CENTRE NATIONAL D'ÉTUDES SPATIALES

ONERA

EREMS

SET Characterisations
&
Impact of Test Parameters

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Summary:

- Introduction
- LET
- Range
- Tilt
- Biasing
- Cable length
- Combined effects…

Overview

Since 2004, several studies upon SET on linear devices:

- CNES/TRAD: Impact of LET/range and Tilt angle on LN124 & LM139 devices.
- EADS/IWG: determination of SET sensitive volume using laser probing
- ONERA: Range of ions and probing of the sensitive volume
- IMS: TPA laser based SET probing
- CNES: impact of measurement system.

Impact of LET/range/angle on SET response

This study has been done by CNES & TRAD using LM124 and LM139 from NSC.

- Tests were performed at Institut de Physique Nucléaire and Université Catholique de Louvain la Neuve using heavy ions from the 2 available cocktails.

Ion	Energie (MeV)	Range (µm)	LET (MeV.cm²/mg)
Cl	156	43.8	13.1
Ni	182	27.65	29.8

(IPN, Orsay, France)

Cocktail No 1:

M/Q=5	DUT energy [MeV]	Range [µm Si]	LET [MeV/mg/cm²]
$^{40}Ar^{8+}$	150	42	14.1
$^{20}Ne^{4+}$	78	45	5.85
$^{15}N^{3+}$	62	64	2.97
$^{10}B^{2+}$	41	80	1.7

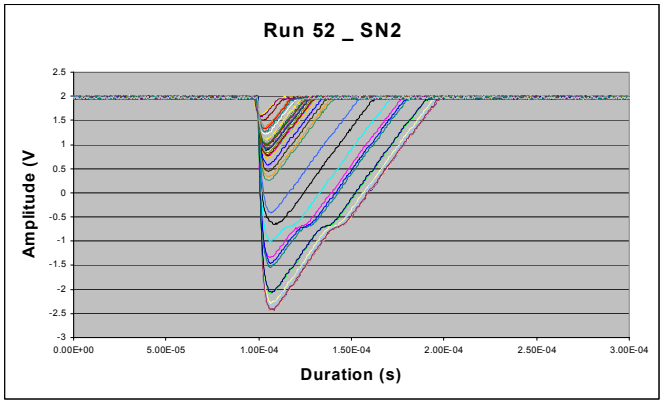
*Cocktail No 2: **High penetration***

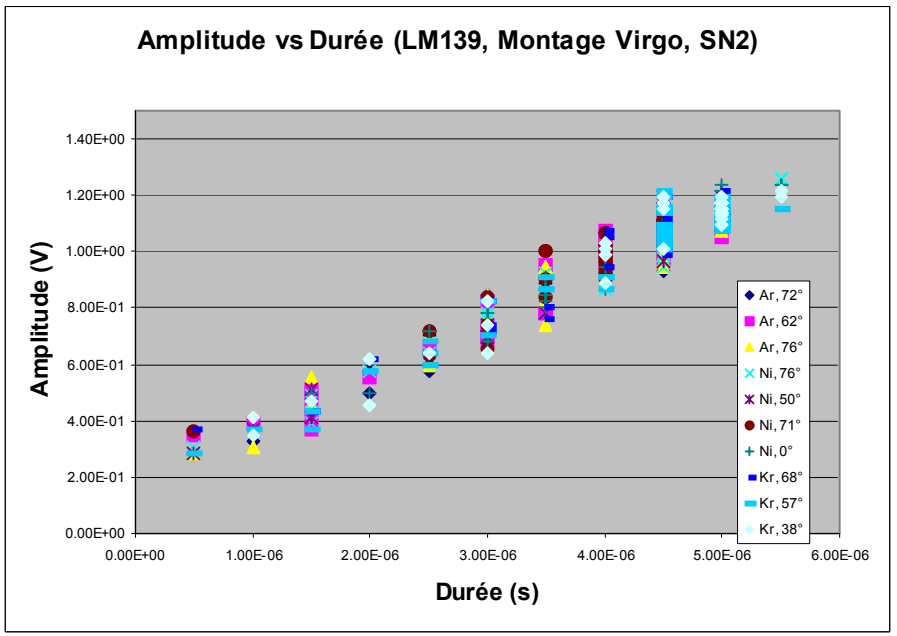
Ion	DUT energy [MeV]	Range [µm Si]	LET [MeV/mg/cm²]
$^{13}C^{4+}$	131	266	1.2
$^{22}Ne^{7+}$	235	199	3.3
$^{28}Si^{8+}$	236	106	6.8
$^{40}Ar^{12+}$	372	119	10.1
$^{58}Ni^{17+}$	500	85	21.9
$^{83}Kr^{25+}$	756	92	32.4

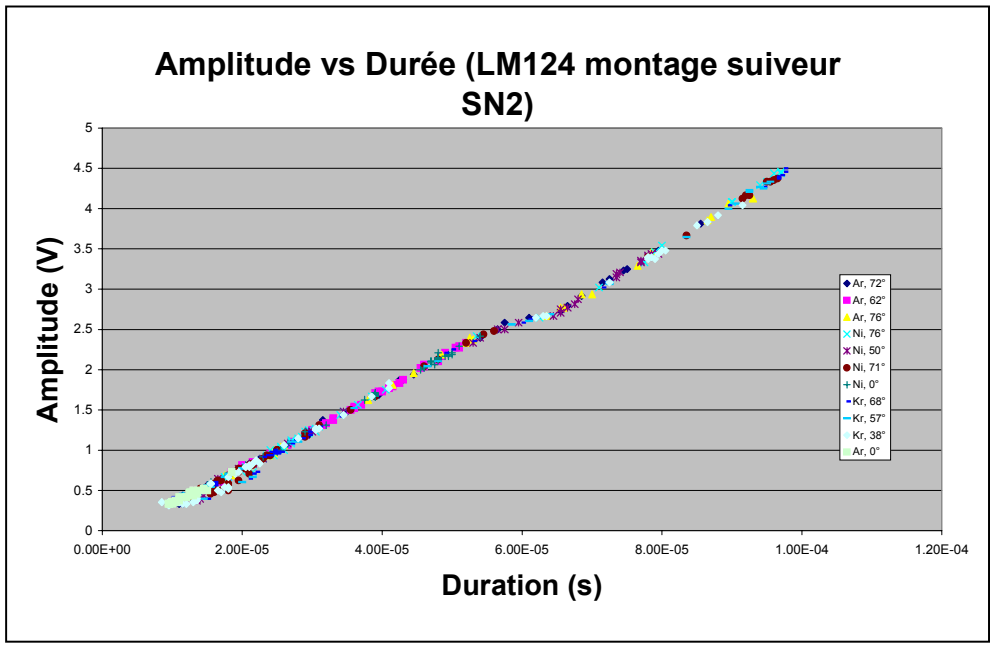
(UCL, Belgium)

- The principle applied consisted in varying the tilt angle in order to reach similar LET values with various ranges.
- LM124 was biased with gain = 1 or 2
- LM139 was tested using the VIRGO application already tested by ESA for SOHO.

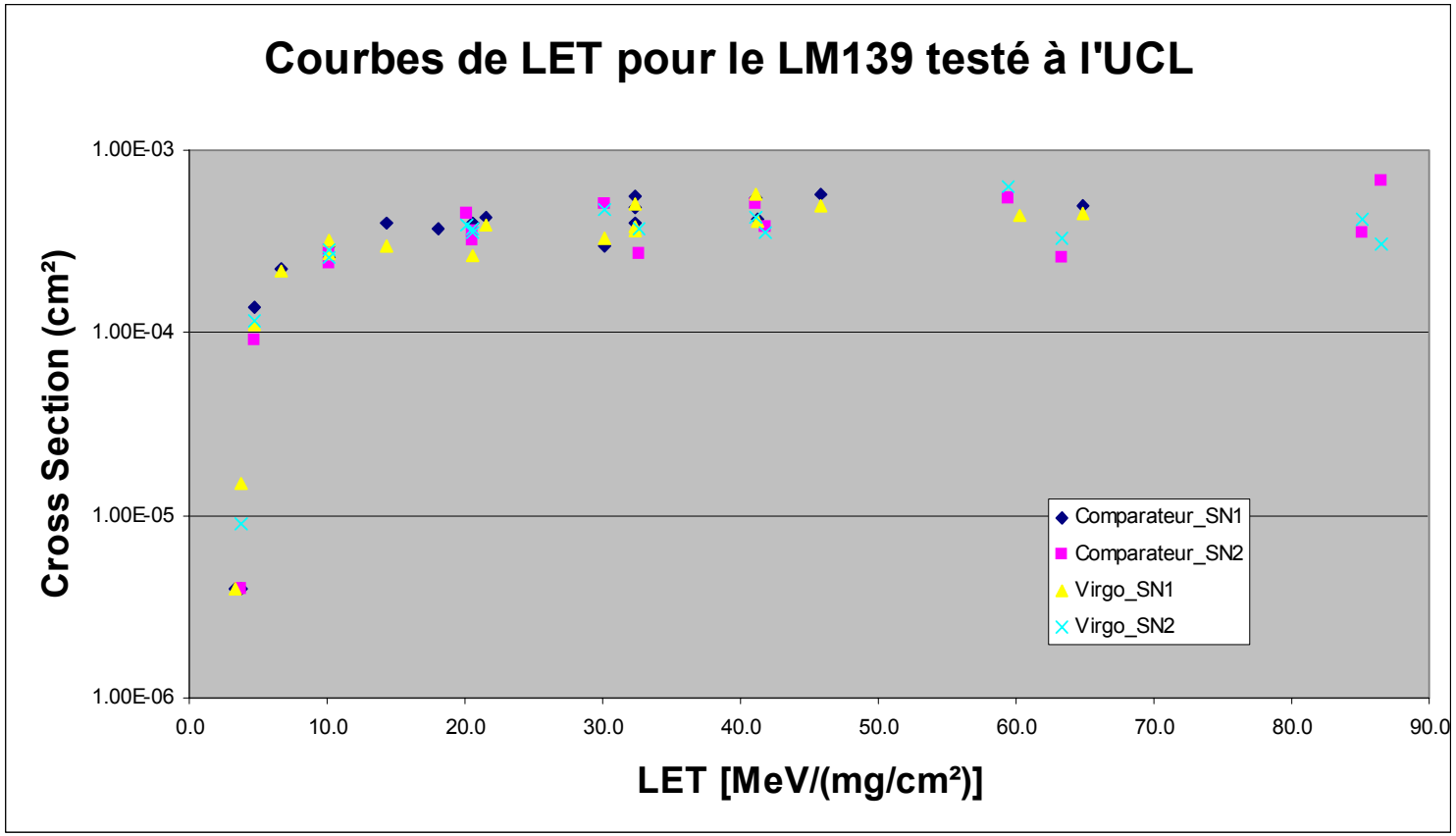
Result 1: Strong correlation Duration/Amplitude



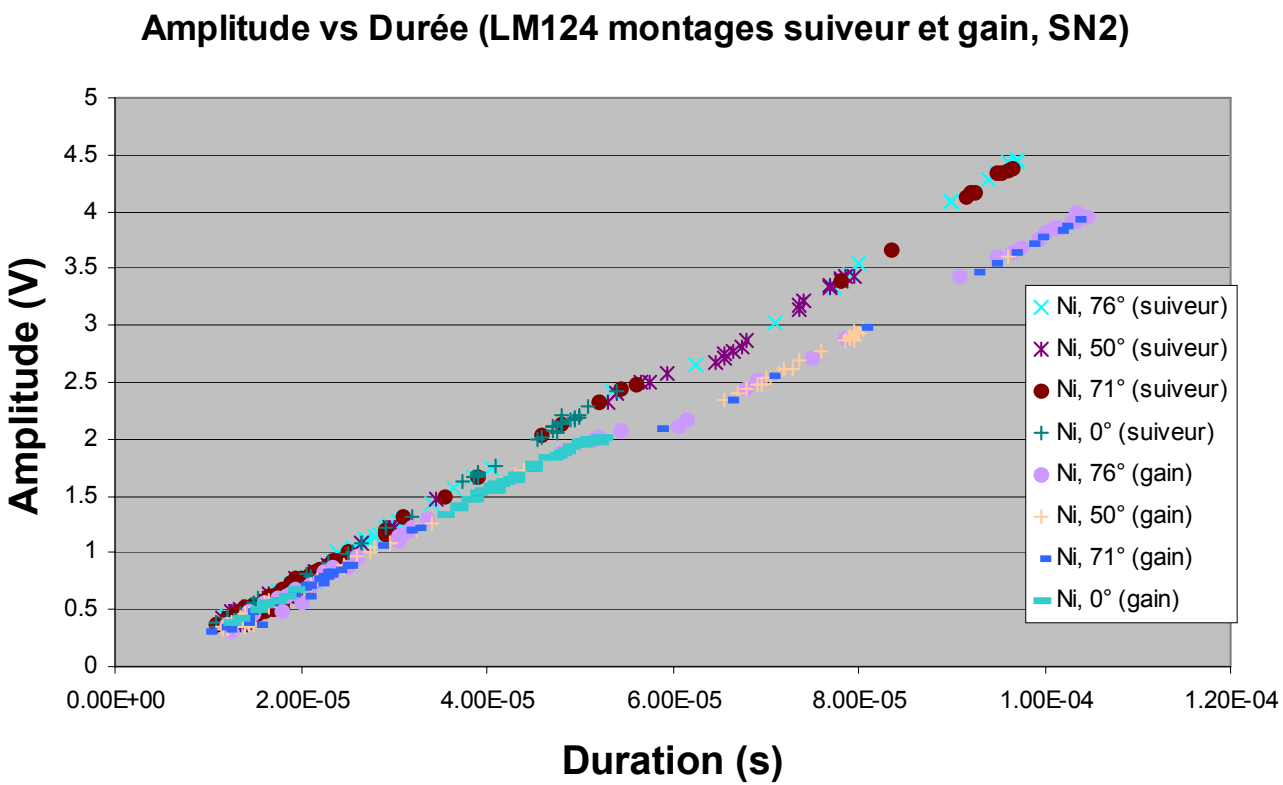




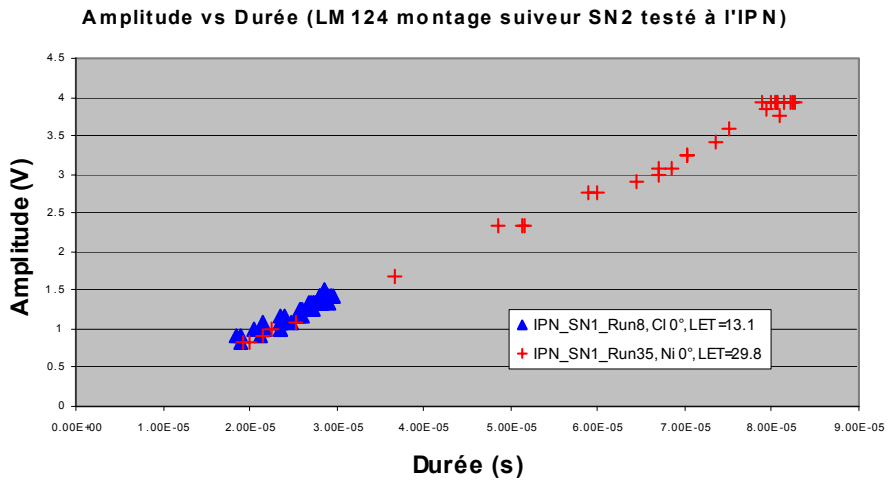
Result 2: No major change of the cross section curve with range, tilt or application.

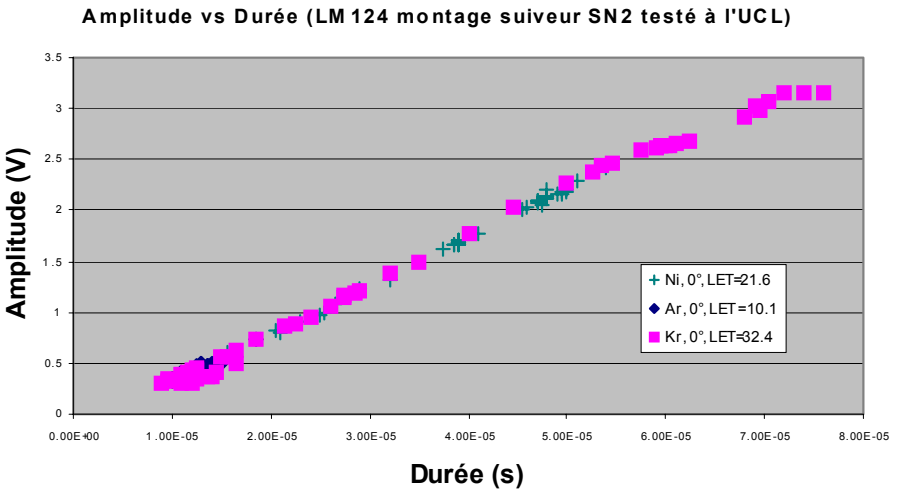


Result 3: Impact of the biasing condition on the amplitude and duration.



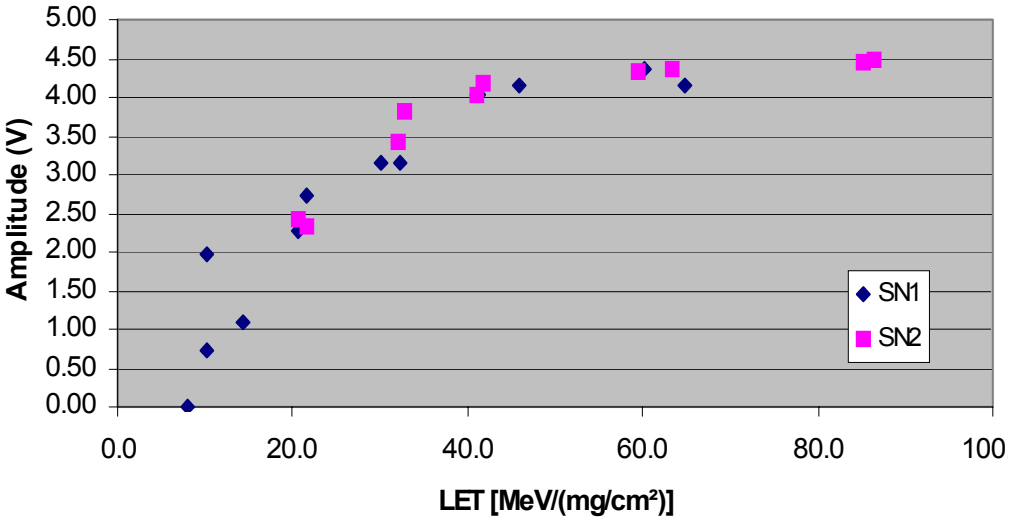
Result 4: impact of LET/range on Amplitude /duration



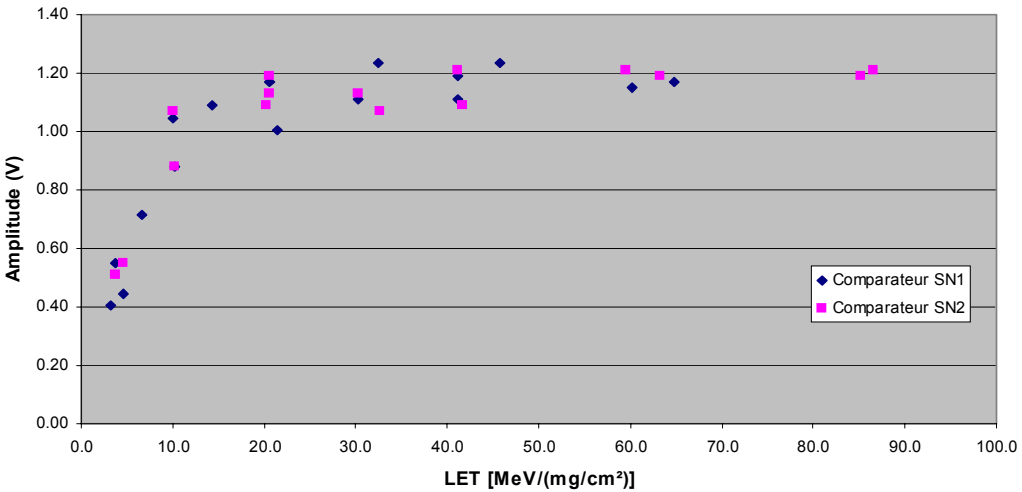


Result 5: impact of LET on Amplitude (duration)

LM124 (suiveur) Amplitude Max Vs LETeff (test à l'UCL)

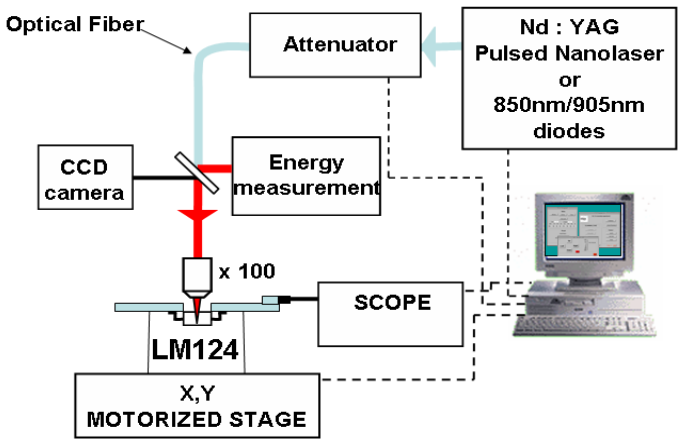


LM139 (Comparateur) - Amplitude max vs LET effectif

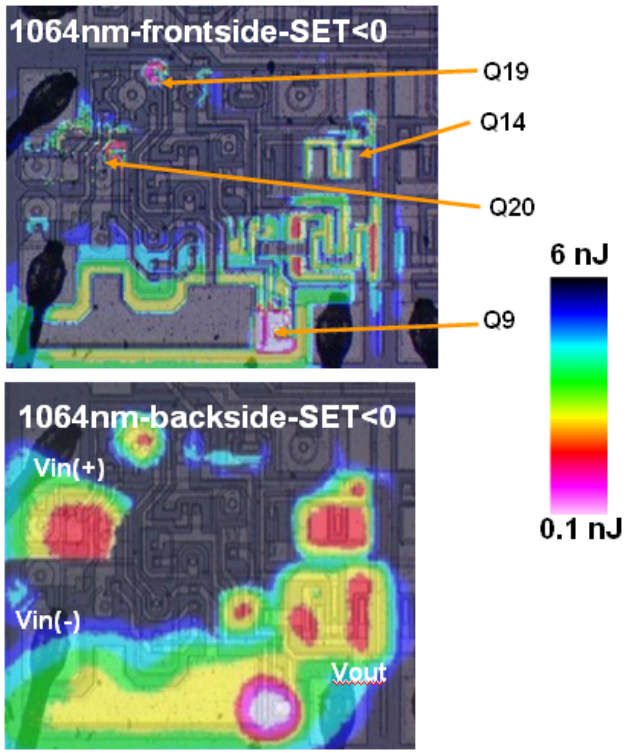


Determination of SET sensitive volume using laser probing

- This study has been done by EADS/IWG under CNES R&D contract and presented at 2007 QCA/CNES FPday by C. Weulersse. See also RADECS 2007.
- Objective: To explore the ability of laser irradiations to determine the SET sensitive depths of a linear device by using several wavelengths.
- Tests were performed on LM124 from NSC irradiated frontside or backside.

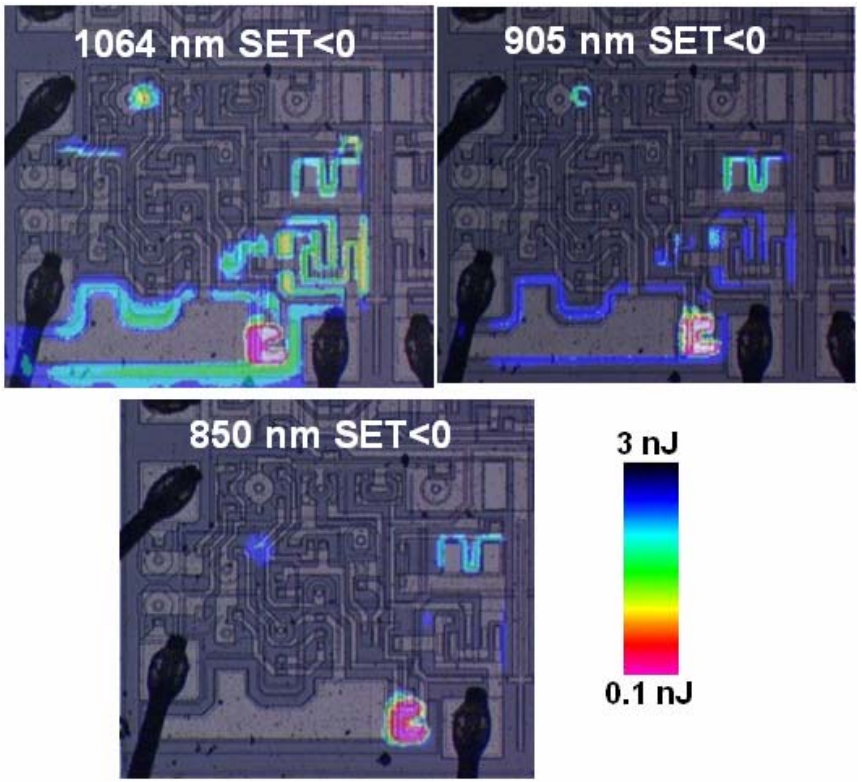


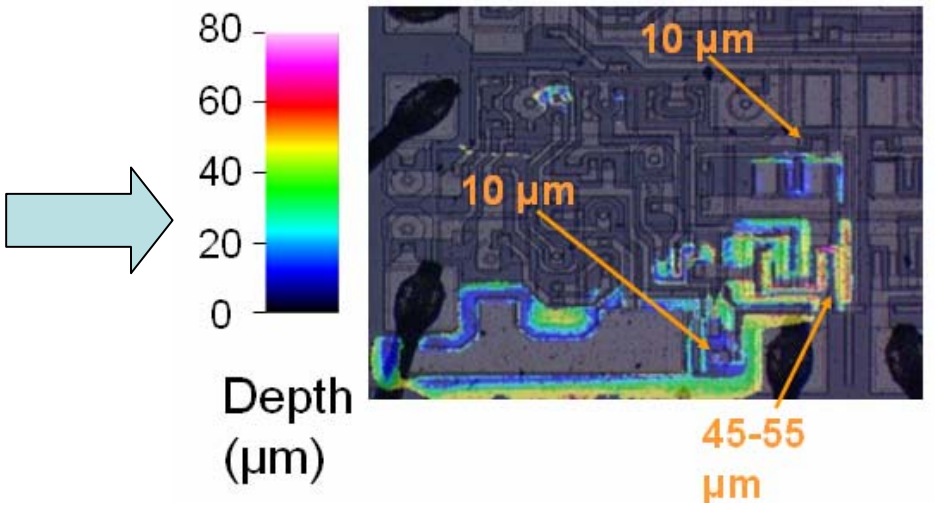
EADS/IWG test bench



Result1: Various sensitive volumes in the device

- Using various wavelength, frontside, backside irradiation and defocusing, EADS/IWG has demonstrated that various SV are involved in the SET sensitivity of LM124.
- These SV are located from 10 to 100µm from the die surface.



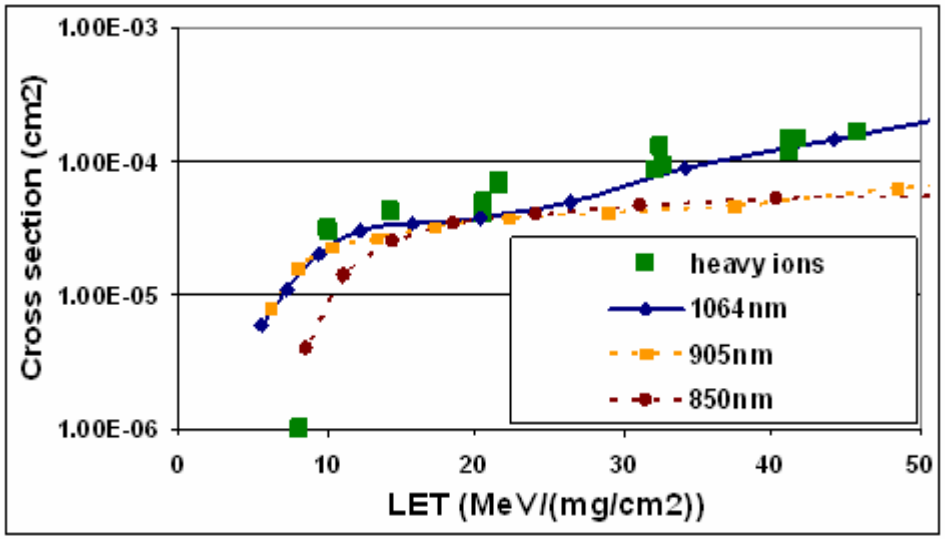


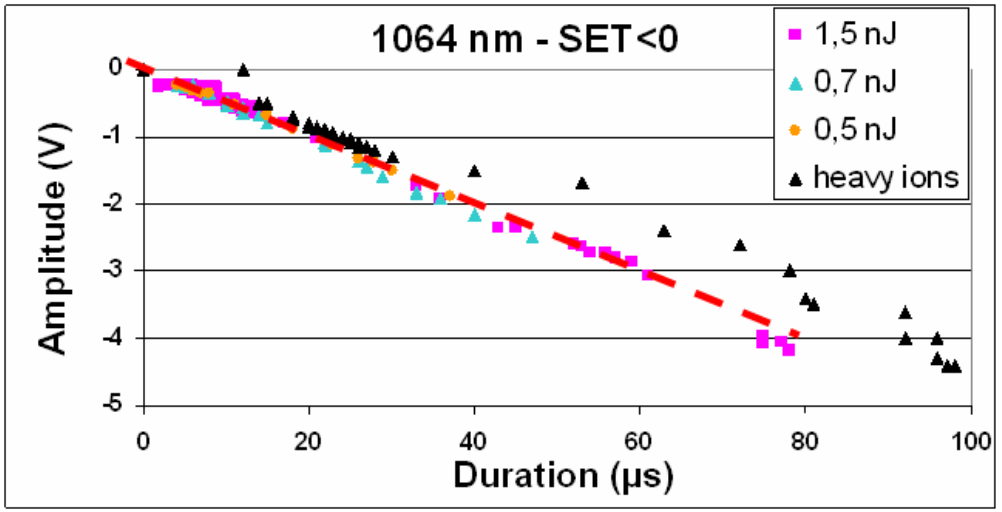
These results confirm previous ones (Mc. Morrow)

. Negative transient threshold mappings at the three wavelengths

Result 2: Comparison with heavy ions results

- Laser facility is very often presented as an alternative solution to heavy ions testing.





Laser gives good idea of amplitude /duration but cross section curves need to be normalized with heavy ions data.

Range of ions and probing of the sensitive volume

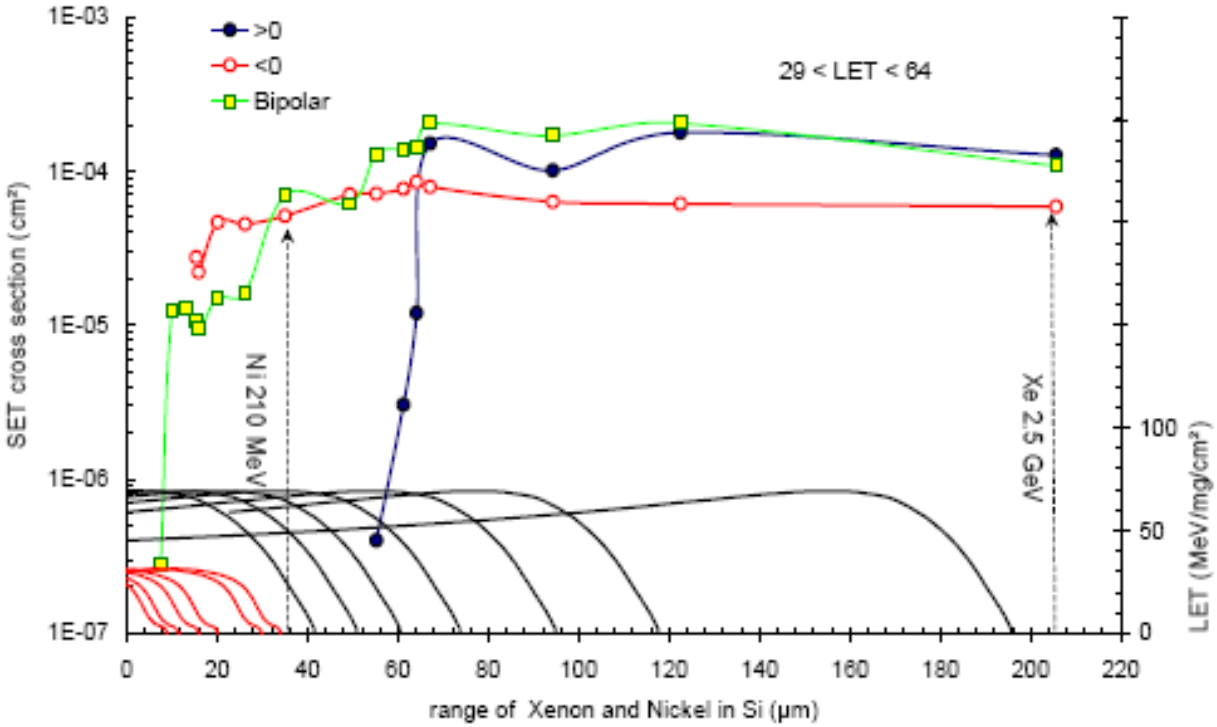
- This study has been done by ONERA/DESP under CNES R&D contract and presented yesterday at 2009 QCA/CNES FPday by T. Nuns. See also NSREC2008.

- Objective: Use various limited range heavy ions (IPN, GANIL) in order to estimate the SET depth location of sensitive structures and provide experimental insight into the SET test recommendations and prediction rate methodology.

- Tests were performed on LM124 from NSC and TI.

Result 1: Confirmation of SV locations

- Good correlation with laser results



IPN Nickel + GANIL Xenon

Result 2: recommendations for predictions.

- In order to predict SET error rates, it is necessary to have a better idea of the sensitive volume location and thickness. By this way, the deposited charge is better estimated and the predictions more realistic.

- Laser may be a tool for this SV determination.

- Heavy ion test have to cover the whole SV thicknesses. In case of heavy ion limited range, some SET populations may be widely underestimated (>0 SET in the case of LM124).

Use of TPA laser method for the SET SV probing

- This study is on-going with IMS Bordeaux under CNES R&D contract and was presented yesterday at 2009 QCA/CNES FPday by V. Pouget. See also NSREC2008.

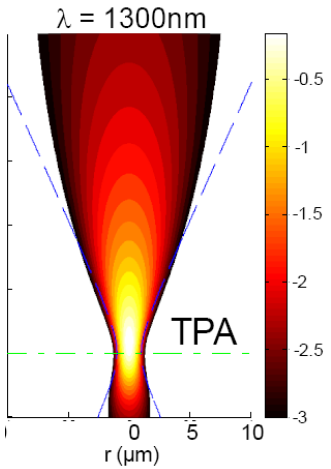
- Objective: Use the TPA laser method in order to perform a 3D determination of the SET SV.

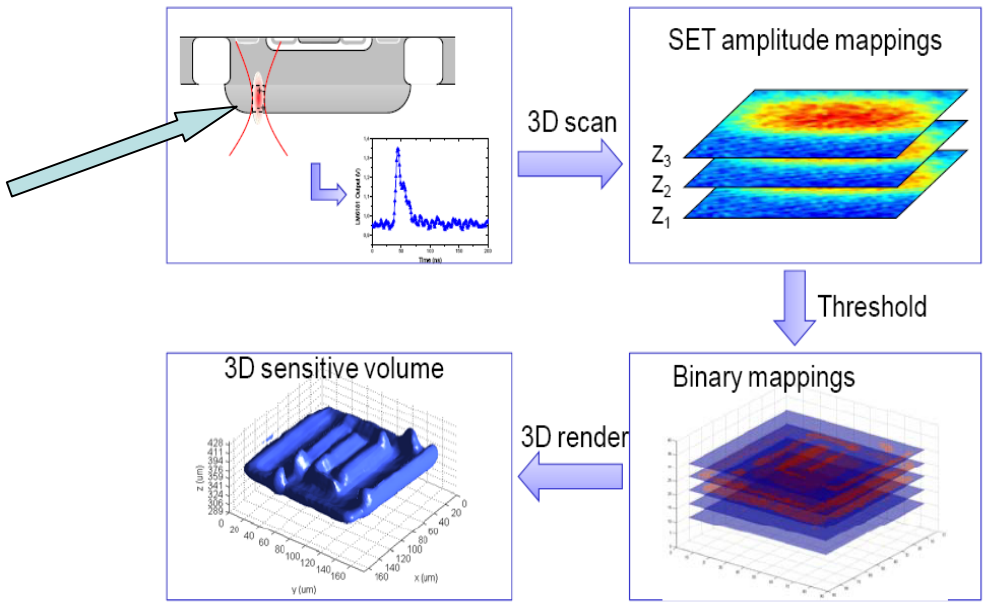
- DUT used for this study are:
  - AD9617 ADI and LM6181 NSC (already characterized)
  - LM124, OP470*, OP400*. (to be tested in S1/2009)

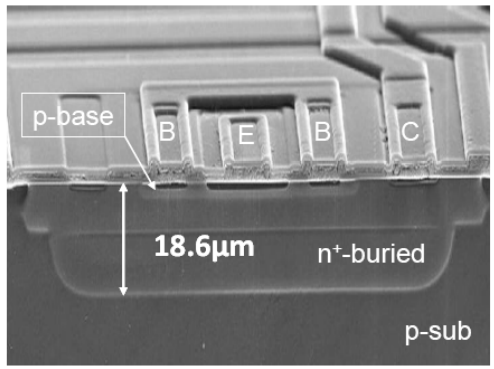
    * SET & SEDR are studied.

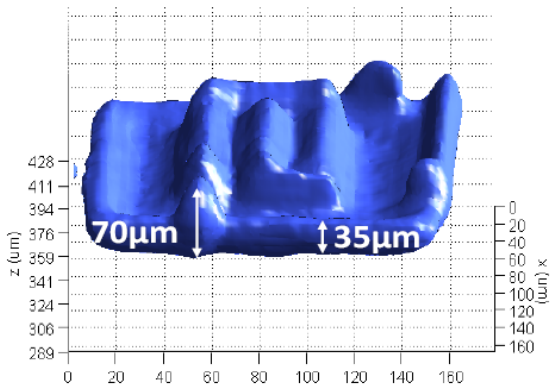
Use of TPA laser method for the SET SV probing

Ex: TPA laser probing of the SET SV corresponding to Q2 transistor in the LM6181







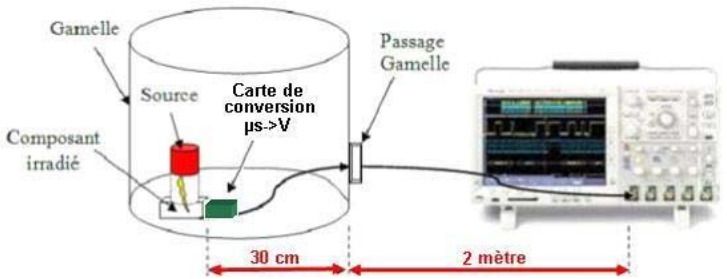


Very promising technique.

Study of the impact of test system on the SET amplitude/duration.

- This internal study has been done by a student (Nicolas REVOL) using LM124 from NSC and TI.

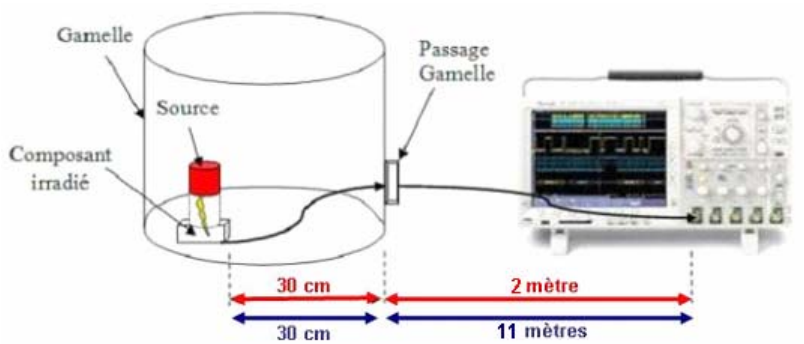
- Objective: Use a Cf252 source in order to verify if cable length has in impact on the SET measurement.

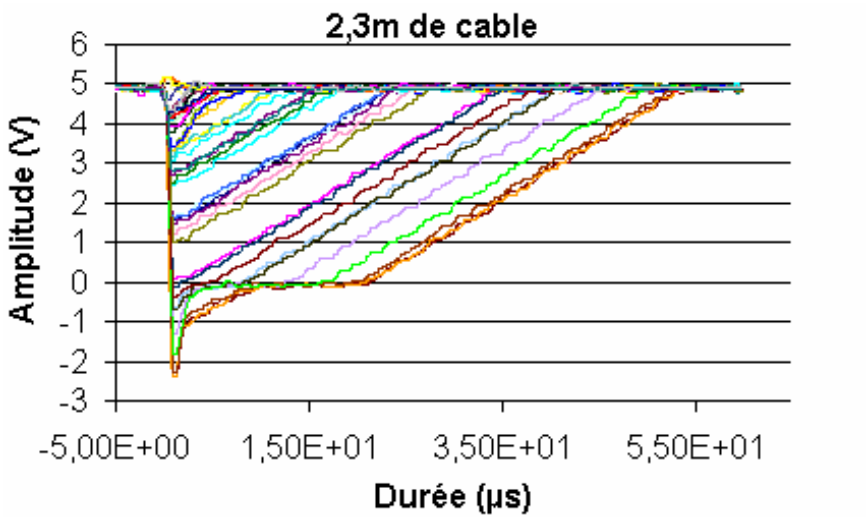


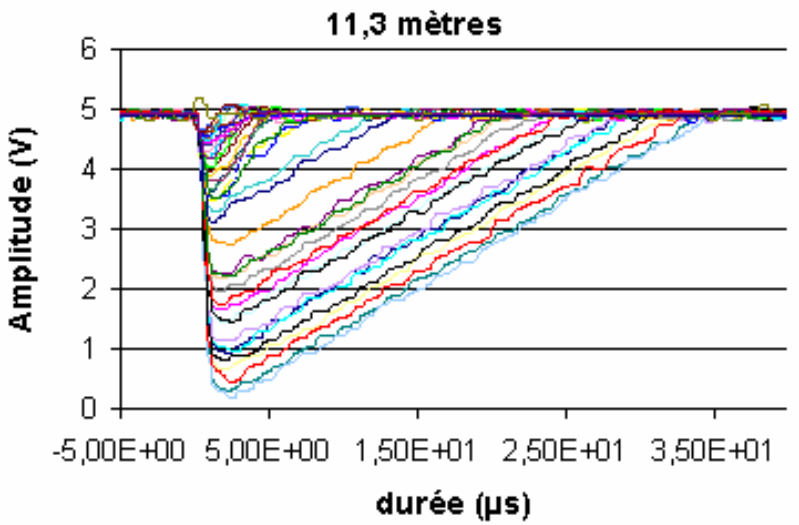
- An alternative measurement method has been proposed : Conversion of the useful information (duration of the SET) in voltage by integration at the output of the DUT.

=> It has shown that after 2 to 3 m of BNC cables, the SET length is not modified.

Study of the impact of test system on the SET amplitude/duration.







Conclusion & perspectives

A lot of work but … it's not the end!

CNES and THALES ALENIA SPACE are also accompanying work performed at IES, University Montpellier II under DGA contract. This study focuses on the understanding at circuit level of SET amplitude/range profile and evolution with cumulated dose.

Many thanks to all previously mentioned teams (*TRAD, EADS/IWG, ONERA DESP, IMS and IES).*