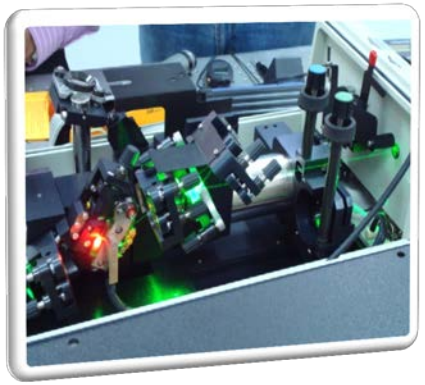
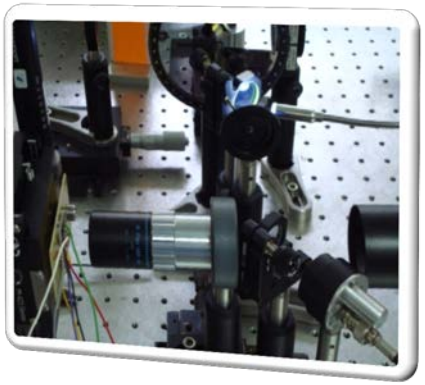
amicsa
26-28 August 2012
European Space Agency

A New Laser Source for SEE Testing



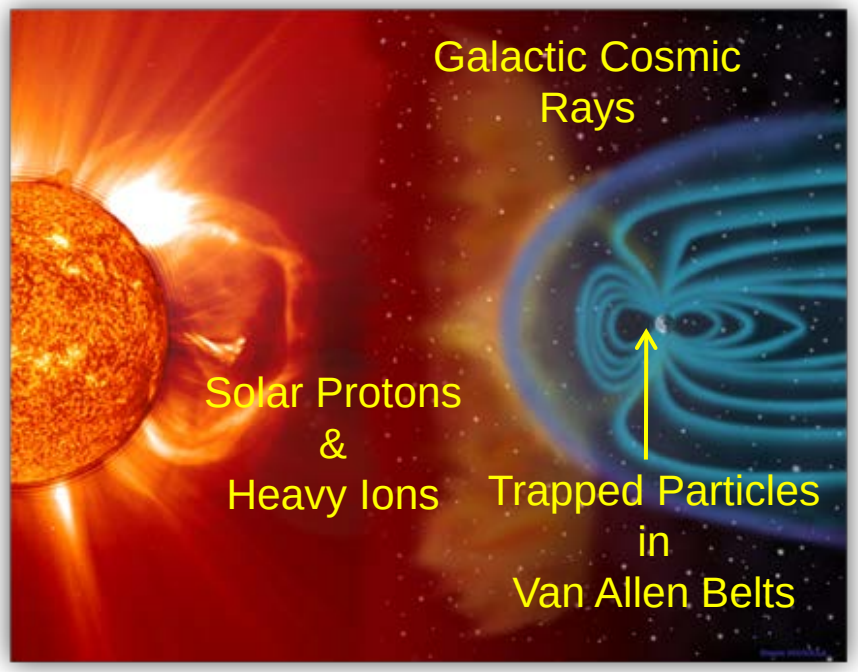



Presented by Isabel López-Calle
ESA/ ESTEC/ TEC-QEC Section & Complutense University of Madrid

ESA/ESTEC, Noordwijk, The Netherlands

➢ Challenge

Selection of space components capable of withstanding the harsh radiation environment for which they operate in



➢ Issues

Development of radiation hard components and evaluation of EEE components suitable for flight on spacecraft.

➢ Solution

LASER SYSTEM FOR Simulation of SPACE ENVIRONMENT as a complementary tool for EEE component SEE characterization/screening

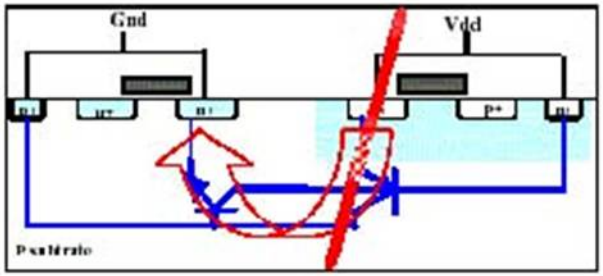
Radiation Effects or Induced Damage on Materials

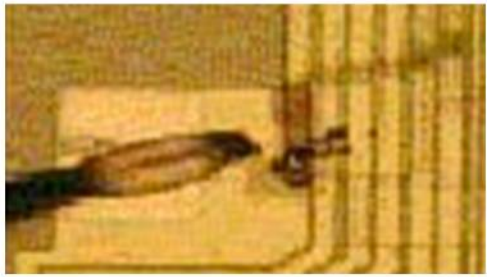
Electrical Properties	Ionizing Radiation	Non Ionizing Radiation
Metal	Immune from the point of view of their electrical properties.	Immune from the point of view of their electrical properties.
Semiconductor	Generation of electron/hole pairs: Transient currents inside a device.	Creation of energy states in the band-gap, resulting in the alteration of electrical parameters.
Insulator	Charge trapping and insulator break-down.	Immune from the point of view of their electrical properties. except opto-electronics

By LASER SOURCE

SEE RADIATIONS EFFECTS ON Devices

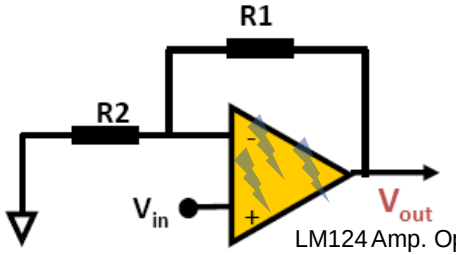
HARD ERROR → COMPLETE DEVICE DESTRUCTION

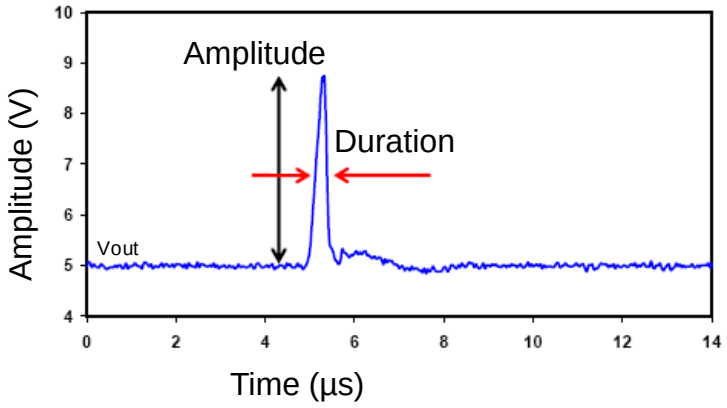




SOFT ERROR

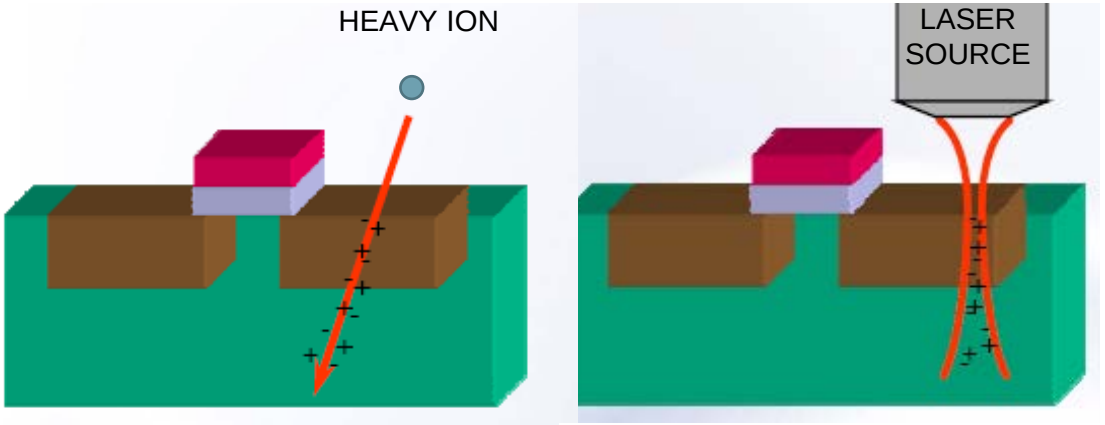
By LASER SOURCE





The laser pulse, as for an ionising particle, generates charge along a track in the semiconductor. However, the shape of charge distribution is understood to be different.

Althought the shape of the charge distribution is different, the laser pulse parameters may be tune such that the Single Event Effects observed are the same.

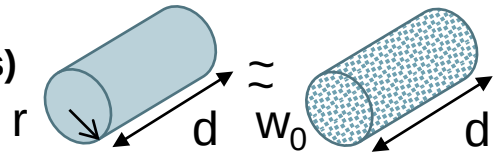


- Ionizing Particle (Energy, Mass)
- Coulombian Interaction

- Laser Pulse (spot, duration, energy, wavelength)
- Electromagnetic Interaction

Ion Induced Charge Distribution simulated by a laser pulse

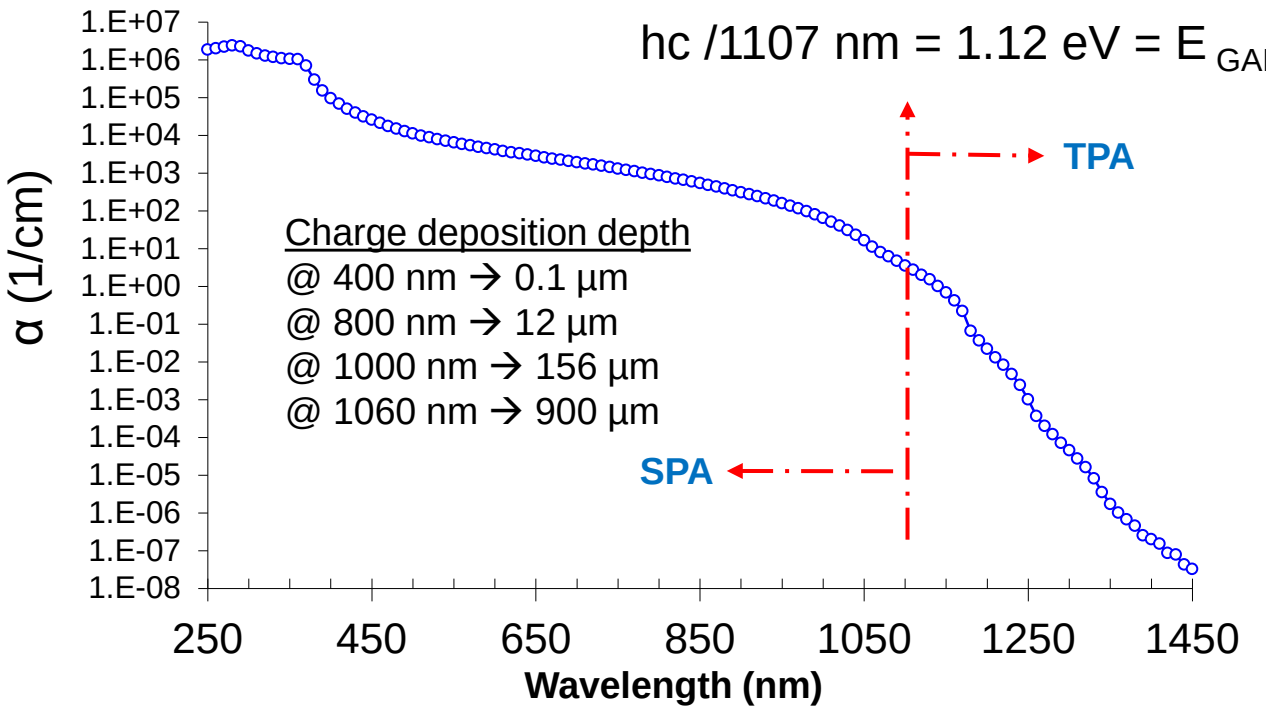
ION (Energy, Mass)



LASER (Pulse Energy, Spot Size)

Absorption Coefficient of **Silicon**

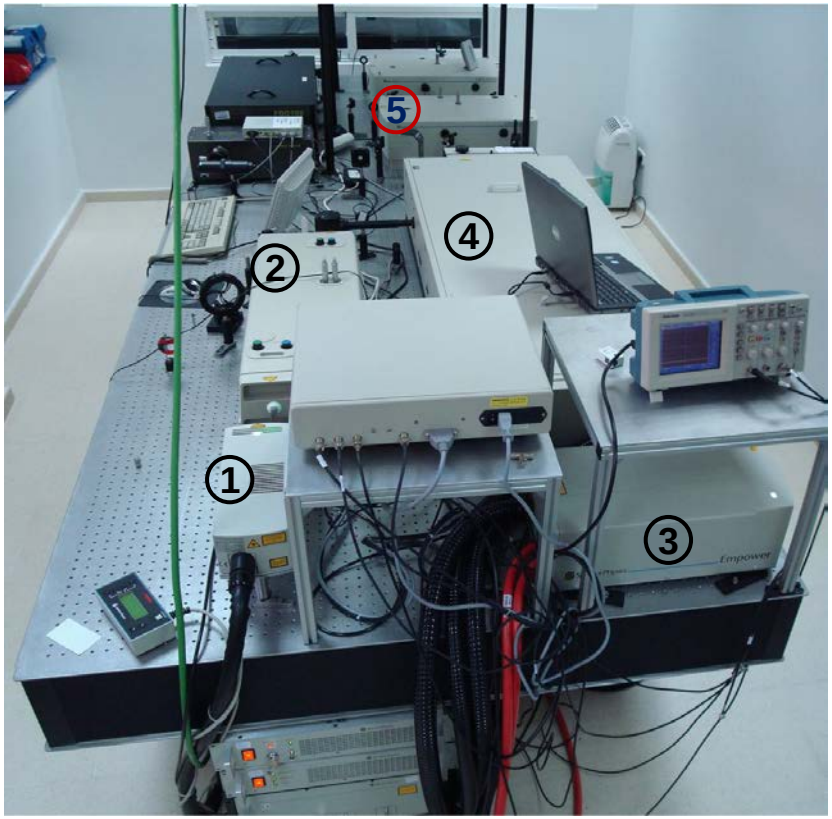
Green, M.A. and Keevers, M. "Optical properties of intrinsic silicon at 300 K ", Progress in Photovoltaics, p.189-92, vol.3, no.3; (1995)



Wavelenght	Adventages	Disadventages
SPA (Single Photon Absorption)	Linear photo-absorption (Very well characterized by the absorption coefficient α)	Charge deposition close to the irradiation surface (depends on the wavelenght)
TPA (Two Photon Absorption)	Charge deposition at any depth in the device	Non-Linear absorption (not well characterized but experimentally proven)

Work developed since 2008 …

Femtosecond LASER Pulse



1) Femtosecond Oscilator "Tsunami"
Ti:Zafiro 430 mW, 800 nm, 80 MHz, 50 fs/pulso

2) Pumped LASER "Millenia"
Nd:Vanadato
5W, 532 nm

3) Pumped LASER "Empower" Nd:YLF
20 mJ/pulso, 527nm, 1 KHz

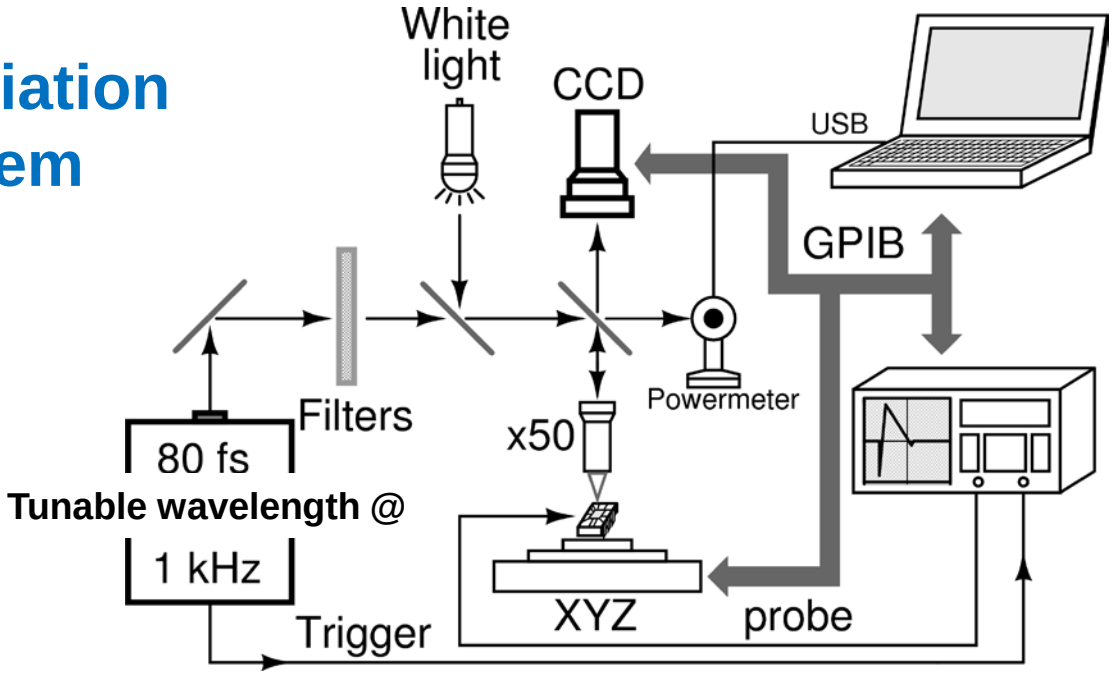
4)Regenerative Amplifier "Spitfire"
Ti:Zafiro 3.6 mJ/pulso, 800 nm, 1 KHz, 35 fs/pulso

5) Optical Parametric Amplifier "OPA". Tunable Wavelength from UV (300 nm) to IR (3 μm)

Irradiation System

Data Acquisition Module - Capture Data Synchronization - Printed Circuit Boards - Device Microphotograph - Device Characterization - Data Analysis - One shot System

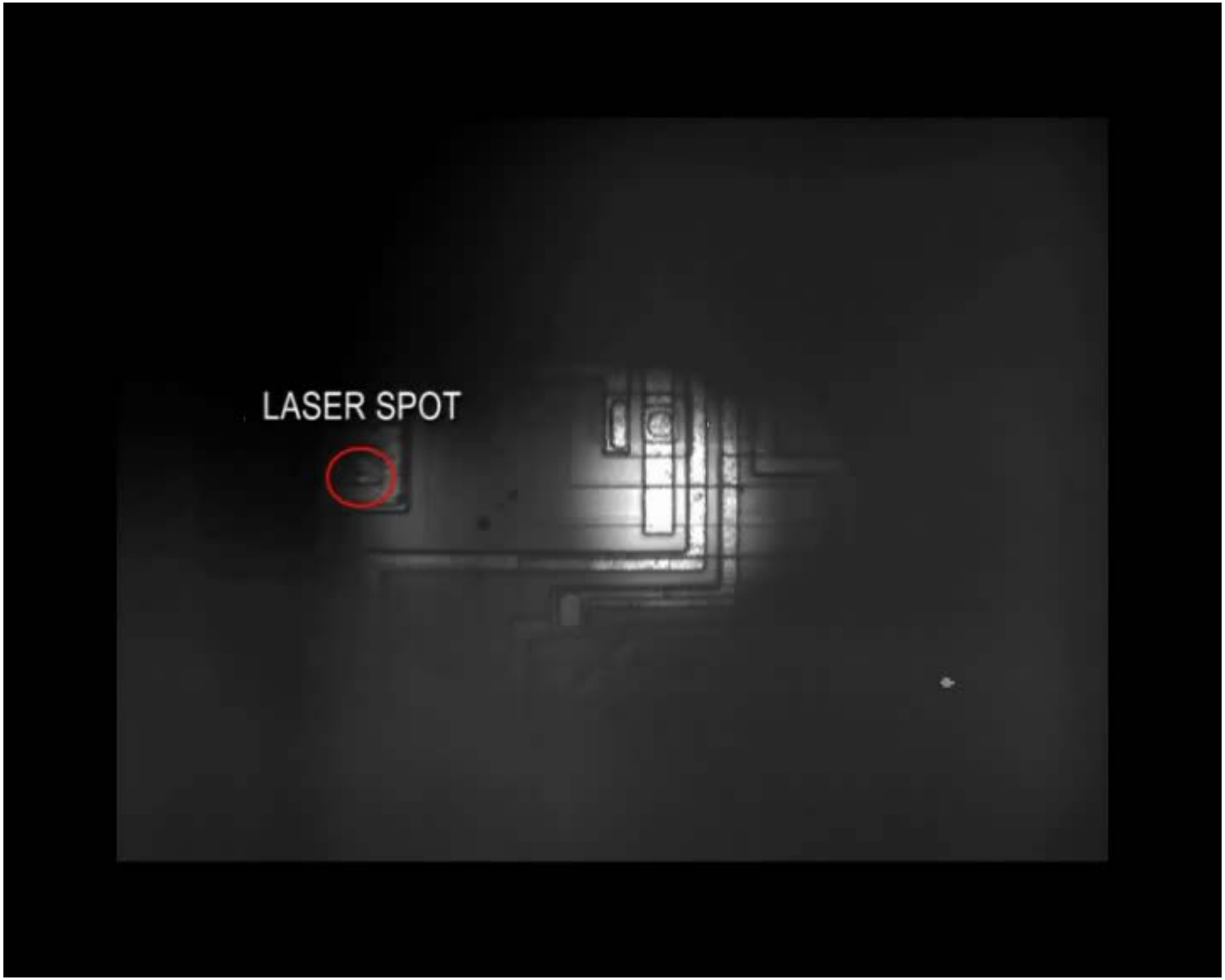
Irradiation System



Scan over entire integrated circuit or selected areas.

LabView to control all the system by means of the GPIB protocol.

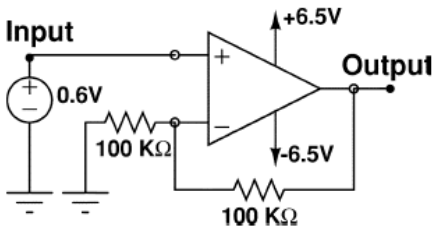
Irradiation System



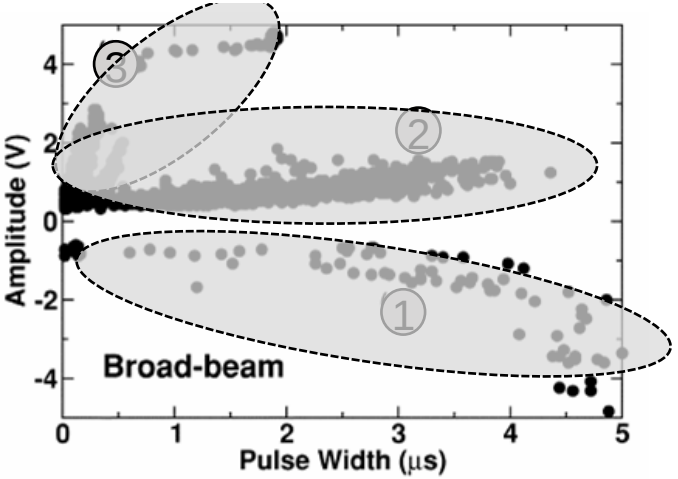
Comparison between heavy ion irradiation (a) and laser irradiation at UCM (b) over LM124.

a) Heavy ions irradiations

LM124 (CP) - Voltage follower



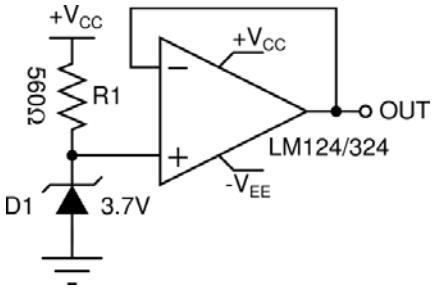
LM124 ion cocktail: Br, Mg, Cl



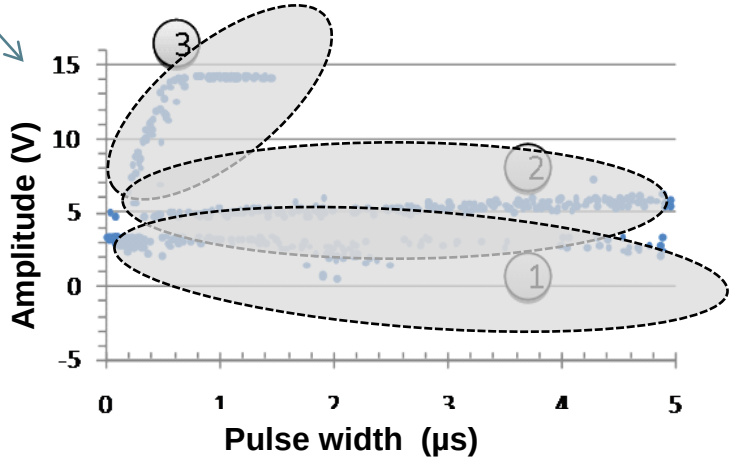
Y. Boulghassoul. et al. IEEE Trans. Nucl. Sci. vol. 49. pp. 3090-2096. Dec 2002

b) LASER at UCM shows similar results

LM324 (PP) – Voltage follower



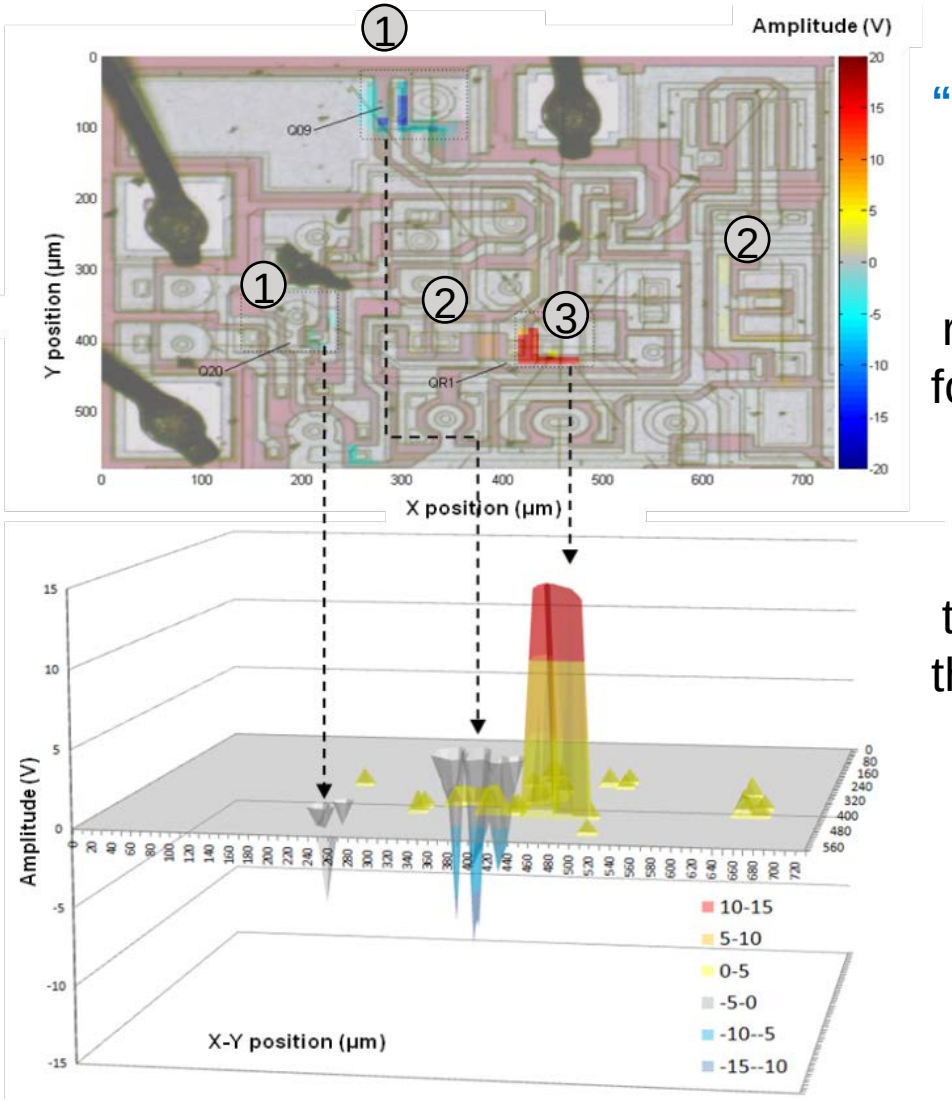
TPA Laser Irradiation



Example of 2D (a) and 3D (b) sensitive map after a complete LASER scan over LM124

a)

b)



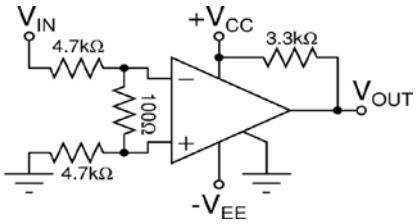
"Hot Spots" have been detected

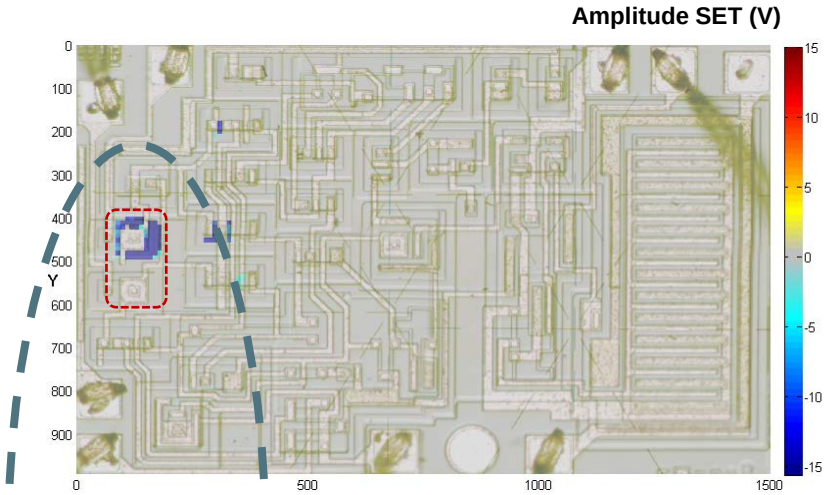
New representations for analysing the data.

This is one of the strengths of the laser testing.

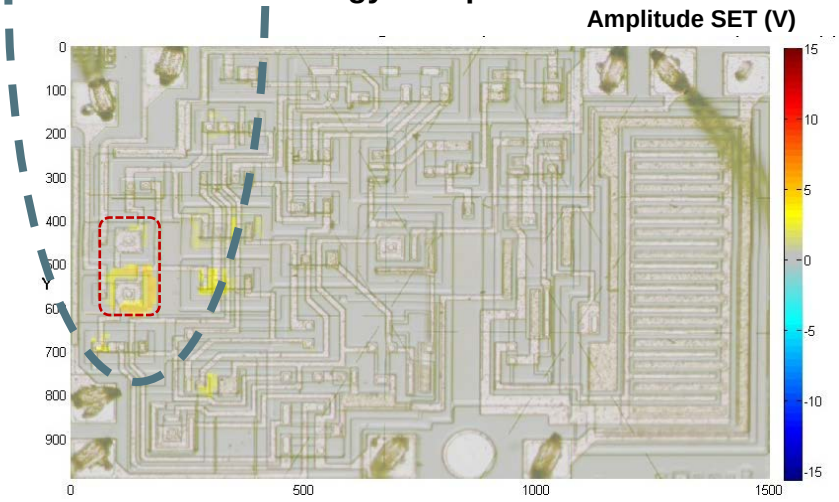
The most sensitive transistor changes as a function of the input stage

LM111 – Voltage comparator
SEE laser test @ 800 nm

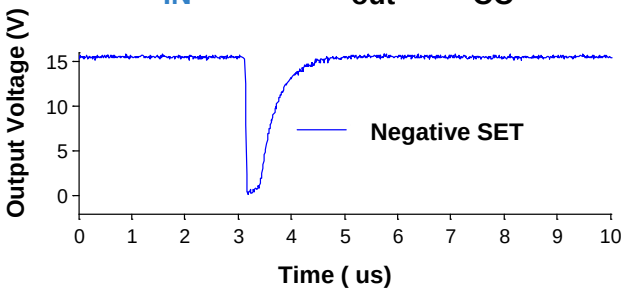




Same Pulse Energy = 40 pJ

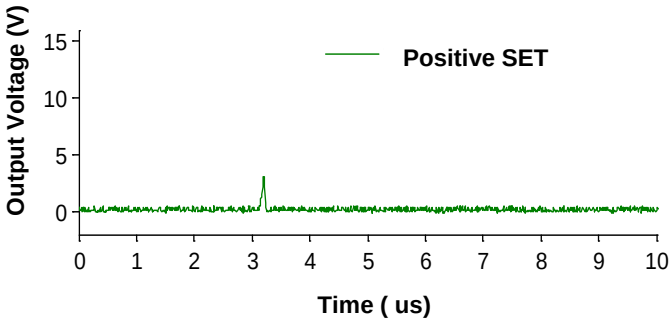


$V_{IN} < 0 \rightarrow V_{out} = V_{CC}$



Q1 is the most sensitive area

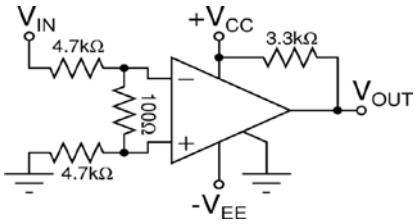
$V_{IN} > 0 \rightarrow V_{out} = V_{EE}$



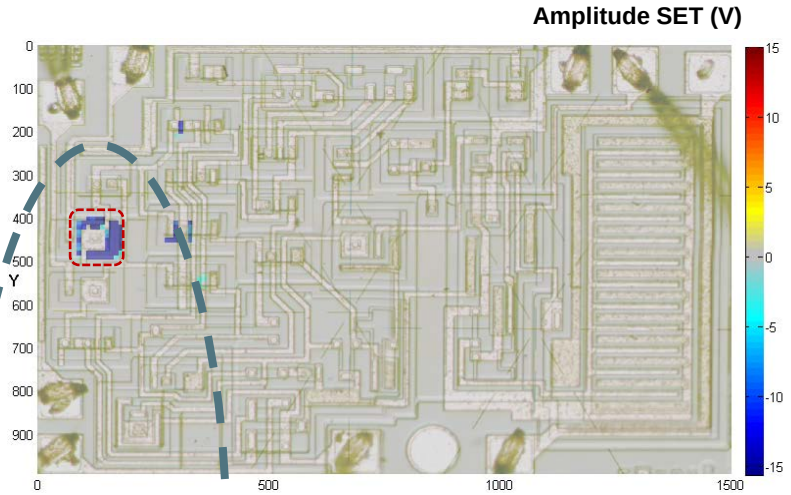
Q2 is the most sensitive area

The most sensitive transistor changes as a function of the input stage

LM111 – Voltage comparator
SEE laser test @ 800 nm

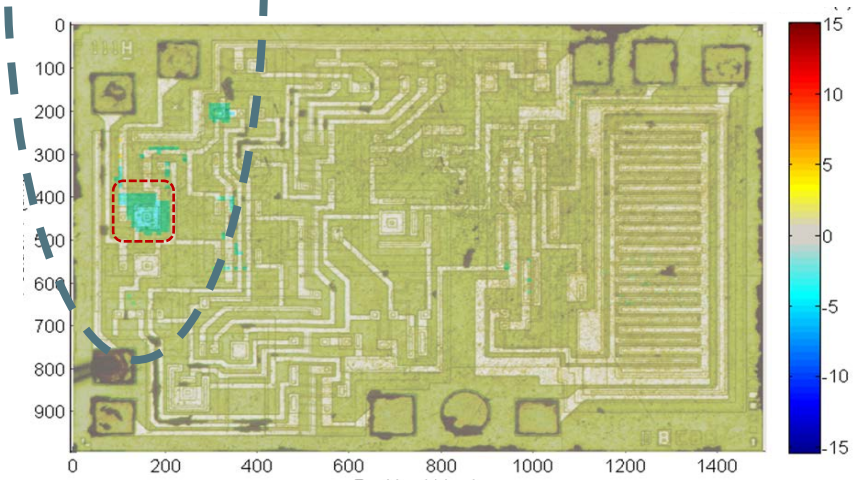


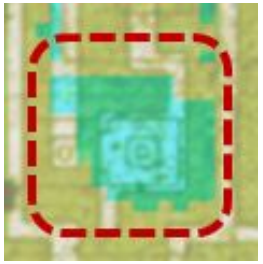
Same configuration



SPA @ 800 nm fron-side irradiation

TPA @ 1300 nm & backside irradiation

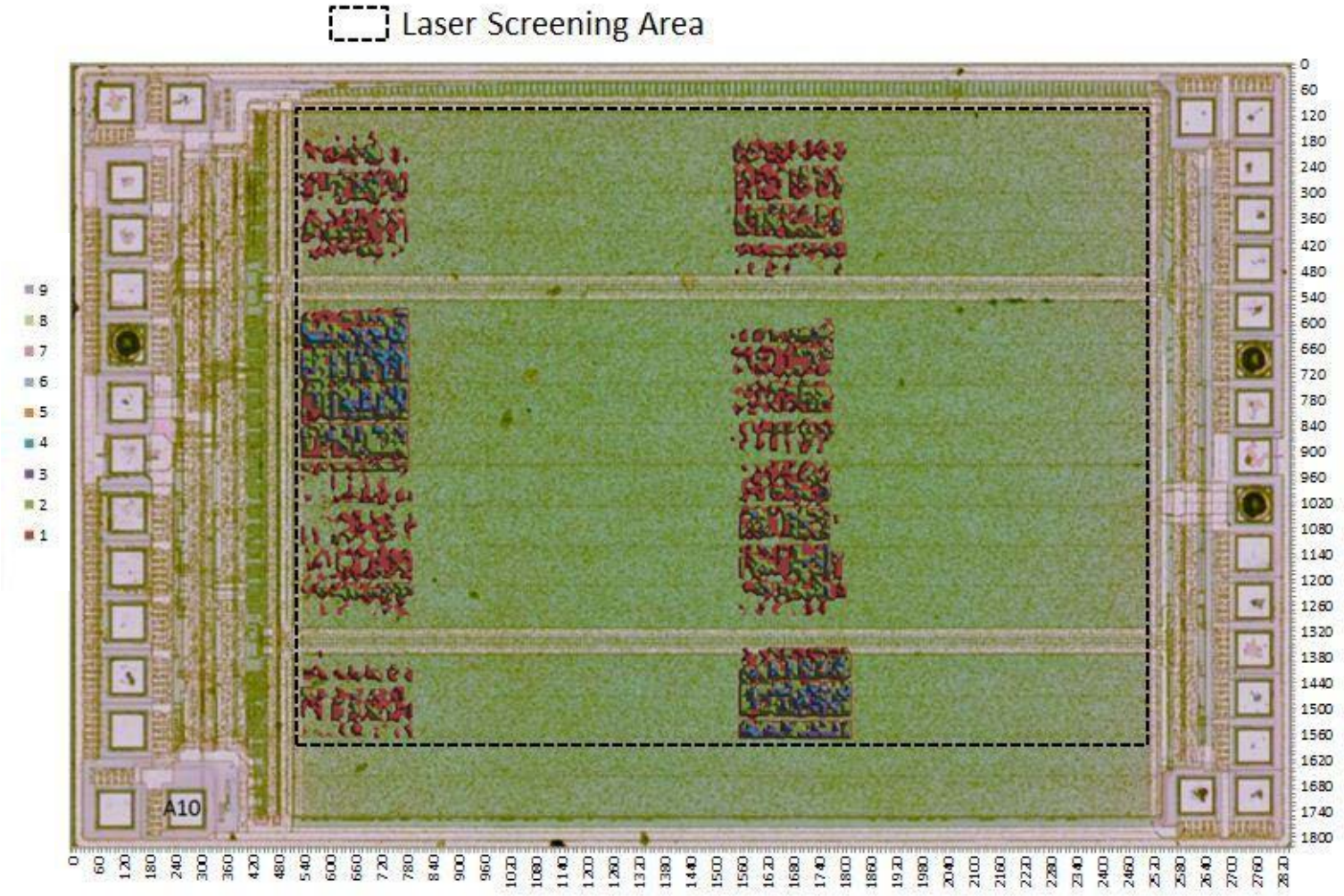




TPA @ 1300 nm back-side irradiation

The metal layer has been avoided with TPA backside irradiation

COTS SRAM screening map.
Sensitive memory cell blocks have been detected



“Hot Spots” have been detected

Alliance LOW POWER CMOS SRAM 64 Kbytes

The laser irradiation becomes a <u>complementary</u> and <u>useful</u> tool to evaluate the radiation tolerance of the electronic devices

- Complementary tool: For the core SEE irradiation testing, today, the laser test system can not replace the heavy facility.
- Reduce cost of screening activities: When the comparison between HI and Laser is available because of prior tests. Lasers may be used for additional SEE testing.
- Detecting 'hot spots': Lasers are excellent tools to identify sensitive nodes in components and subsequently improve radiation hardness in rad. hard EEE component development work.

Some publications related with SEE Laser testing at UCM-Spain

- Peak Detector Effect in Low-Dropout Regulators – RADECS 2012
- Laser Tests on a Power Operational Amplifier – RADECS 2011
- Modification of the LM124 Single Event Transients by Load Resistors – TNS 2010
- Influence of the Bias Conditions on the Single Event Transients of the LM311 Voltage Comparator – RADECS 2010
- Two-Photon Absorption (TPA) Backside Pulsed Laser Tests in the LM324 – RADECS 2009

Where are we?

www.ucm.es/info/electron/sensor/en_welcome.htm

ELECTRONIC INSTRUMENTATION AND SENSORS GROUP

Department of Applied Physics III (Electricity and Electronics)
University Complutense of Madrid

Access

- **Underground:** "Ciudad Universitaria" station (Line 6).
- **Buses:** 82, F, G, U.
- **Car:** Parking is allowed in the surroundings.

Address

- Faculty of Physics
  3rd floor
  East wing.
  Av. Complutense, 26
  28040 MADRID

See the whole Moncloa Campus (Zone 9)

isabelcalle@fis.ucm.es / agapito@fis.ucm.es / fjfranco@fis.ucm.es

THANKS FOR YOUR ATTENTION

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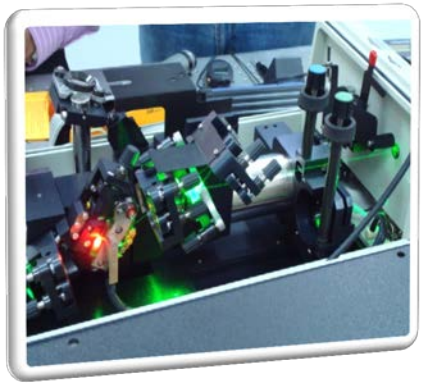

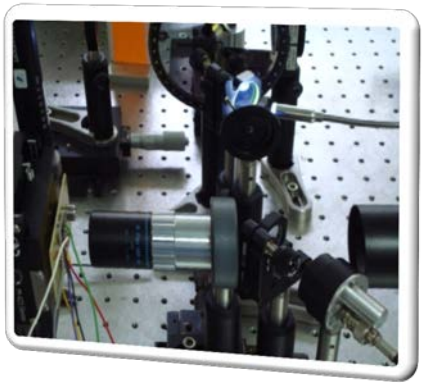


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