SEE characterization on Operational Amplifiers

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1. Products characteristics

Two operational amplifiers have been tested:

- **RHF43B:** Rad-hardened **precision** bipolar single operational amplifier, in **2µm BiCMOS** technology.

  Voltage Feedback Operational Amplifier.

- **RHF310:** Rad-hardened **high-speed** bipolar single operational amplifier, in **0.25µm BiCMOS** technology.

  Current Feedback Operational Amplifier.

	RHF43B Precision VFA	**RHF310** High-Speed CFA
V_{CC}	4 to 14V	4.5 to 5.5V
V_{IO}	100µV	1.7mV
I_{CC}	2.3mA	400µA
-3dB Bandwidth	A_V=+5 2MHz	A_V=+2, R_{fb}=3kΩ 120MHz
Slew Rate	2.85V/µs	115V/µs

2. Test definitions

- SEL: @125°C, Fluence=1x10^7#/cm², 2 parts tested / ref.

– **RHF43B:** RADEF (Finland),
LET$_{eff}$=120MeV.cm²/mg
Range=48µm
Flux ~ 2E+04ions/cm²

Config	V_{CC}	V_{IN}	V_{OUT}
Non Inv	± 7V	6.5V	Saturated
Non Inv	± 7V	-6.5V	Saturated
Non Inv	± 7V	0V	Non Saturated
Inverting	± 7V	2V	Saturated
Inverting	± 7V	-2V	Saturated
Inverting	± 7V	0V	Non Saturated

– **RHF310:** LBNL (USA)
LET$_{eff}$=110.9MeV.cm²/mg
Range=60µm
Flux ~ 2E+05ions/cm²

Config	V_{CC}	V_{IN}	f (MHz)	V_{OUT}
Non Inv	± 2.8V	$2V_{p-p}$	5	Saturated
Non Inv	± 2.8V	$0.5V_{p-p}$	5	Non Sat
Inverting	± 2.8V	$2V_{p-p}$	5	Saturated
Inverting	± 2.8V	$0.6V_{p-p}$	5	Non Sat

2. Test definitions

- SET: @T_{amb}.
  - **RHF43B:** HIF (Belgium),

    Ions cocktail:

Ion	**Energy** (MeV)	**LET** (MeV.cm²/mg)	**Range (Si)** (µm)
22 Ne +7	235	3.30	199
41 Ar +12	372	10.10	119
83 Kr +25	756	32.40	92
132 Xe +26	459	55.90	43

Configurations:

Config	**V_{CC}** (V)	**V_{IN}** (V)	**V_{OUT}** (V)
Inverting	±7V	±1.25V	±5V
		0V	0V
Non-Inverting	±7V	±0.8V	±5V
		0V	0V
Subtracting	±1.5V	±1.9V	0V
		0V	0V

2. Test definitions

- SET: @T_{amb}.
  - **RHF310:** LBNL (USA),

    Ions cocktail:

Ion	**Energy** (MeV)	**LET** (MeV.cm²/mg)	**Range (Si)** (µm)
22 Ne +6	216.28	3.49	174.6
40 Ar +11	400.00	9.74	130.1
86 Kr +18	885.59	30.86	109.9
136 Xe +34	1232.55	58.78	90.0

Configurations:

Config	**V_{CC}** (V)	**V_{IN}** (V)	**f** (MHz)	**V_{OUT}** (V)
Inverting	±2.8V	$0.6V_{P-P}$	5	±1.5V
Non-Inverting	±2.8V	$0.5V_{P-P}$	5	±1.5V
Subtracting	±2.2V	$2V_{P-P}$	5	0V

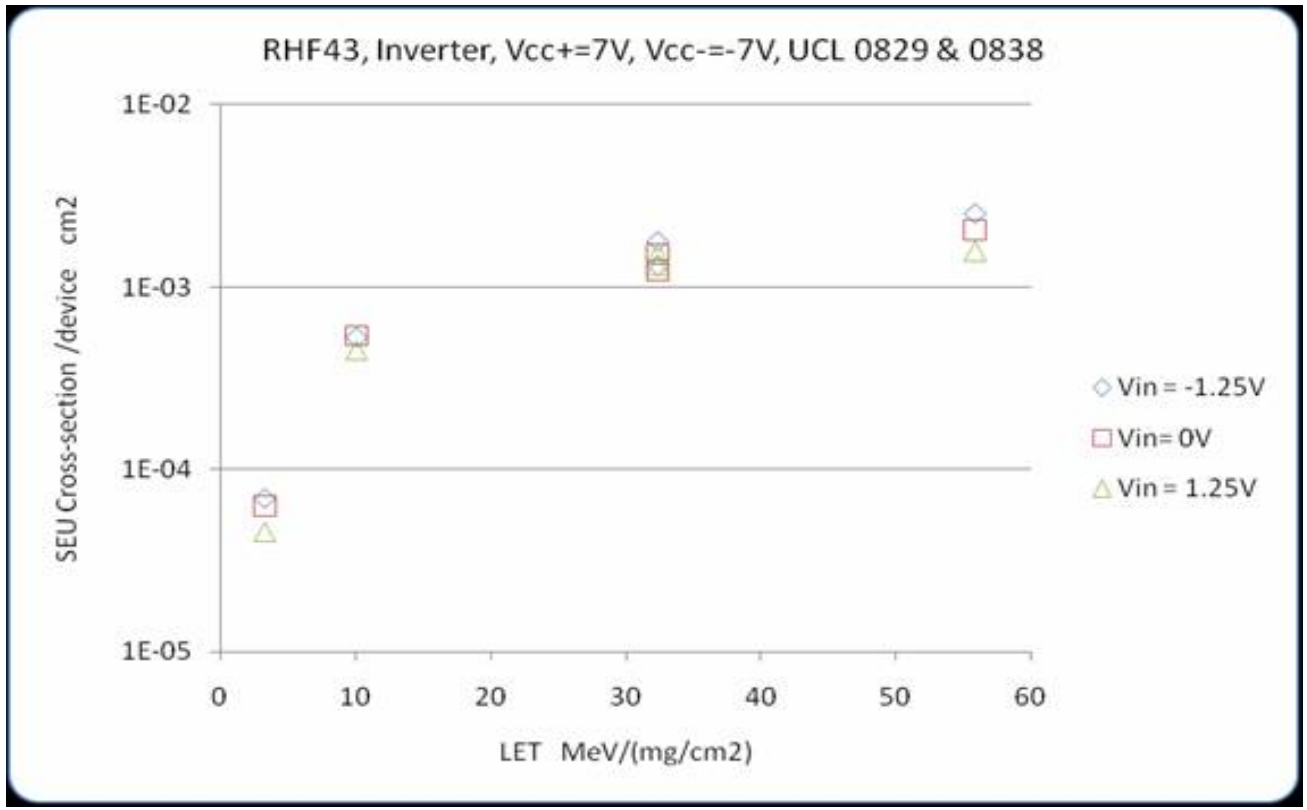
3. Experimental results

- RHF43B:
  - No SEL @ 110MeV.cm²/mg, 125°C
  - SET worst cases:

Config	V_{CC} (V)	V_{IN} (V)	**Amplitude** (V)	**Duration** (µs) (50% of the amplitude)
Subtracting	±1.5V	+1.9V	1.10	1.05
		-1.9V	1.11	0.85
		0V	1.11	0.95
Inverting	±7V	+1.25V	-6.64	1.8
		-1.25V	-10.1	2.5
		0V	-6.85	1.75
Non-Inverting	±7V	+0.8V	-2.07	0.6
		-0.8V	3.12	3.15
		0V	-6.88	1.85

3. Experimental results

- RHF43B: Inverting configuration

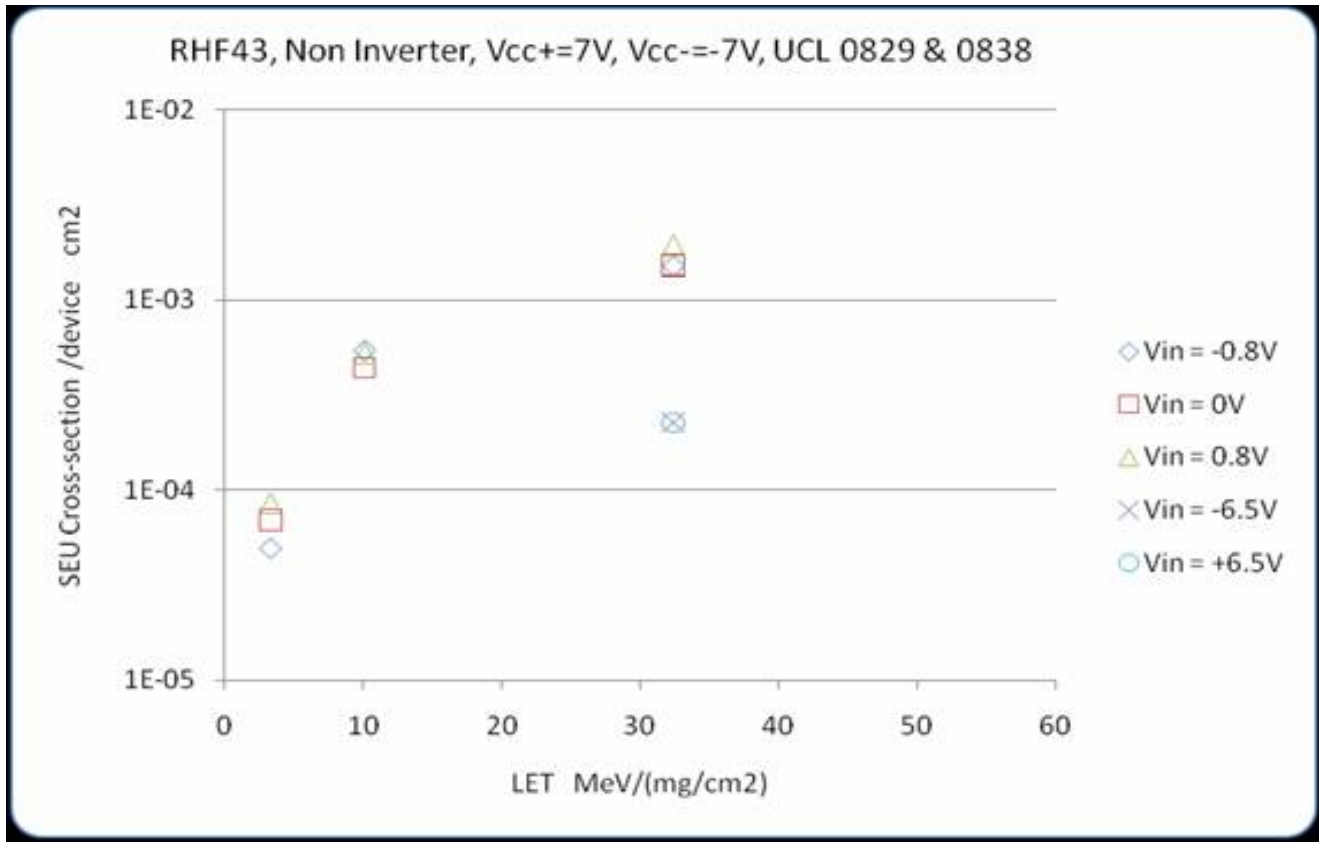


Saturated cross-section=2.04E-03cm²

LET_{th}=10.9MeV.cm²/mg

3. Experimental results

- RHF43B: Non-Inverting configuration

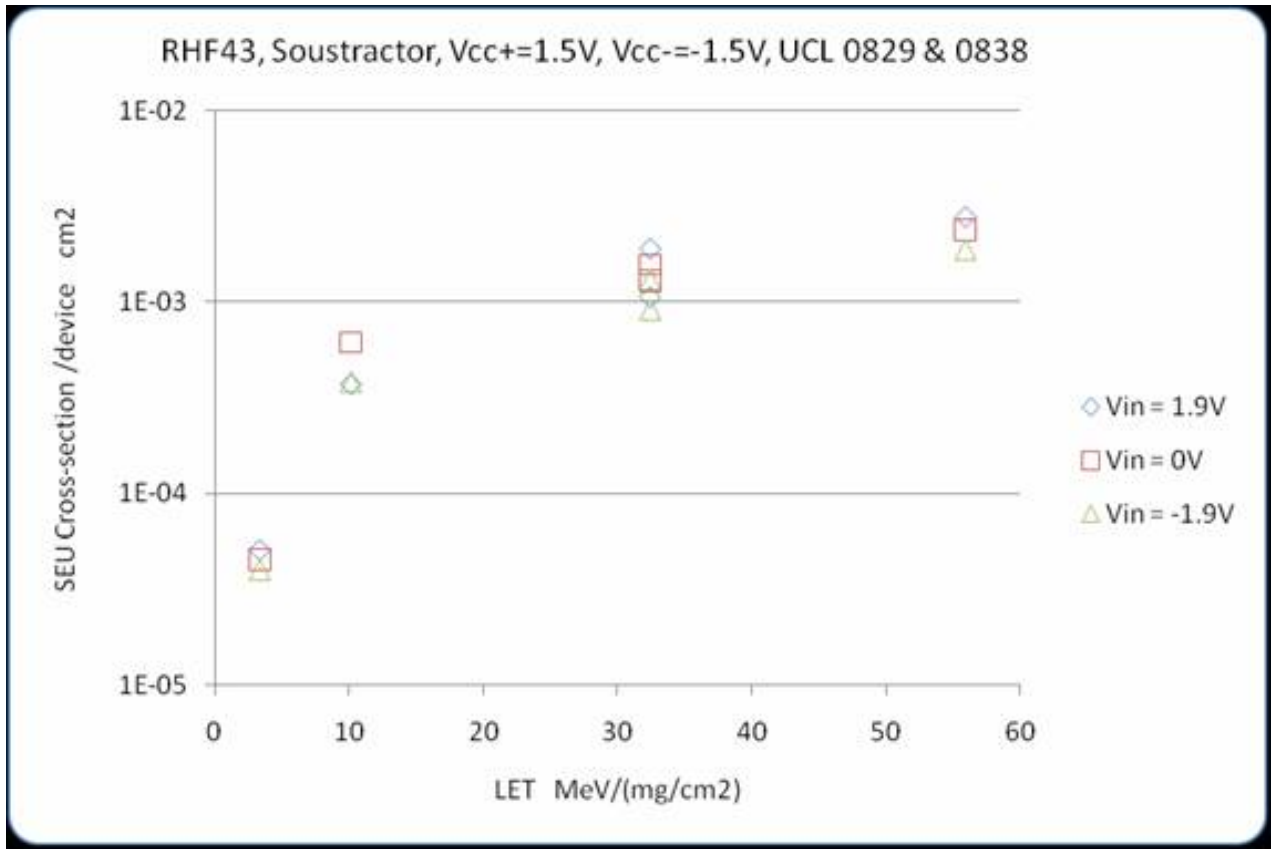


Saturated cross-section=1.17E-03cm²

LET_{th}=10.9MeV.cm²/mg

3. Experimental results

- RHF43B: Subtracting configuration

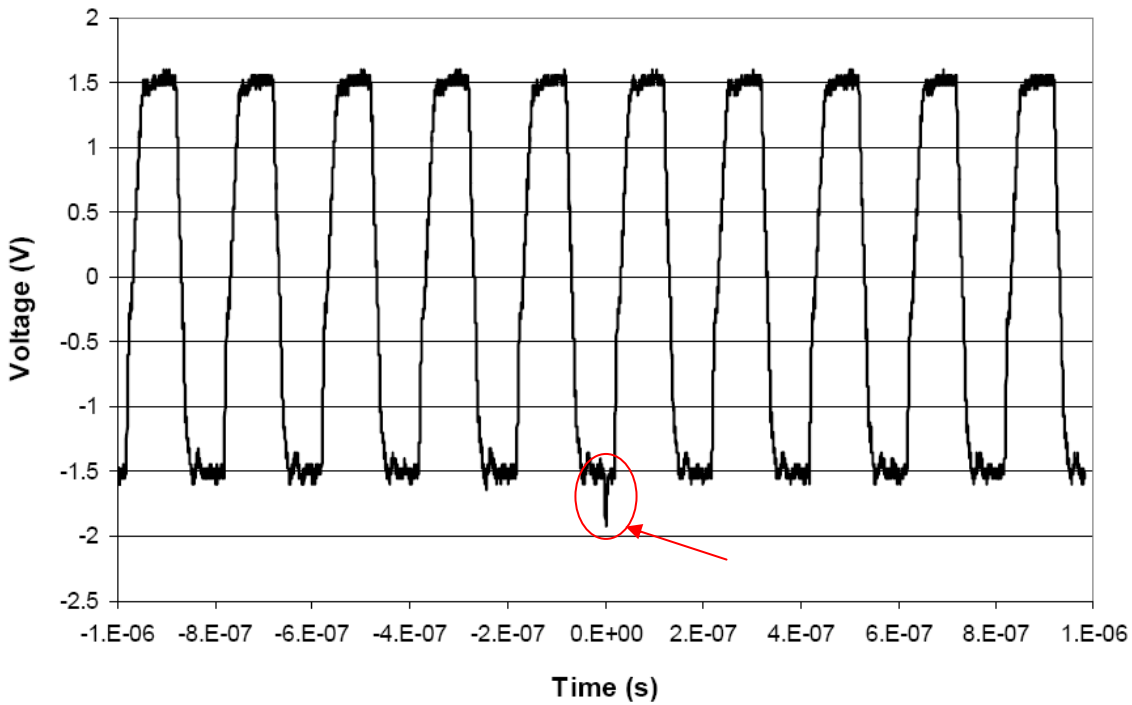


Saturated cross-section=2.30E-03cm²

LET_{th}=10.9MeV.cm²/mg

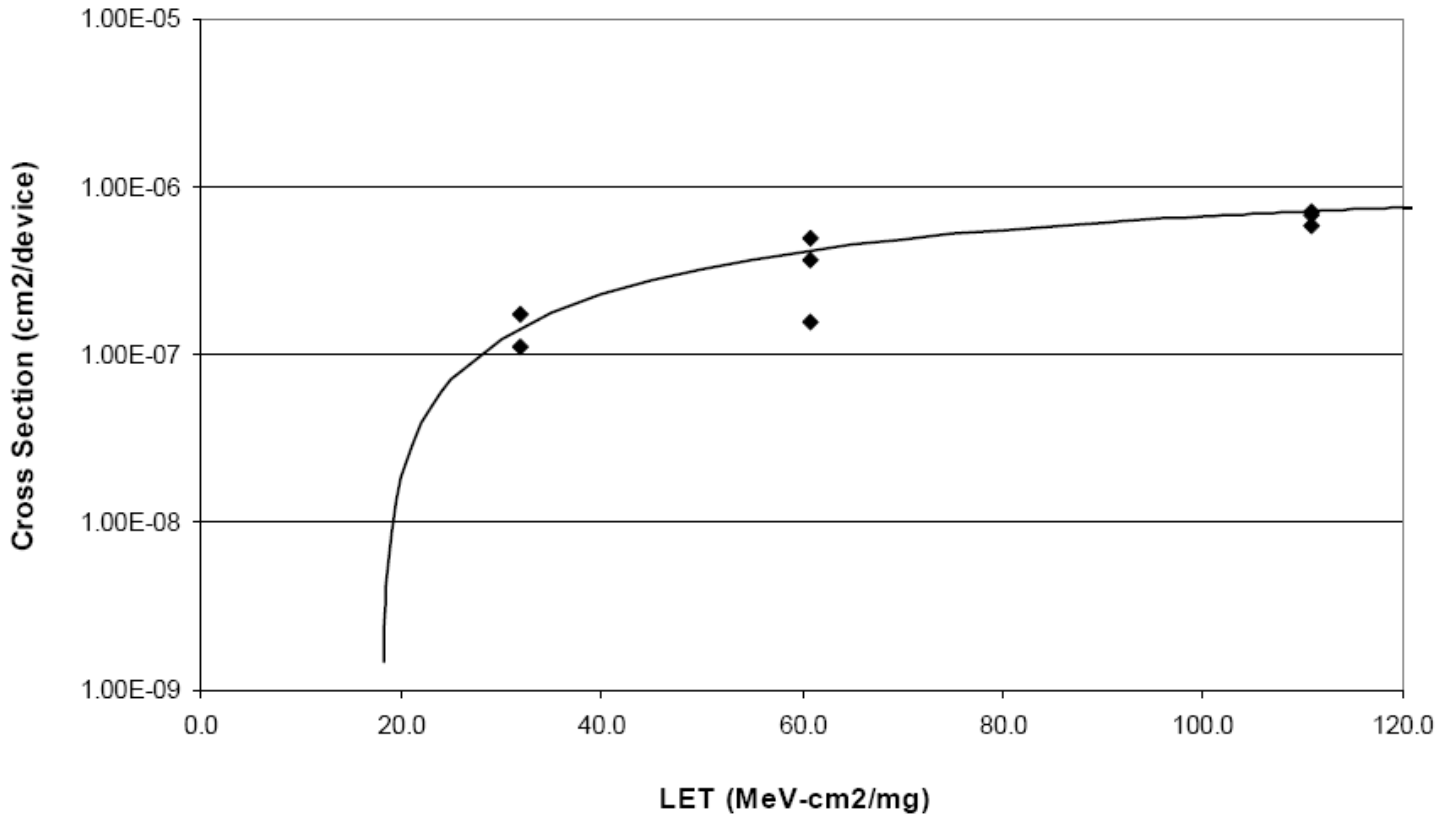
3. Experimental results

- RHF310:
  - No SEL @ 111MeV.cm²/mg, 125°C
  - SET :
    - **No SET** in Inverting configuration
    - Very little SET in Non-Inverting and Subtracting configurations



3. Experimental results

- RHF310: Non-Inverting configuration

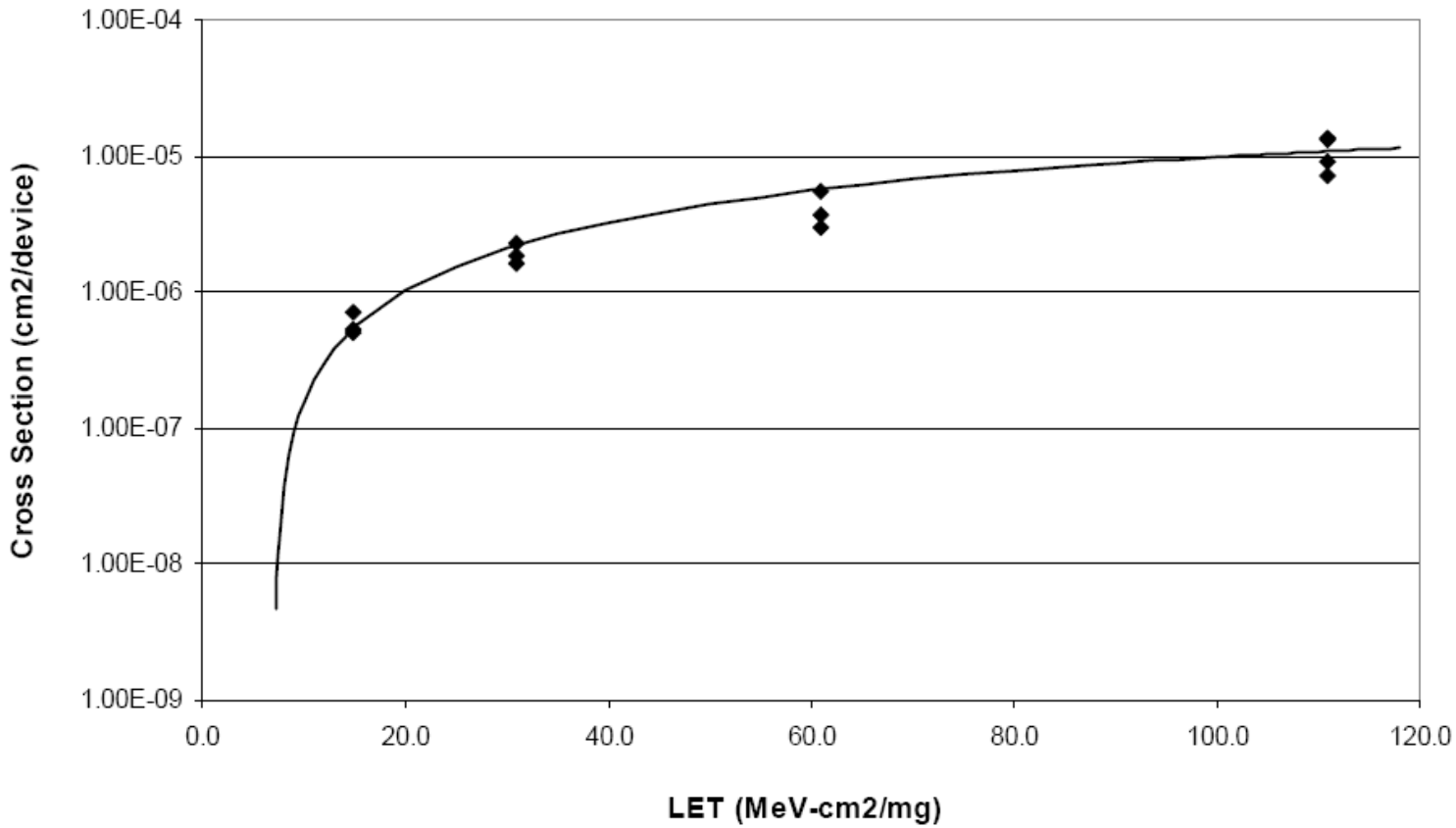


Saturated cross-section=1.00E-06cm²/device

LET_{th}=18MeV.cm²/mg

3. Experimental results

- RHF310: Subtracting configuration



Saturated cross-section=2.00E-05cm²

LET_{th}=7MeV.cm²/mg

4. Conclusion

- Similar heavy ions tests have been done on RHF43B and RHF310 operational amplifiers.

- RHF43B and RHF310 are **SEL immune** for a LET = 110MeV.cm²/mg @ 125°C

- RHF310 has a better behavior in term of SET : immunity in Inverting configuration, saturated cross-sections > 2.00E-05cm² for Non-Inverting and Subtracting configurations.