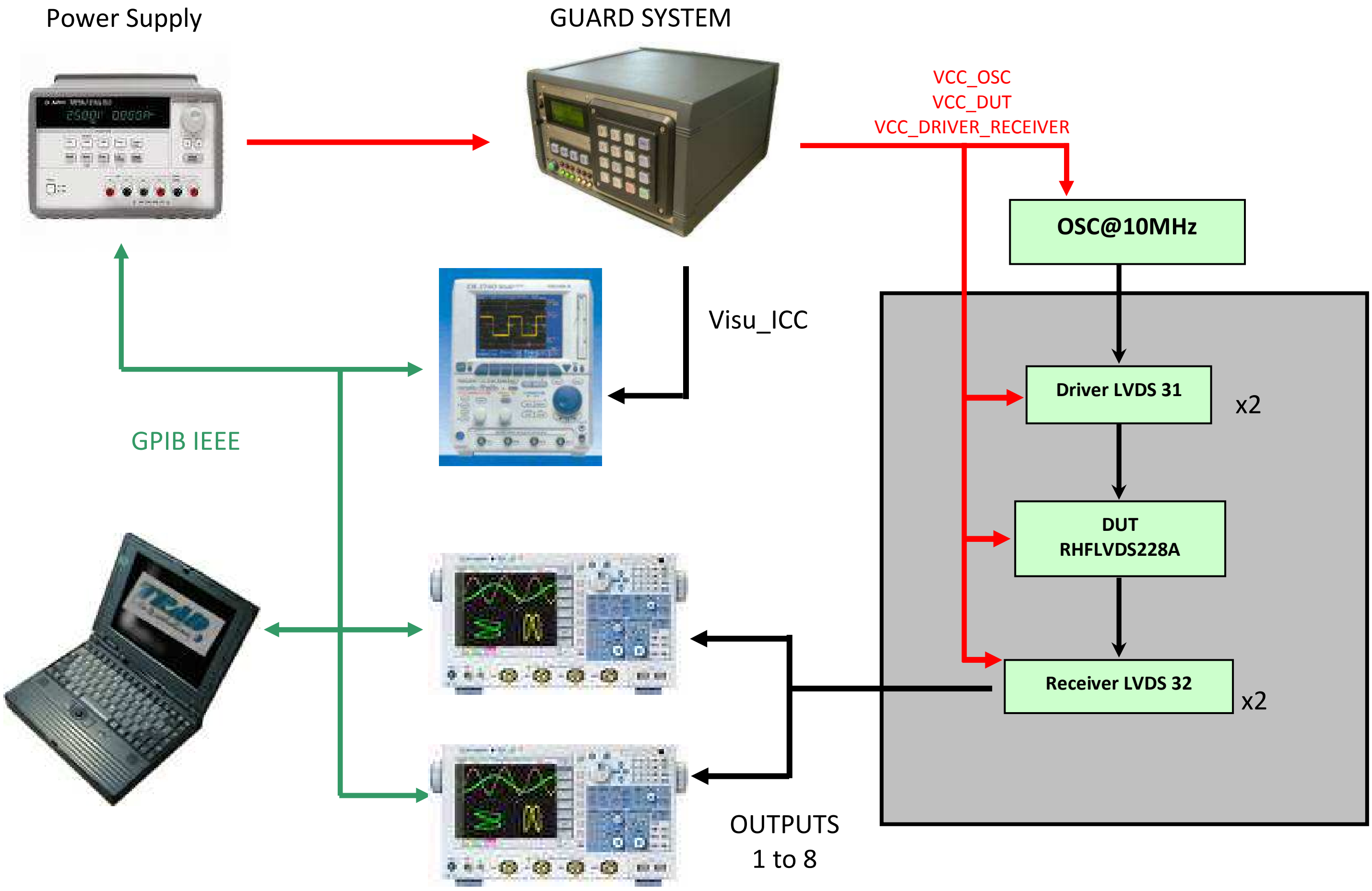



**Figure 7: Test system description**

### 6.2.4. Device setup and Test conditions

Trigger thresholds for SET test are defined in the following table:

| | |
|---|---|
| Vcc | 3.3V |
| VOH Threshold | 2.0V |
| $T_H$ max threshold | 49ns |
| $T_H$ min threshold | 51ns |
| Temperature | 25°C |

**Table 4: High level SET detection threshold**

| | |
|---|---|
| Vcc | 3.3V |
| VOH Threshold | 0.8V |
| $T_L$ max threshold | 50ns |
| $T_L$ min threshold | 52ns |
| Temperature | 25°C |

**Table 5: Low level SET detection threshold**

Trigger threshold for SEL test is defined in the following table:

| | |
|---|---|
| Vcc | 3.6V |
| $I_{nominal}$ | 70mA |
| $I_{threshold}$ | 140mA |
| $T_{hold}$ | 1ms |
| $T_{cut}$ | 7ms |
| Temperature | 125°C |

**Table 6: SEL detection threshold**

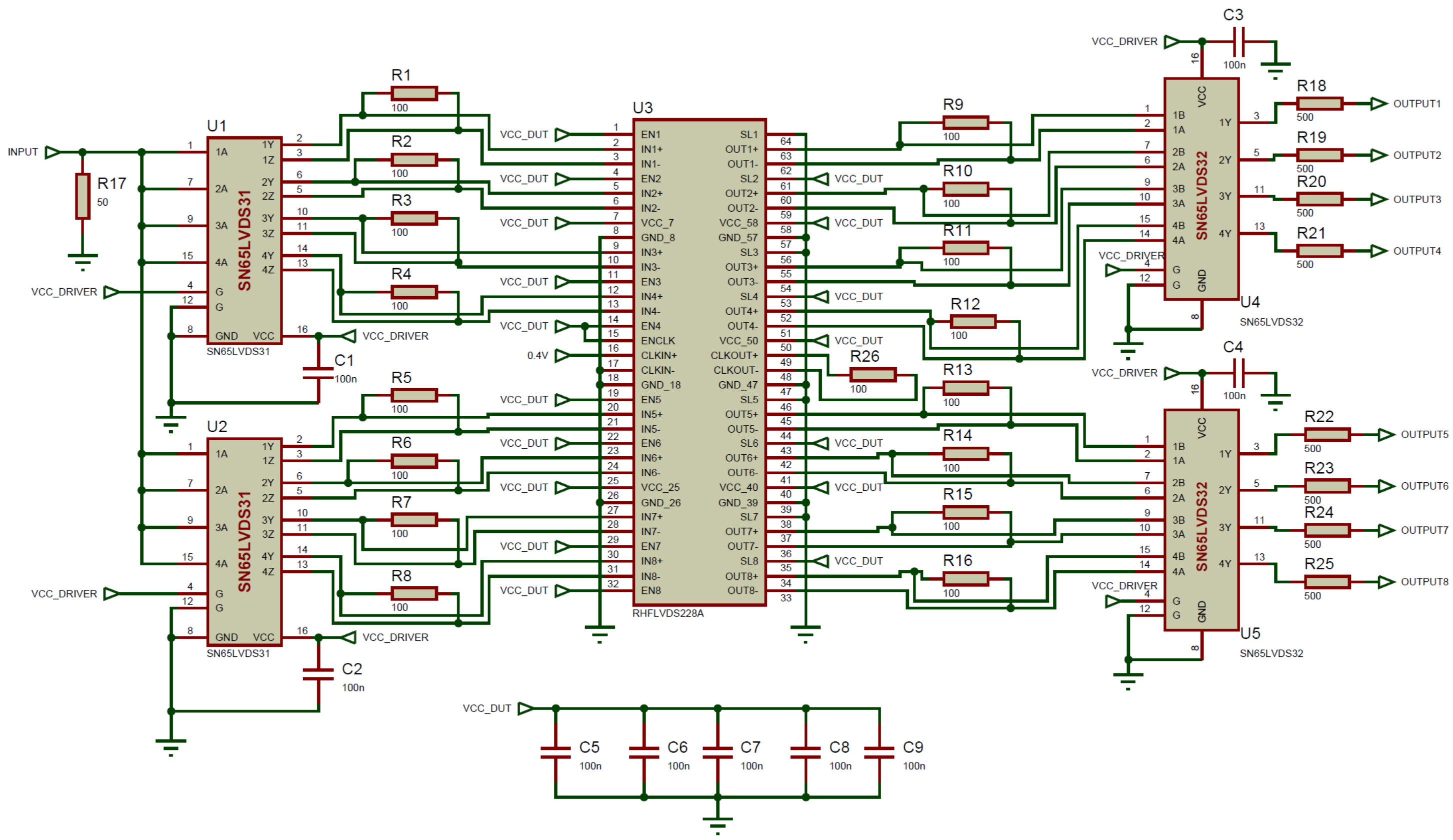



Figure 8: Test board schematic

## 7. Non conformance

A Non conformance NC_20131016_LS_1 was created.

Non conformance description:

At the beginning of the first test campaign one of the two SET visualization oscilloscope broke down. Without this equipment, all the required SET runs couldn't be done in time during the first test campaign.

In accordance to the mail received from Mrs E. Rousseau dated September 10, 2013, a second test campaign was scheduled in order to get the remaining SET runs. During this second campaign, test sequence, test and measurement conditions were nominal.

# 8. RESULTS

## 8.1. Runs' summary.

Hereafter you will find the Runs performed during this campaign.

| RHFLVDS228A<br>SEL: VCC = 3.6V / T° = 125°C<br>SET: VDD = 3.3V / T° = 25°C | | | | | | | | | | | | | | | | LATCHUP | | SET | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Run | Part | Config | T° | Ion | Energy (MeV) | Range (µm) | LET (MeV.cm²/mg) | Tilt (°) | Eff. LET (MeV.cm²/mg) | Eff. Range (µm Si) | Flux (φ) ($cm^{-2}.s^{-1}$) | Time (s) | Run Fluence (Φ) ($cm^{-2}$) | Run Dose (krad) | Cumulated Dose (krad) | Vcc | Cross Section | Out_1 | Cross Section |
| High LET M/Q=5 | | | | | | | | | | | | | | | | | | | |
| 1 | 1 | SEL | 125 | 124Xe 26+ | 420 | 37 | 67.7 | 0 | 67.70 | 37.0 | 9.37E+03 | 1069 | 1.00E+07 | 10.854 | 10.854 | 0 | <1.00E-07 | - | - |
| 2 | 2 | SEL | 125 | 124Xe 26+ | 420 | 37 | 67.7 | 0 | 67.70 | 37.0 | 1.07E+04 | 939 | 1.00E+07 | 10.851 | 10.851 | 0 | <1.00E-07 | - | - |
| 3 | 3 | SEL | 125 | 124Xe 26+ | 420 | 37 | 67.7 | 0 | 67.70 | 37.0 | 1.30E+04 | 772 | 1.00E+07 | 10.857 | 10.857 | 0 | <1.00E-07 | - | - |
| 4 | 4 | SEL | 125 | 124Xe 26+ | 420 | 37 | 67.7 | 0 | 67.70 | 37.0 | 1.40E+04 | 713 | 1.00E+07 | 10.848 | 10.848 | 0 | <1.00E-07 | - | - |
| 5 | 4 | SEL | 125 | 124Xe 26+ | 420 | 37 | 67.7 | 60 | 135.40 | 18.5 | 8.72E+03 | 1148 | 1.00E+07 | 21.696 | 32.545 | 0 | <1.00E-07 | - | - |
| 6 | 3 | SEL | 125 | 124Xe 26+ | 420 | 37 | 67.7 | 60 | 135.40 | 18.5 | 7.57E+03 | 1323 | 1.00E+07 | 21.686 | 32.544 | 0 | <1.00E-07 | - | - |
| 7 | 2 | SEL | 125 | 124Xe 26+ | 420 | 37 | 67.7 | 60 | 135.40 | 18.5 | 7.53E+03 | 1330 | 1.00E+07 | 21.683 | 32.534 | 0 | <1.00E-07 | - | - |
| 8 | 1 | SEL | 125 | 124Xe 26+ | 420 | 37 | 67.7 | 60 | 135.40 | 18.5 | 7.56E+03 | 1325 | 1.00E+07 | 21.691 | 32.545 | 0 | <1.00E-07 | - | - |
| 9 | 2 | SET 1H | 25 | 124Xe 26+ | 420 | 37 | 67.7 | 0 | 67.70 | 37.0 | 1.51E+04 | 662 | 1.00E+07 | 10.853 | 43.387 | 0 | <1.00E-07 | 0 | <1.00E-07 |
| High Range M/Q=3.3 | | | | | | | | | | | | | | | | | | | |
| 10 | 1 | SET 1H | 25 | 83 Kr 25+ | 756 | 92 | 32.6 | 0 | 32.60 | 92.0 | 7.82E+03 | 1282 | 1.00E+07 | 5.227 | 37.771 | 0 | <1.00E-07 | 1 | 1.00E-07 |
| 11 | 1 | SET 1L | 25 | 83 Kr 25+ | 756 | 92 | 32.6 | 0 | 32.60 | 92.0 | 8.14E+03 | 1230 | 1.00E+07 | 5.225 | 42.997 | 0 | <1.00E-07 | 1 | 1.00E-07 |
| 12 | 2 | SET 1H | 25 | 83 Kr 25+ | 756 | 92 | 32.6 | 0 | 32.60 | 92.0 | 9.94E+03 | 1008 | 1.00E+07 | 5.228 | 48.616 | 0 | <1.00E-07 | 0 | <1.00E-07 |
| 13 | 2 | SET 1L | 25 | 83 Kr 25+ | 756 | 92 | 32.6 | 0 | 32.60 | 92.0 | 1.10E+04 | 912 | 1.00E+07 | 5.224 | 53.840 | 0 | <1.00E-07 | 0 | <1.00E-07 |
| 14 | 3 | SET 1H | 25 | 83 Kr 25+ | 756 | 92 | 32.6 | 0 | 32.60 | 92.0 | 1.08E+04 | 924 | 1.00E+07 | 5.228 | 37.771 | 0 | <1.00E-07 | 0 | <1.00E-07 |
| 15 | 3 | SET 1L | 25 | 83 Kr 25+ | 756 | 92 | 32.6 | 0 | 32.60 | 92.0 | 1.12E+04 | 891 | 1.00E+07 | 5.226 | 42.997 | 0 | <1.00E-07 | 0 | <1.00E-07 |
| 16 | 4 | SET 1H | 25 | 83 Kr 25+ | 756 | 92 | 32.6 | 0 | 32.60 | 92.0 | 1.09E+04 | 917 | 1.00E+07 | 5.223 | 37.768 | 0 | <1.00E-07 | 0 | <1.00E-07 |
| 17 | 4 | SET 1L | 25 | 83 Kr 25+ | 756 | 92 | 32.6 | 0 | 32.60 | 92.0 | 1.15E+04 | 874 | 1.00E+07 | 5.223 | 42.991 | 0 | <1.00E-07 | 0 | <1.00E-07 |
| 18 | 1 | SET 1H | 25 | 58 Ni 18+ | 567 | 100 | 20.4 | 0 | 20.40 | 100.0 | 1.13E+04 | 886 | 1.00E+07 | 3.271 | 46.267 | 0 | <1.00E-07 | 0 | <1.00E-07 |
| 19 | 1 | SET 1L | 25 | 58 Ni 18+ | 567 | 100 | 20.4 | 0 | 20.40 | 100.0 | 1.18E+04 | 846 | 1.00E+07 | 3.268 | 49.536 | 0 | <1.00E-07 | 0 | <1.00E-07 |

Table 7: RHFLVDS228A first campaign test results

| RHFLVDS228A SET: VCC = 3.3V / T° = 25°C | | | | | | | | | | | | | | | | LATCHUP | | SET | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Run | Part | Config | T° | Ion | Energy (MeV) | Range (µm) | LET (MeV.cm²/mg) | Tilt (°) | Eff. LET (MeV.cm²/mg) | Eff. Range (µm Si) | Flux (φ) ($cm^{-2}.s^{-1}$) | Time (s) | Run Fluence (Φ) ($cm^{-2}$) | Run Dose (krad) | Cumulated Dose (krad) | Vcc | Cross Section | Out_1 | Cross Section | Out_2 | Cross Section | Out_3 | Cross Section | Out_4 | Cross Section | Out_5 | Cross Section | Out_6 | Cross Section | Out_7 | Cross Section | Out_8 | Cross Section |
| High LET M/Q=5 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 20 | 1 | SET 1H 5L | 25 | 124Xe 26+ | 420 | 37 | 67.7 | 0 | 67.70 | 37.0 | 1.50E+04 | 670 | 1.00E+07 | 10.853 | 60.389 | 0 | <1.00E-07 | 1 | 1.00E-07 | - | - | - | - | - | - | 0 | <9.98E-08 | - | - | - | - | - | - |
| 21 | 1 | SET 1L 5H | 25 | 124Xe 26+ | 420 | 37 | 67.7 | 0 | 67.70 | 37.0 | 1.53E+04 | 654 | 1.00E+07 | 10.865 | 71.254 | 0 | <1.00E-07 | 1 | 1.00E-07 | - | - | - | - | - | - | 0 | <9.97E-08 | - | - | - | - | - | - |
| 22 | 1 | SET 2H 6L | 25 | 124Xe 26+ | 420 | 37 | 67.7 | 0 | 67.70 | 37.0 | 1.53E+04 | 654 | 1.00E+07 | 10.849 | 82.103 | 0 | <1.00E-07 | - | - | 0 | <1.00E-07 | - | - | - | - | - | - | 0 | <1.00E-07 | - | - | - | - |
| 23 | 1 | SET 2L 6H | 25 | 124Xe 26+ | 420 | 37 | 67.7 | 0 | 67.70 | 37.0 | 1.53E+04 | 654 | 1.00E+07 | 10.859 | 92.962 | 0 | <1.00E-07 | - | - | 1 | 1.00E-07 | - | - | - | - | - | - | 0 | <1.00E-07 | - | - | - | - |
| 24 | 1 | SET 3H 7L | 25 | 124Xe 26+ | 420 | 37 | 67.7 | 0 | 67.70 | 37.0 | 1.53E+04 | 655 | 1.00E+07 | 10.854 | 103.815 | 0 | <1.00E-07 | - | - | - | - | 2 | 2.00E-07 | - | - | - | - | - | - | 0 | <1.00E-07 | - | - |
| 25 | 1 | SET 3L 7H | 25 | 124Xe 26+ | 420 | 37 | 67.7 | 0 | 67.70 | 37.0 | 1.56E+04 | 644 | 1.00E+07 | 10.851 | 114.667 | 0 | <1.00E-07 | - | - | - | - | 0 | <1.00E-07 | - | - | - | - | - | - | 0 | <1.00E-07 | - | - |
| 26 | 1 | SET 4H 8L | 25 | 124Xe 26+ | 420 | 37 | 67.7 | 0 | 67.70 | 37.0 | 1.54E+04 | 650 | 1.00E+07 | 10.858 | 125.525 | 0 | <1.00E-07 | - | - | - | - | - | - | 0 | <1.00E-07 | - | - | - | - | - | - | 0 | <1.00E-07 |
| 27 | 1 | SET 4L 8H | 25 | 124Xe 26+ | 420 | 37 | 67.7 | 0 | 67.70 | 37.0 | 1.55E+04 | 646 | 1.00E+07 | 10.856 | 136.381 | 0 | <1.00E-07 | - | - | - | - | - | - | 0 | <1.00E-07 | - | - | - | - | - | - | 1 | 1.00E-07 |
| 28 | 2 | SET 1H 5L | 25 | 124Xe 26+ | 420 | 37 | 67.7 | 0 | 67.70 | 37.0 | 1.54E+04 | 651 | 1.00E+07 | 10.871 | 64.711 | 0 | <1.00E-07 | 0 | <1.00E-07 | - | - | - | - | - | - | 197* | 1.95E-05* | - | - | - | - | - | - |
| 29 | 3 | SET 1H 5L | 25 | 124Xe 26+ | 420 | 37 | 67.7 | 0 | 67.70 | 37.0 | 1.53E+04 | 653 | 1.00E+07 | 10.855 | 53.852 | 0 | <1.00E-07 | 0 | <1.00E-07 | - | - | - | - | - | - | 0 | <1.00E-07 | - | - | - | - | - | - |
| 30 | 4 | SET 1H 5L | 25 | 124Xe 26+ | 420 | 37 | 67.7 | 0 | 67.70 | 37.0 | 1.52E+04 | 657 | 1.00E+07 | 10.850 | 53.841 | 0 | <1.00E-07 | 0 | <1.00E-07 | - | - | - | - | - | - | 0 | <1.00E-07 | - | - | - | - | - | - |
| 31 | 1 | SET 1H 5L | 25 | 124Xe 26+ | 420 | 37 | 67.7 | 60 | 135.40 | 18.5 | 7.69E+03 | 1302 | 1.00E+07 | 21.685 | 158.067 | 0 | <1.00E-07 | 2 | 2.00E-07 | - | - | - | - | - | - | 1 | 1.00E-07 | - | - | - | - | - | - |
| 32 | 2 | SET 1H 5L | 25 | 124Xe 26+ | 420 | 37 | 67.7 | 60 | 135.40 | 18.5 | 7.74E+03 | 1294 | 1.00E+07 | 21.692 | 86.403 | 0 | <1.00E-07 | 0 | <1.00E-07 | - | - | - | - | - | - | 0 | <1.00E-07 | - | - | - | - | - | - |
| 33 | 3 | SET 1H 5L | 25 | 124Xe 26+ | 420 | 37 | 67.7 | 60 | 135.40 | 18.5 | 7.62E+03 | 1313 | 1.00E+07 | 21.685 | 75.537 | 0 | <1.00E-07 | 3 | 3.00E-07 | - | - | - | - | - | - | 0 | <1.00E-07 | - | - | - | - | - | - |
| 34 | 4 | SET 1H 5L | 25 | 124Xe 26+ | 420 | 37 | 67.7 | 60 | 135.40 | 18.5 | 7.75E+03 | 1292 | 1.00E+07 | 21.682 | 75.523 | 0 | <1.00E-07 | 0 | <1.00E-07 | - | - | - | - | - | - | 2 | 2.00E-07 | - | - | - | - | - | - |
| 35 | 2 | SET 1H 5L | 25 | 124Xe 26+ | 420 | 37 | 67.7 | 0 | 67.70 | 37.0 | 1.60E+04 | 64 | 1.03E+06 | 1.111 | 87.514 | 0 | <1.00E-06 | 0 | <1.00E-06 | - | - | - | - | - | - | 0 | <1.00E-06 | - | - | - | - | - | - |

**Table 8: RHFLVDS228A second campaign test results**

*: During run n°28 an unusual high number of events happened on output 5. On tilted Xe run n°32, no events were observed. Therefore, we made an additional run, run n°35, up to a fluence of $1.10^6$ to check this behaviour. On this run we did not observe any events, it implies that the cross section is lower than $1.10^6$ and that the result of run 28 is not valid. This behaviour may be due to a bad connection of the DUT on the PCB test board.

No SEL events were detected during this test.
SET events were detected during this test.
SET and SEL tests results are described hereafter.

## 8.2. SEL test results.

The SEL test was performed at 125°C.
No SEL was observed during this test under Xenon irradiation with a total fluence equal to 1E+7 $cm^{-2}$:
- with a particle angle of 60° (LET = 135.4 MeV.cm²/mg and range = 18.5µm).
- with a particle angle of 0° (LET = 67.7 MeV.cm²/mg and range = 37µm).

## 8.3. SET tests results

The SET test was performed at 25°C, two configurations were tested on the DUT outputs.
SETs were observed during the irradiation until the Nickel Heavy Ion (LET = 20.4 MeV.cm²/mg).

### 8.3.1. SET Cross sections.

| LET Eff (MeV.cm².$mg^{-1}$) | RHFLVDS228A High Level SET Cross Section ($cm^2$) | | | |
|---|---|---|---|---|
| | N° 1 | N° 2 | N°3 | N° 4 |
| 135.4 | 2.0E-07 | <1.0E-07 | 3.0E-07 | <1.0E-07 |
| 67.7 | 2.0E-07 | <1.0E-07 | <1.0E-07 | <1.0E-07 |
| 32.6 | 1.0E-07 | <1.0E-07 | <1.0E-07 | <1.0E-07 |
| 20.4 | <1.0E-07 | - | - | - |

**Table 9: RHFLVDS228A High Level SET cross section results**

| LET Eff (MeV.cm².$mg^{-1}$) | RHFLVDS228A Low Level SET Cross Section ($cm^2$) | | | |
|---|---|---|---|---|
| | N° 1 | N° 2 | N°3 | N° 4 |
| 135.4 | 1.0E-07 | <1.0E-07 | <1.0E-07 | 2.0E-07 |
| 67.7 | 1.0E-07 | <1.0E-06* | <1.0E-07 | <1.0E-07 |
| 32.6 | 1.0E-07 | <1.0E-07 | <1.0E-07 | <1.0E-07 |
| 20.4 | <1.0E-07 | - | - | - |

**Table 10: RHFLVDS228A Low Level SET cross section results**

*: Explanations p15.

The following figures present the cross section of the SET event on the outputs of the RHFLVDS228A part.
Points represented by an arrow pointing down indicate that no event was observed at the corresponding LET.
The evaluated cross section is then lower than 1.00 $10^{-7}cm^{-2}$, value corresponding to one event at maximum fluence.

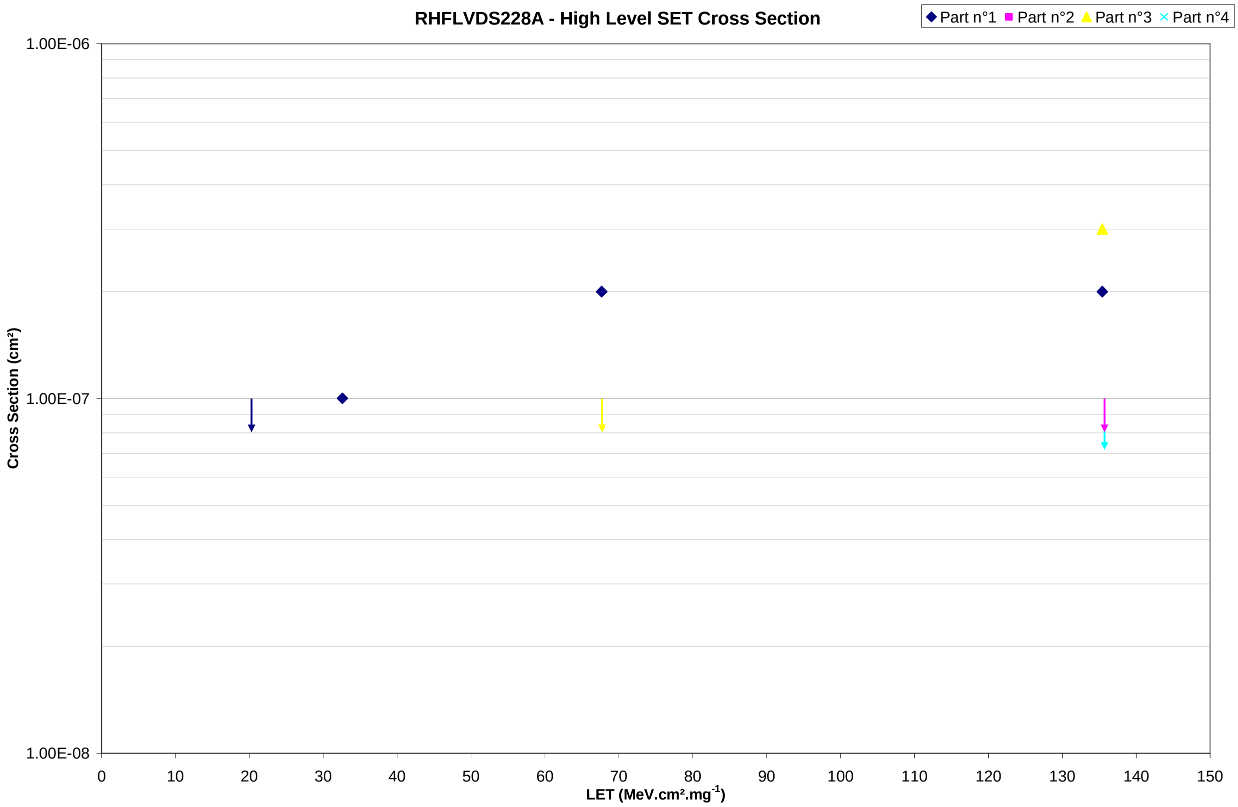



**Figure 9: High level SET cross section curve for RHFLVDS228A.**

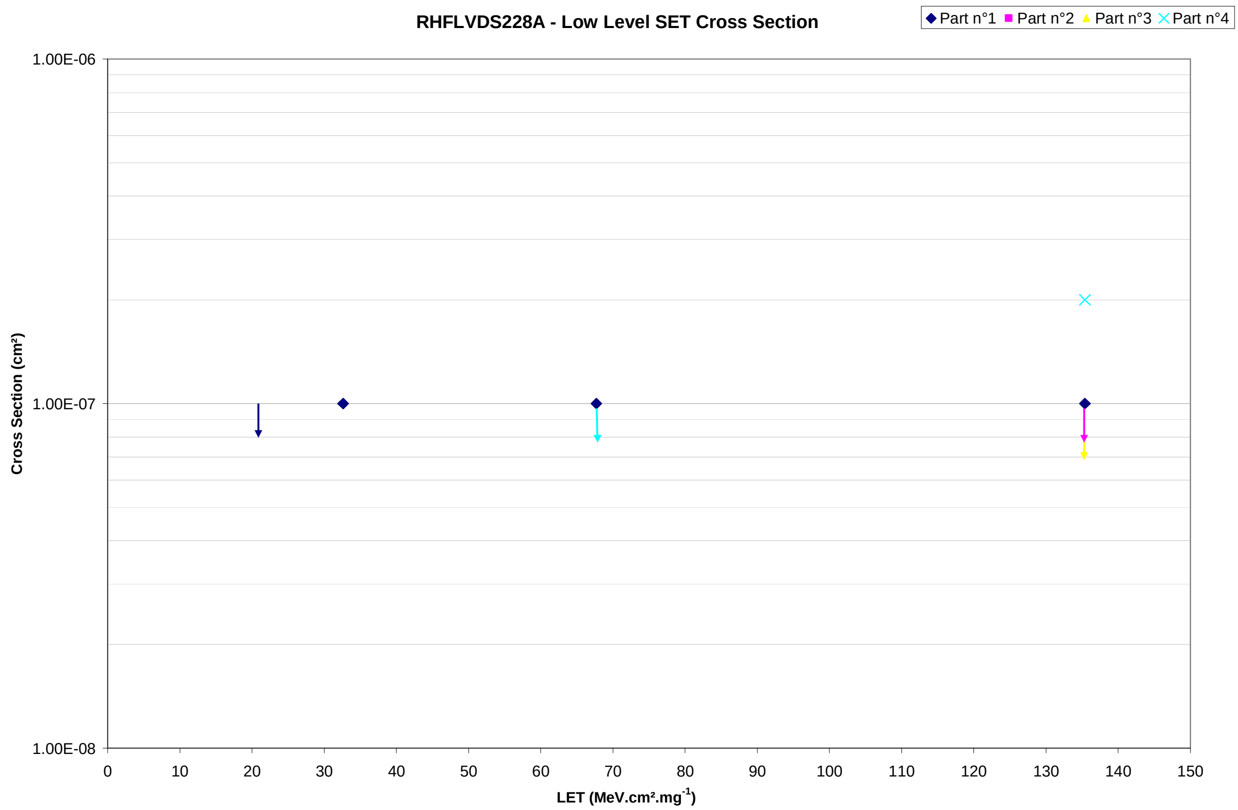



**Figure 10: Low level SET cross section curve for RHFLVDS228A.**

The tilted Xe runs were an express request of our customer.

### 8.3.2. Worst Cases SET Observed

The worst case on High level mode occurs on Part N°1 during run n°31 event n°1 (Xe, tilt = 60°, LET = 135.4 MeV.cm²/mg and range = 18.5µm).

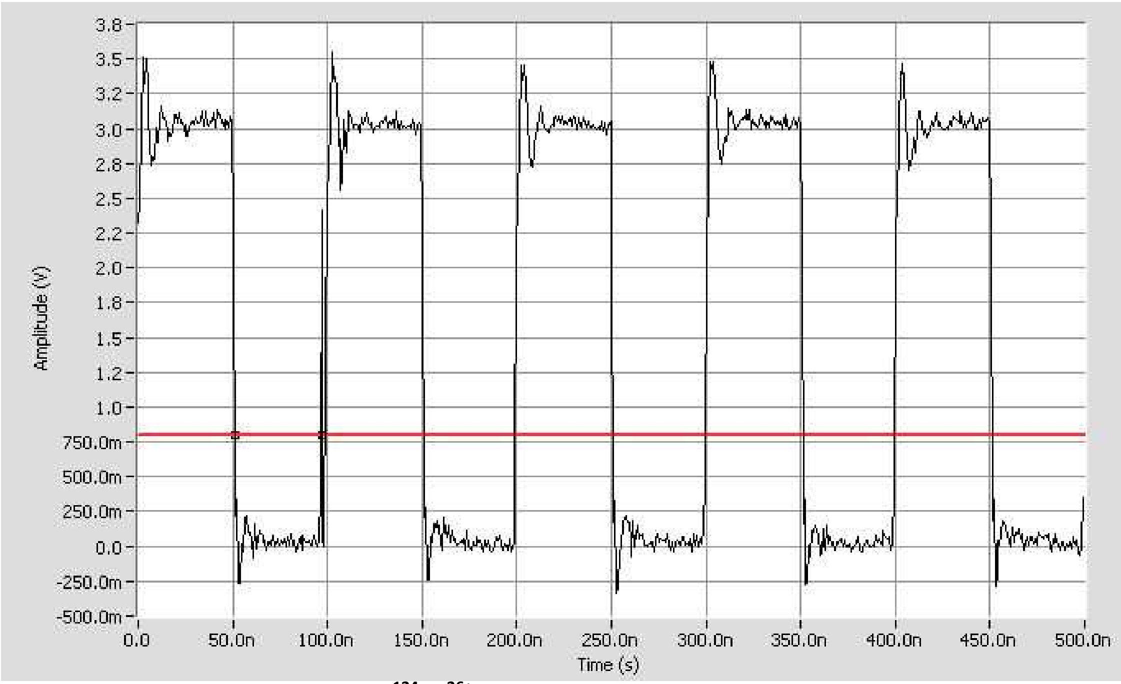



**Figure 11: SET curve, Heavy Ion $^{124}Xe^{26+}$ tilted 60° (LET of 135.4 MeV.mg/cm²), Part 1, Run n°31, Event n°1.**

The worst case on Low level mode occurs on Part N°3 during run n°33 event n°1 (Xe, tilt = 60°, LET = 135.4 MeV.cm²/mg and range = 18.5µm).

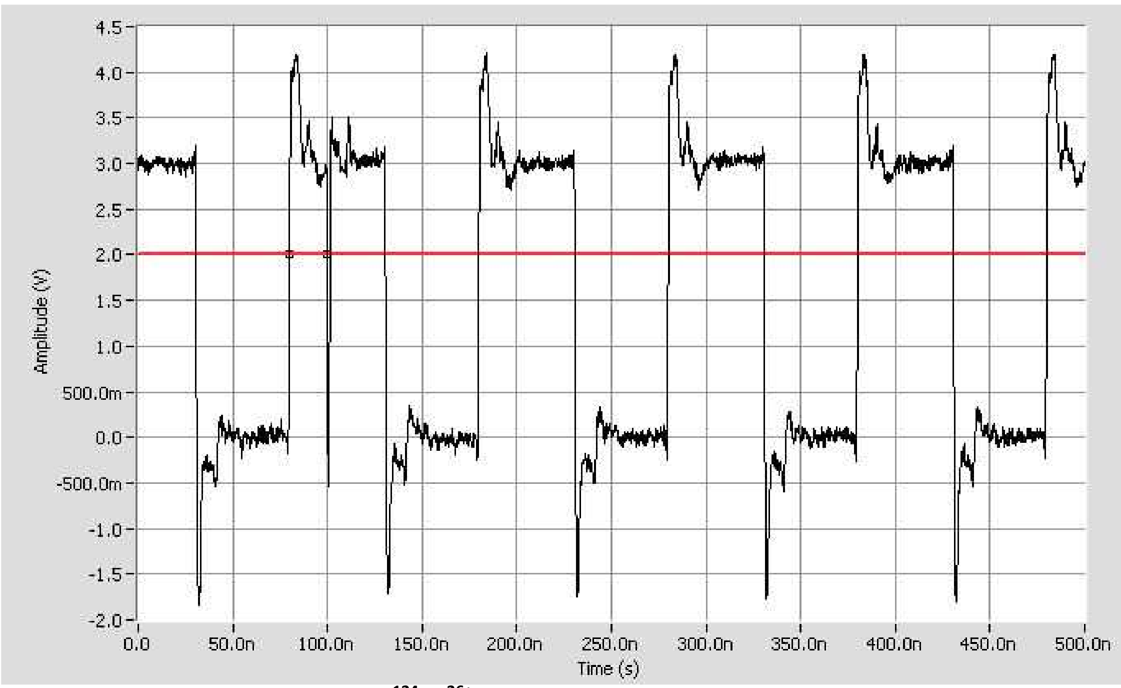



**Figure 12: SET curve, Heavy Ion $^{124}Xe^{26+}$ tilted 60° (LET of 135.4 MeV.mg/cm²), Part 3, Run n°33, Event n°1.**

# 9. Conclusion

Heavy ions test were performed on RHFLVDS228A. The aim of the test was to evaluate the sensitivity of the device versus SEL and SET.

No SELs were observed with the LET value of 67.7MeV.cm²/mg (Xenon heavy ions).

SETs were observed on the RHFLVDS228A with a minimum LET of 32.6 MeV.cm²/mg. No SET was detected with a LET of 22.4 MeV.cm²/mg.

# 10. Appendix 1 UCL beam calibration sheets

# FICHE DE CALIBRATION DU FAISCEAU HIF

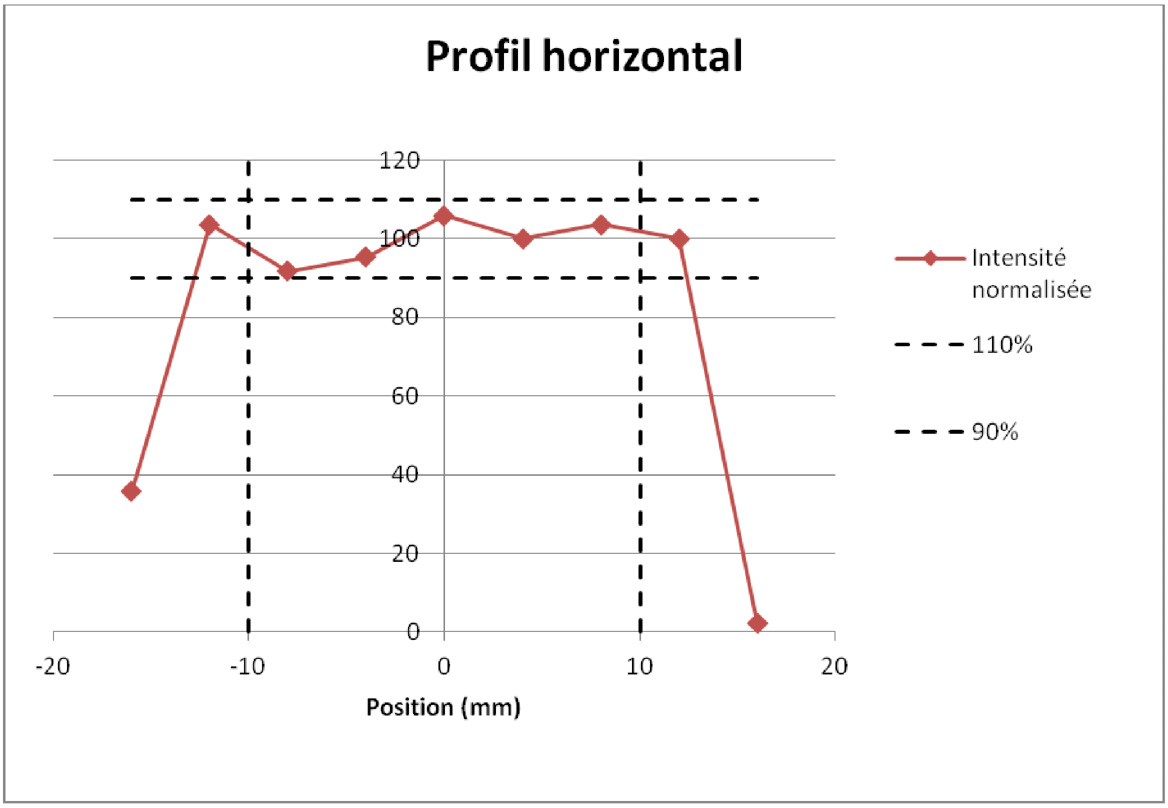
**Date de calibration :** 29/08/2013
**Semaine :** W35
**Opérateur(s) responsable(s) de la calibration :** ML-JVH-KS
**Cocktail :** ~~**M/Q = 5**~~ - **M/Q = 3,33**

## I. Profil du faisceau

Le profil du faisceau est mesuré à l'aide d'un détecteur de type PIPS. Le détecteur est centré dans la chambre d'irradiation et réalise 9 mesures selon les axes X et Y Le faisceau doit être homogène à +/-10% sur 20 mm aussi bien horizontalement que verticalement.

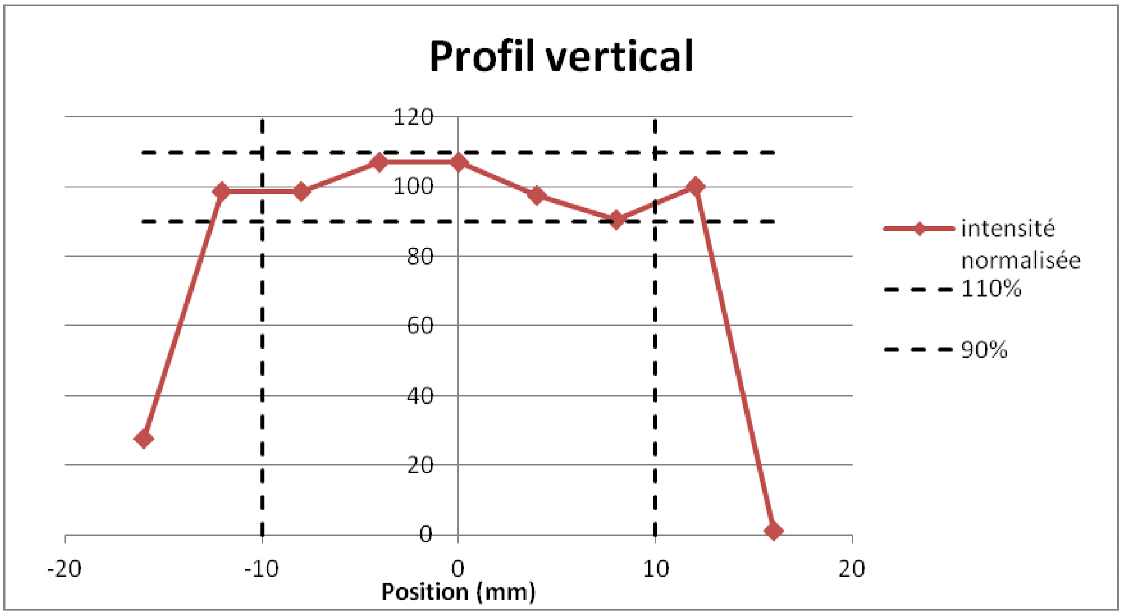
### 1) Profil Horizontal

| | |
|---|---|
| **Faisceau de référence :** | $^{40}Ar^{12+}$ 372 MeV |
| **Homogénéité horizontale :** | 24 mm |
| **Valeur de X minimum (mm) :** | -12 mm |
| **Valeur X maximum (mm) :** | +12 mm |



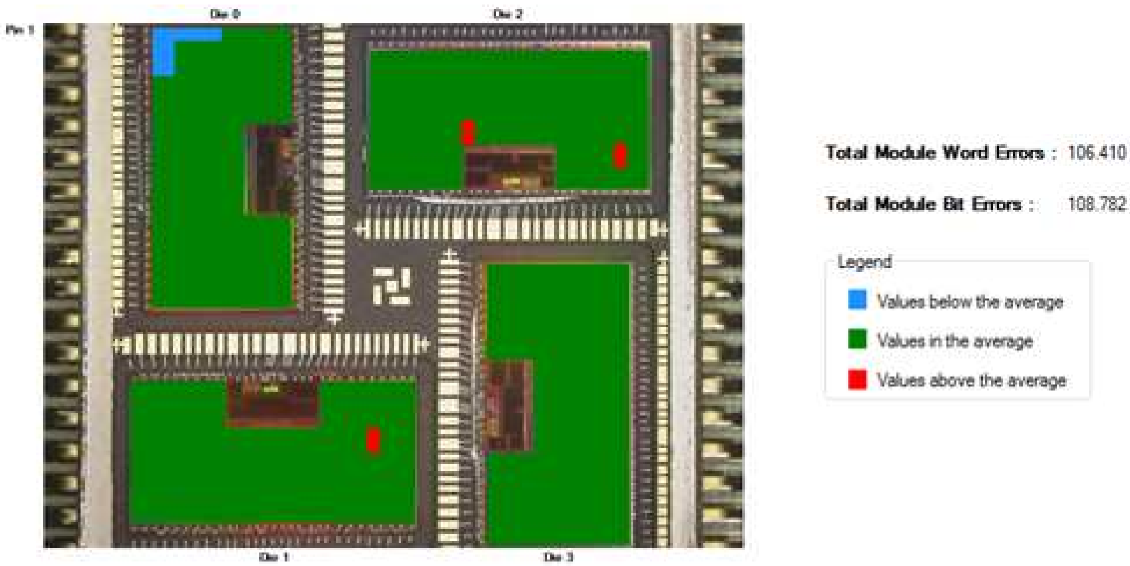
## 2) Scan Vertical

| | |
|---|---|
| **Faisceau de référence :** | $^{40}Ar^{12+}$ 372 MeV |
| **Homogénéité verticale :** | 24 mm |
| **Valeur de Y minimum (mm) :** | -12 mm |
| **Valeur Y maximum (mm) :** | +12 mm |




## 3) Profil transverse du faisceau mesuré avec le SEU Monitor

En plus de la procédure de scan, le profil du faisceau est contrôlé à l'aide du SEU Monitor fourni par l'ESA (20mm*20 mm). Tous les faisceaux du cocktail sont contrôlés par cette méthode. Seul le profil du faisceau de référence est présenté dans ce document mais les profils des autres ions du cocktail sont disponibles sur demande de l'utilisateur.



# II. Calibration en énergie du faisceau

L'énergie de chaque faisceau est contrôlée par un chaine de mesure comprenant un détecteur de type PIPS, une chaine d'amplification et un analyseur multicanal avec son logiciel associé.

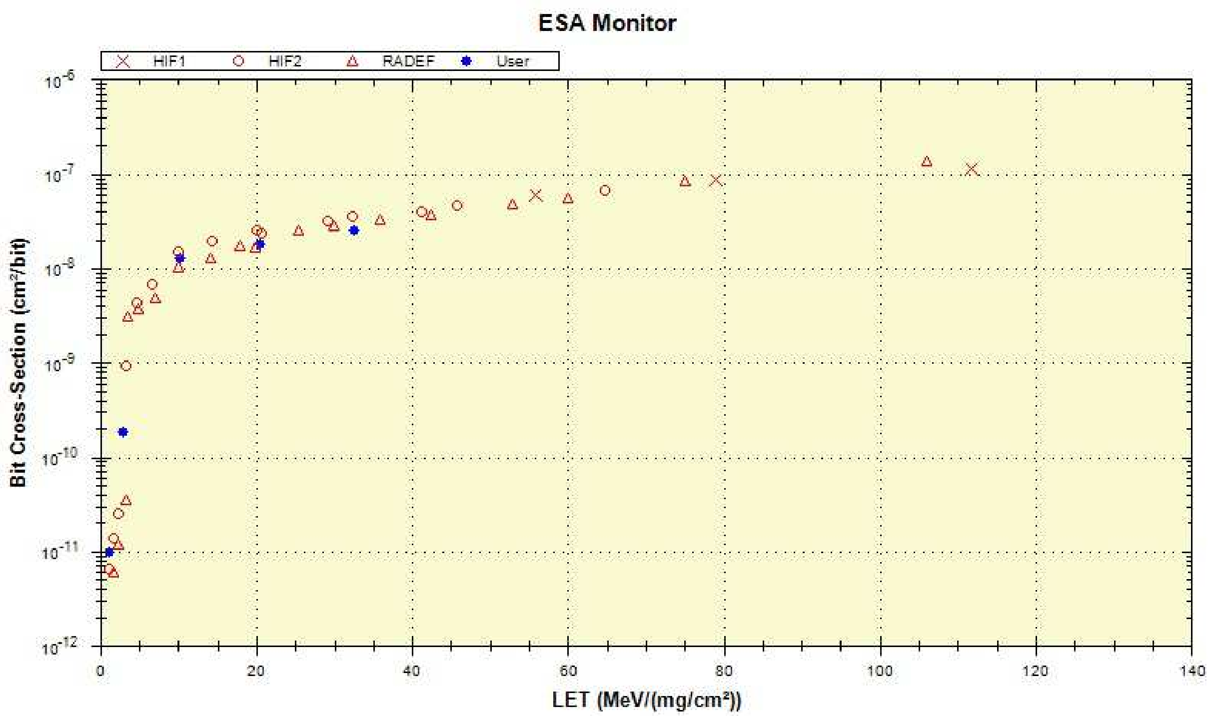
| Cocktail | Particule | Energie DUT (MeV) | Energie mesurée (MeV) |
|---|---|---|---|
| M/Q = 3 | $^{13}C^{4+}$ | 131 | 130 |
| | $^{22}Ne^{7+}$ | 235 | 234 |
| | $^{40}Ar^{12+}$ | 372 | 371 |
| | $^{58}Ni^{18+}$ | 567 | 562* |
| | $^{83}Kr^{25+}$ | 756 | 749* |

*Différence inhérente au détecteur PIPS "pulse height defect", liée notamment à un défaut de collection de charges pour les ions les plus lourds.

# III. SEU MONITOR

Une vérification supplémentaire est réalisée à l'aide d'un SEU monitor fourni par l'ESA et servant de référence pour toutes les installations European Component Irradiation Facilities (ECIF). Celle-ci permet de vérifier la méthode de mesure dans son ensemble. Chaque ion du cocktail est mesuré à l'aide de ce composant de référence.

**Courbe des sections efficace** $\sigma_{(LET)}$



## IV. Validation de la calibration

**Remarque**

**Directeur du CRC**

29 août 2013

M Loiselet

# FICHE DE CALIBRATION DU FAISCEAU HIF

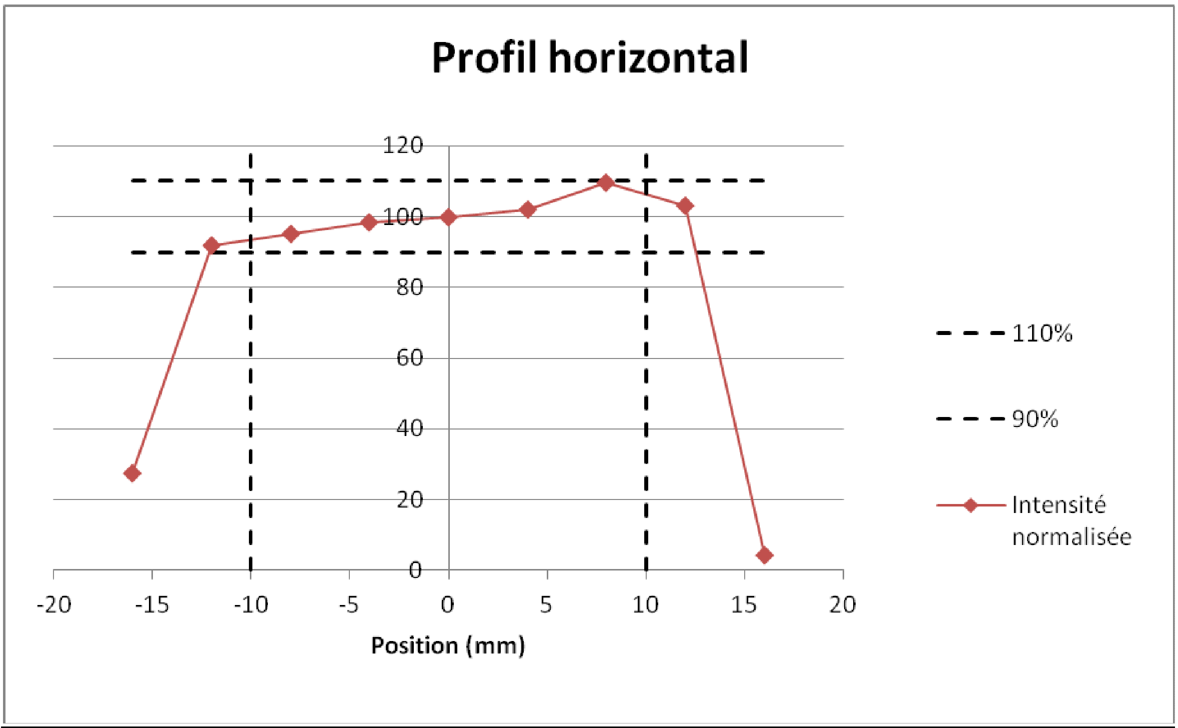
**Date de calibration :** 26/08/2013
**Semaine :** W35
**Opérateur(s) responsable(s) de la calibration :** ML-JVH-KS
**Cocktail : M/Q = 5 - ~~M/Q = 3,33~~**

## I. Profil du faisceau

Le profil du faisceau est mesuré à l'aide d'un détecteur de type PIPS. Le détecteur est centré dans la chambre d'irradiation et réalise 9 mesures selon les axes X et Y Le faisceau doit être homogène à +/-10% sur 20 mm aussi bien horizontalement que verticalement.

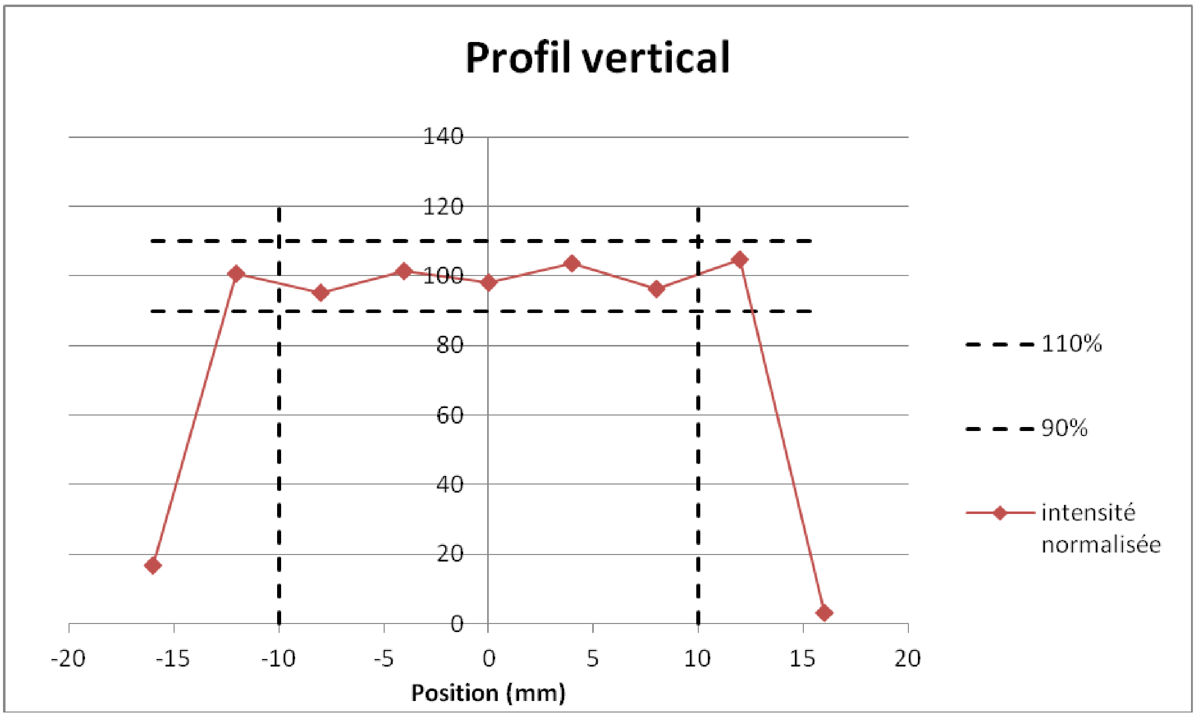
### 1) Profil Horizontal

| | |
|---|---|
| **Faisceau de référence :** | $^{40}Ar^{8+}$ 151 MeV |
| **Homogénéité horizontale :** | 24 mm |
| **Valeur de X minimum (mm) :** | -12 mm |
| **Valeur X maximum (mm) :** | +12 mm |



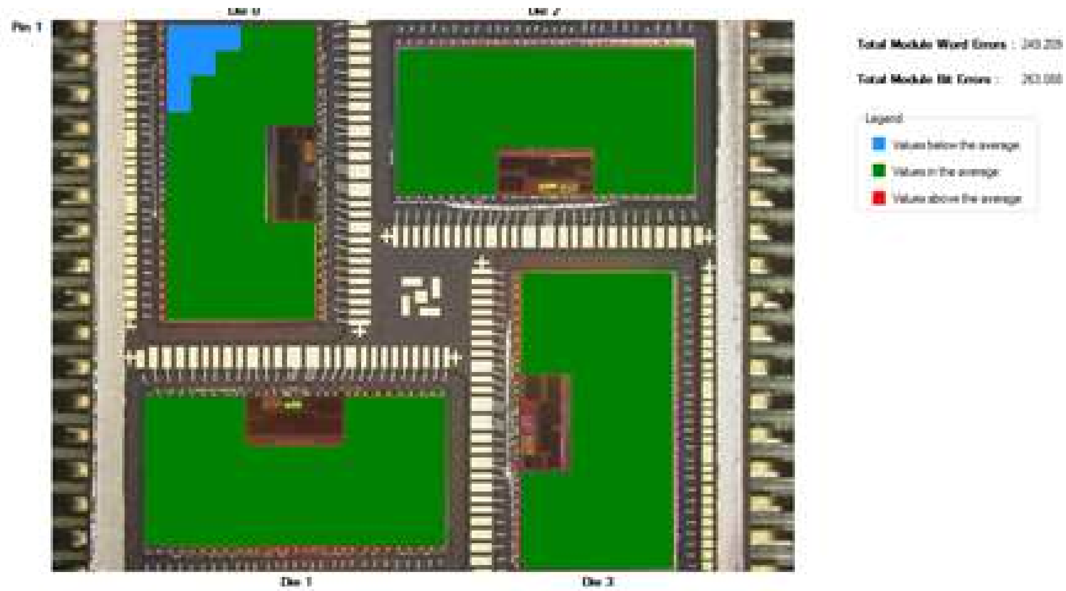
## 2) Scan Vertical

| | |
|---|---|
| **Faisceau de référence :** | $^{40}Ar^{8+}$ 151 MeV |
| **Homogénéité verticale :** | 24 mm |
| **Valeur de Y minimum (mm) :** | -12 mm |
| **Valeur Y maximum (mm) :** | +12 mm |




## 3) Profil transverse du faisceau mesuré avec le SEU Monitor

En plus de la procédure de scan, le profil du faisceau est contrôlé à l'aide du SEU Monitor fourni par l'ESA (20mm*20 mm). Tous les faisceaux du cocktail sont contrôlés par cette méthode. Seul le profil du faisceau de référence est présenté dans ce document mais les profils des autres ions du cocktail sont disponibles sur demande de l'utilisateur.



## II. Calibration en énergie du faisceau

L'énergie de chaque faisceau est contrôlée par un chaine de mesure comprenant un détecteur de type PIPS, une chaine d'amplification et un analyseur multicanal avec son logiciel associé.

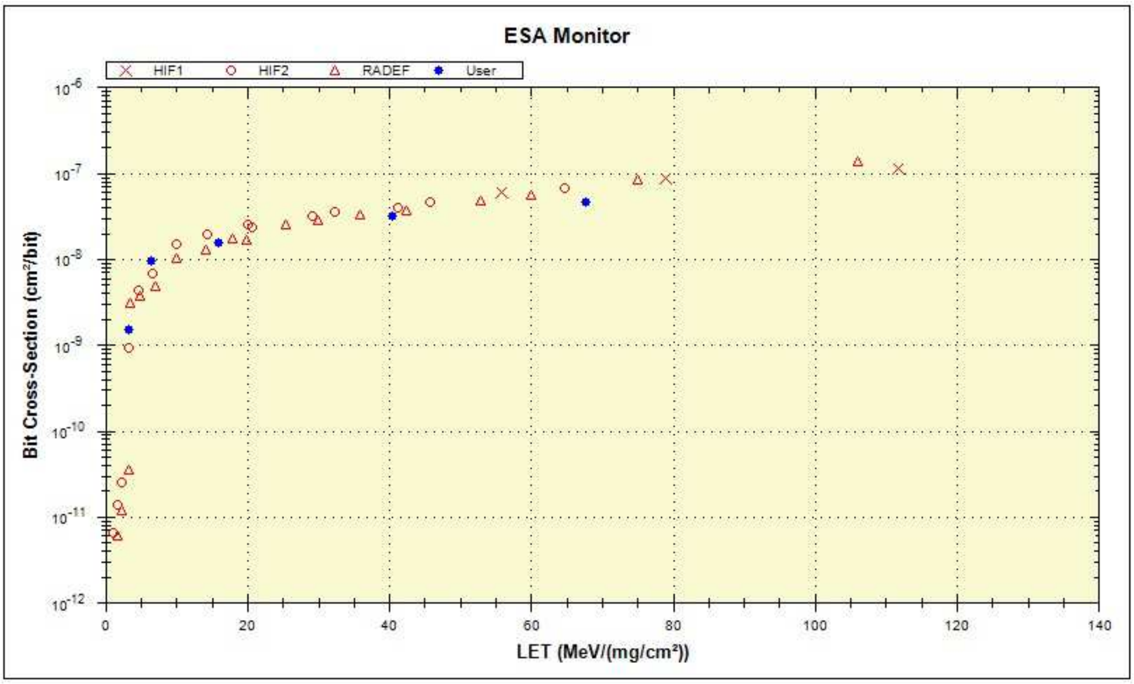
| **Cocktail** | **Particule** | **Energie DUT (MeV)** | **Energie mesurée (MeV)** |
|---|---|---|---|
| **M/Q = 5** | $^{15}N^{3+}$ | 60 | 60 |
| | $^{20}Ne^{4+}$ | 78 | 78 |
| | $^{40}Ar^{8+}$ | 151 | 151 |
| | $^{84}Kr^{17+}$ | 305 | 297* |
| | $^{124}Xe^{25+}$ | 420 | 399* |

*Différence inhérente au détecteur PIPS "pulse height defect", liée notamment à un défaut de collection de charges pour les ions les plus lourds.

## III. SEU MONITOR

Une vérification supplémentaire est réalisée à l'aide d'un SEU monitor fourni par l'ESA et servant de référence pour toutes les installations European Component Irradiation Facilities (ECIF). Celle-ci permet de vérifier la méthode de mesure dans son ensemble. Chaque ion du cocktail est mesuré à l'aide de ce composant de référence.

### Courbe des sections efficace $\sigma_{(LET)}$



# IV. Validation de la calibration

**Remarque**

**Directeur du CRC**

26 août 2013

M Loiselet

# FICHE DE CALIBRATION DU FAISCEAU HIF

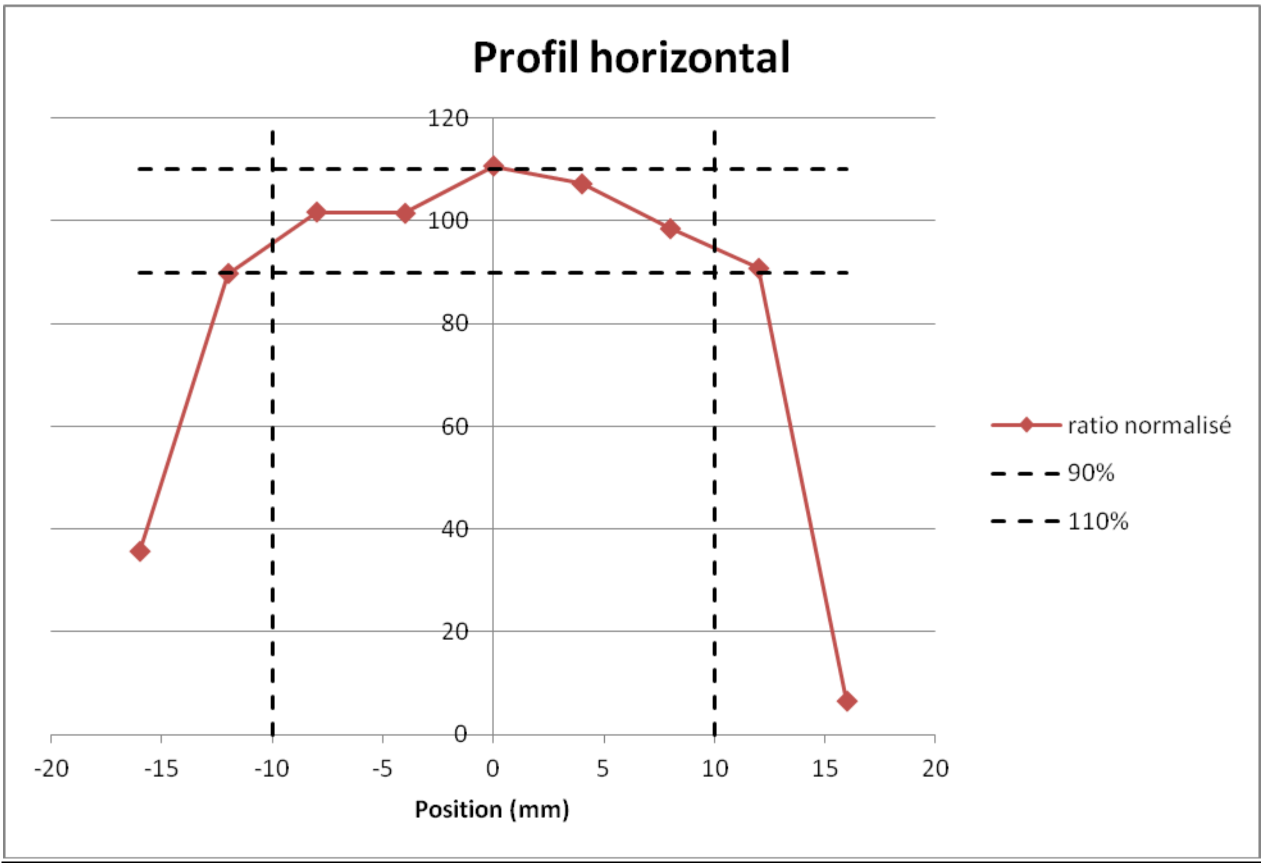
**Date de calibration :** 7/10/2013
**Semaine :** W41
**Opérateur(s) responsable(s) de la calibration :** KS-GU-LS-PJ-JVH
**Cocktail :** **M/Q = 5** - ~~**M/Q = 3,33**~~

## I. Profil du faisceau

Le profil du faisceau est mesuré à l'aide d'un détecteur de type PIPS. Le détecteur est centré dans la chambre d'irradiation et réalise 9 mesures selon les axes X et Y Le faisceau doit être homogène à +/-10% sur 20 mm aussi bien horizontalement que verticalement.

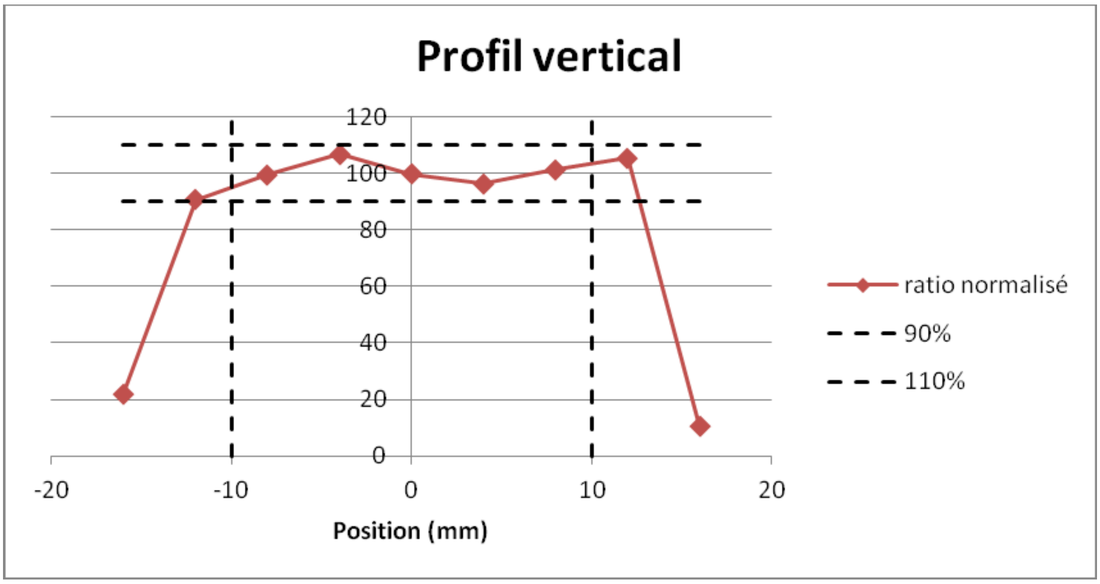
### 1) Profil Horizontal

| | |
|---|---|
| **Faisceau de référence :** | $^{40}Ar^{8+}$ 151 MeV |
| **Homogénéité horizontale :** | 24 mm |
| **Valeur de X minimum (mm) :** | -12 mm |
| **Valeur X maximum (mm) :** | +12 mm |



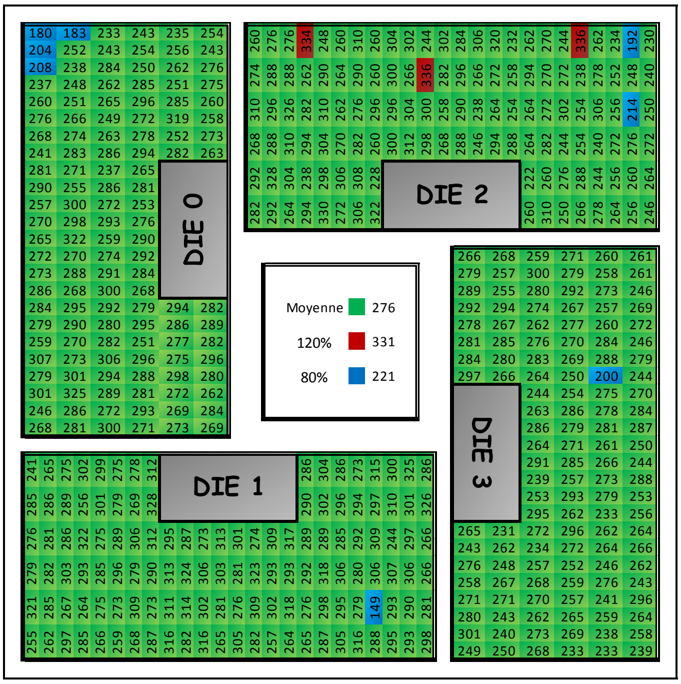
## 2) Scan Vertical

| | |
|---|---|
| **Faisceau de référence :** | $^{40}Ar^{8+}$ 151 MeV |
| **Homogénéité verticale :** | 24 mm |
| **Valeur de Y minimum (mm) :** | -12 mm |
| **Valeur Y maximum (mm) :** | +12 mm |




## 3) Profil transverse du faisceau mesuré avec le SEU Monitor

En plus de la procédure de scan, le profil du faisceau est contrôlé à l'aide du SEU Monitor fourni par l'ESA (20mm*20 mm). Tous les faisceaux du cocktail sont contrôlés par cette méthode. Seul le profil du faisceau de référence est présenté dans ce document mais les profils des autres ions du cocktail sont disponibles sur demande de l'utilisateur.




| | | |
|---|---|---|
| COKTAIL : | M/Q = 5 | |
| ION : | 40Ar8+ | |
| ENERGIE DUT : | 151 | MeV |
| LET : | 20,2 | Mev/(mg/cm²) |
| TOTAL WORD ERROR : | 137337 | |
| TOTAL BIT ERROR : | 141346 | |
| FLUENCE : | 5,00E+05 | Part/cm² |
| CROSS SECTION : | 1,685E-08 | cm²/bit |

## II. Calibration en énergie du faisceau

L'énergie de chaque faisceau est contrôlée par un chaine de mesure comprenant un détecteur de type PIPS, une chaine d'amplification et un analyseur multicanal avec son logiciel associé.

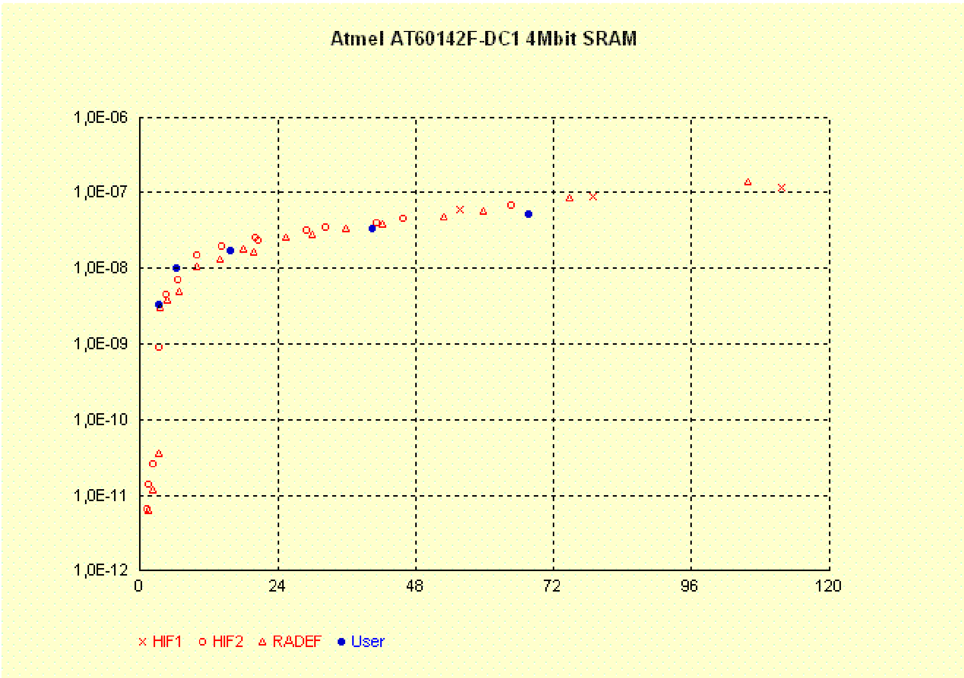
| Cocktail | Particule | Energie DUT (MeV) | Energie mesurée (MeV) |
|---|---|---|---|
| M/Q = 5 | $^{15}N^{3+}$ | 60 | 61 |
| | $^{20}Ne^{4+}$ | 78 | 77 |
| | $^{40}Ar^{8+}$ | 151 | 144* |
| | $^{84}Kr^{17+}$ | 305 | 276* |
| | $^{124}Xe^{25+}$ | 420 | 371* |

*Différence inhérente au détecteur PIPS "pulse height defect", liée notamment à un défaut de collection de charges pour les ions les plus lourds.

## III. SEU MONITOR

Une vérification supplémentaire est réalisée à l'aide d'un SEU monitor fourni par l'ESA et servant de référence pour toutes les installations European Component Irradiation Facilities (ECIF). Celle-ci permet de vérifier la méthode de mesure dans son ensemble. Chaque ion du cocktail est mesuré à l'aide de ce composant de référence.

**Courbe des sections efficace** $\sigma_{(LET)}$



# IV. Validation de la calibration

**Remarque**

La courbe des sections efficaces a été obtenue avec l'ancien SEU monitor fourni par l'ESA.

**Directeur du CRC**

9 septembre 2013

M Loiselet