iROC TECH

Laser Study of SETs in 65nm Bulk Technology

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Outline

- Previous Work – 65nm Test Vehicle
- Test Facilities
  - CNES
  - NRL
- PWMT Experiments
- Elementary Transistors
- Conclusions

Acknowledgements

The work being presented would not have been possible without the help of :

Facilities
CNES : Kevin Sanchez, Guillaume Bascoul
NRL : Stephen Buchner, Jeff Warner

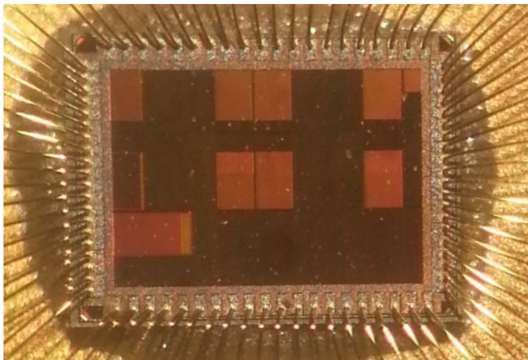
De-lidding and Parts Preparation
Cisco : Shi-Jie Wen, Rick Wong

ESA : Véronique Ferlet-Cavrois

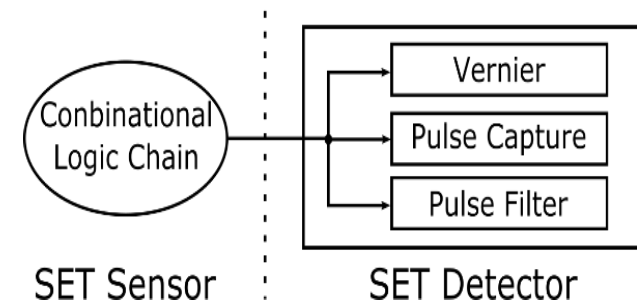
Previous Work – 65nm Test Vehicle

SET65 Activity

- Dedicated test-chip ($4mm^2$) in ST 65nm bulk technology
- Contains multiple experiments for characterizing SETs
  - Elementary transistors
  - Chains of gates, with on-chip measurement (PWMT)
  - Single Event Multiple Transient (SEMT)
  - Dynamic Applicative Measurements (DAMSEL)
- Tested under heavy-ions at RADEF(Jyväskylä)


Die Photo

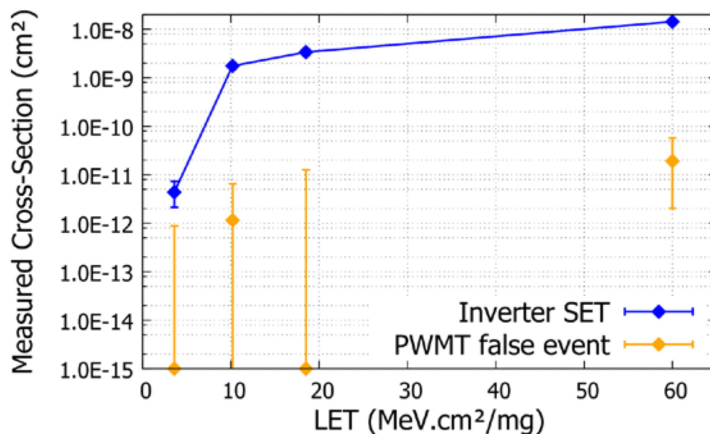
RADEF



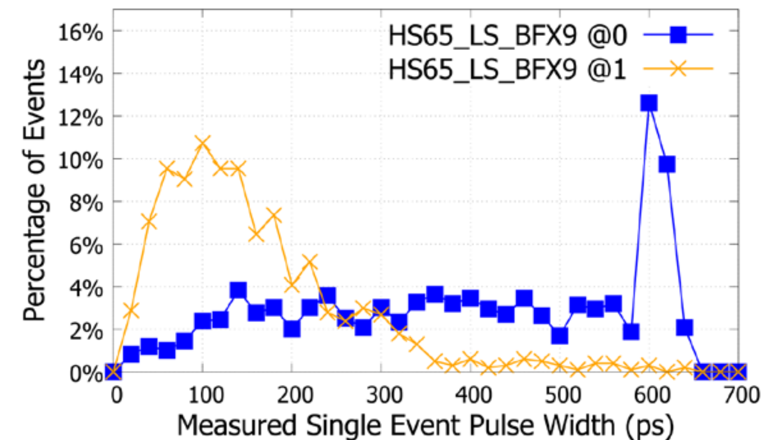
PWMT Experiments

Open Questions from HI Testing

- Heavy-ion tests provided extensive data
- But some questions remained:
  - For gates with broadening/narrowing, how many of the gates in the chain contribute?
  - Understand small (100x smaller) parasitic cross-section



Detector Parasitic Cross Section



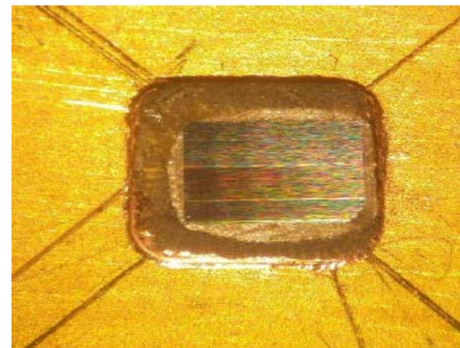
Measured Effect of Broadening

Laser Test Facilities

CNES – SPA Laser

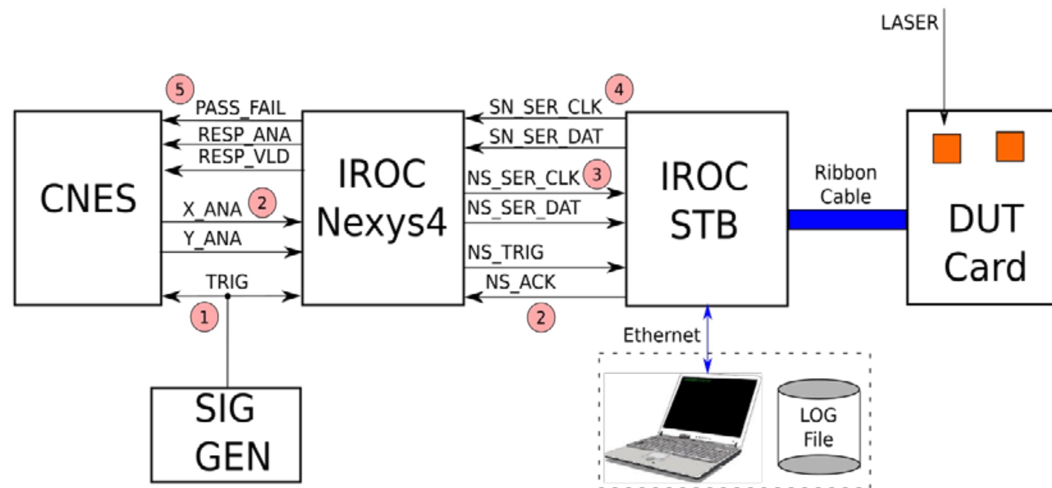
- CNES facility, Toulouse, France
- 80 MHz Meridan 2 system, wavelength=1064nm
- Pulse picker selects individual pulses
- Maximum energy per pulse ≈2.5 nJ
- Scanning is performed by mirrors
- 3 optical lenses
  - 2.5x (5.9 μm resolution, 3 mm x 3 mm scan area)
  - 20x (0.78 μm resolution, 400 μm x 400 μm scan area)
  - 50x (0.39 μm resolution, 200 μm x 200 μm scan area)

Laser Bench at CNES



De-Lidded Test-Chip

CNES – Handshaking



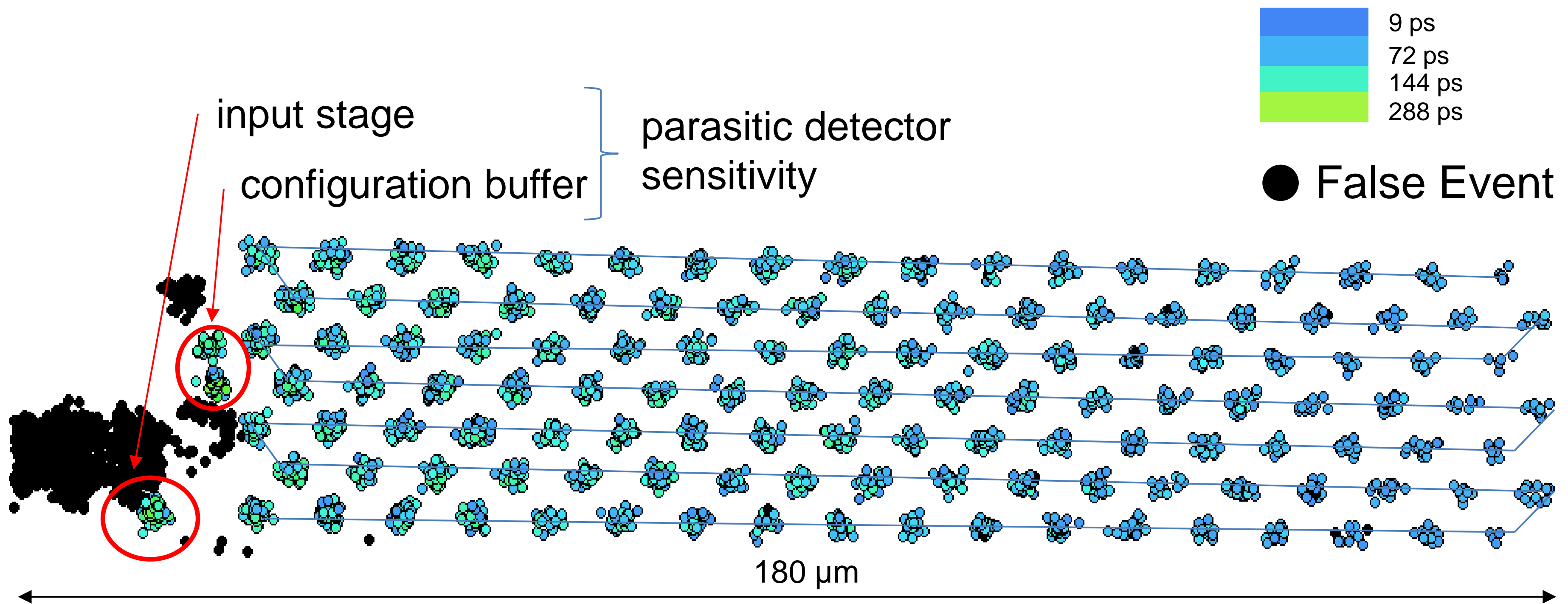
- Trigger provided by signal generator
- Position (X,Y) provided to user as analog voltages
- User provides
  - Digital PASS/FAIL indication
  - Optional : Analog PASS/FAIL Indication

Comparing Laser Facilities

	CNES (SPA)	NRL (TPA)
Wavelength	1064 nm	590 nm
Scanning	Mirrors	XYZ Stage
Fire Rate	Variable < 40 MHz	Fixed – 1 KHz
Optical Image	Directly with laser	Separate camera
Control	Signal Generators	PC with MatLab
User Interface	Analog/Digital signals	RS-232

PWMT

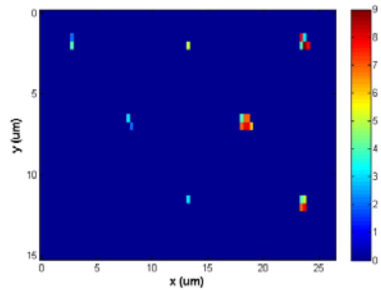
IVX Chain Scan (CNES)



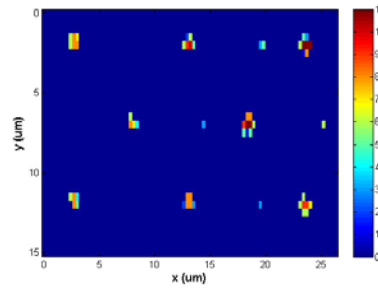
Scan of IVX9 chain with 70% energy at CNES – 20x lens

- Pulse width remains consistent along the chain
- Individual gates can be clearly identified
- Measurement circuit differentiated from gate chains (black areas)
- Small parasitic cross-section identified (shown in red)

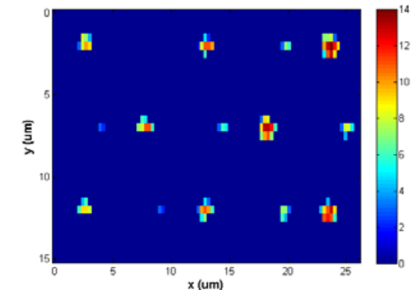
IVX Chain Scan (NRL)



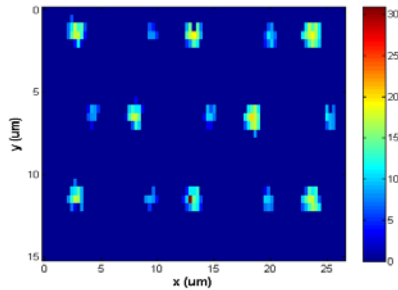
95.3 pJ



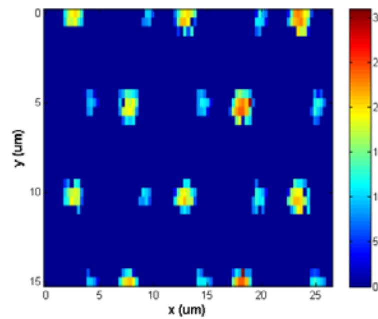
113.5 pJ



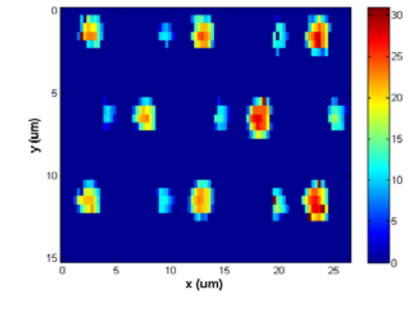
140 pJ



181 pJ



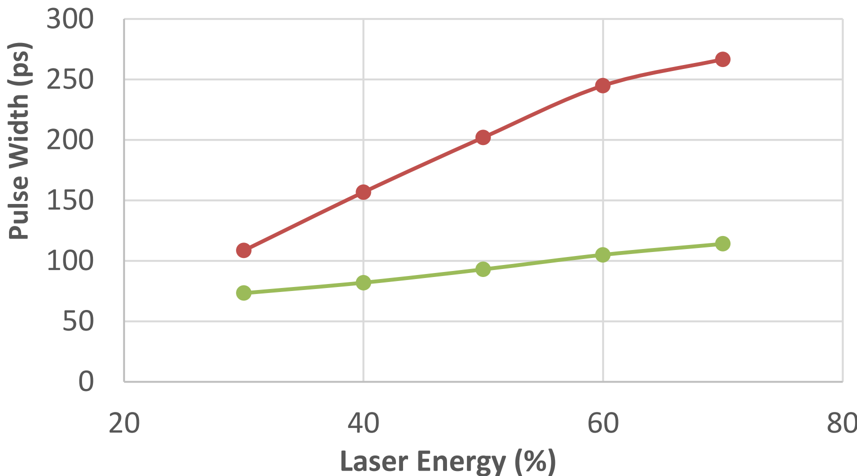
227 pJ



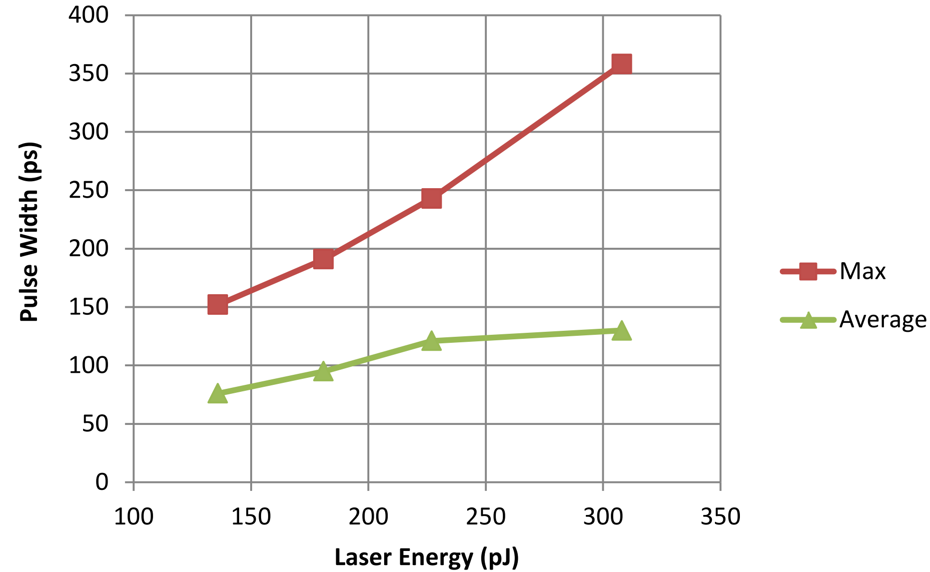
272 pJ

- x-range = 26.4 μm, xstep = 0.3 μm
- y-range = 15.0 μm, ystep=0.5 μm
- note – chains run vertically in these scans

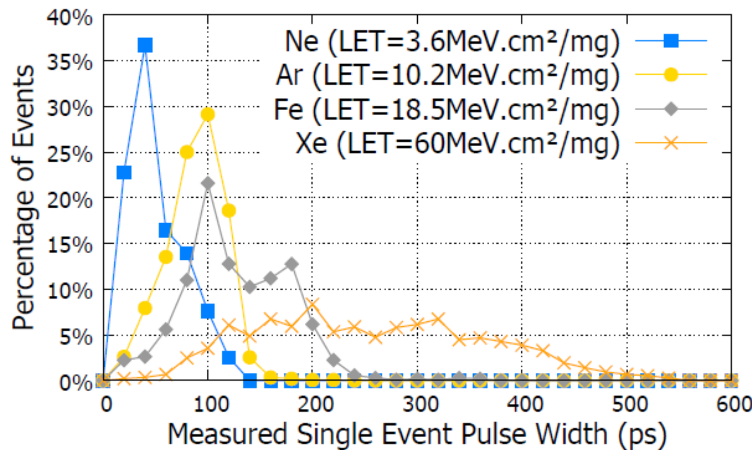
Inverter Pulse Widths



CNES : PW versus Energy



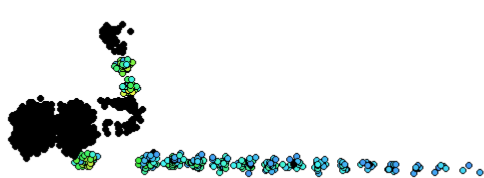
NRL : PW versus Energy



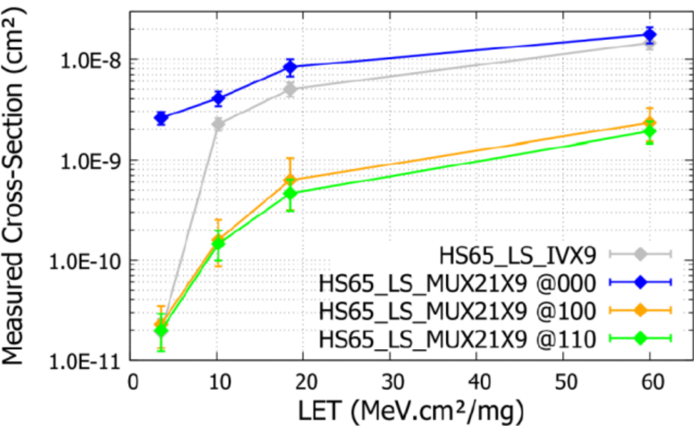
Heavy Ion Pulse Widths

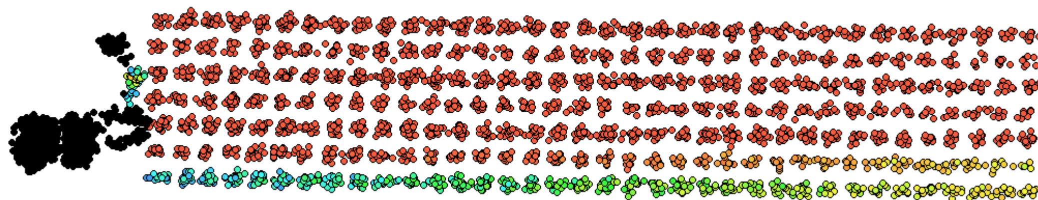
- AVG/MAX pulse widths similar trend
- Lasers PW are comparable to HIs
- Provides correlation between laser and HI

MUX2 Broadening/Narrowing



Narrowing Configuration (100)





Broadening Configuration (000)

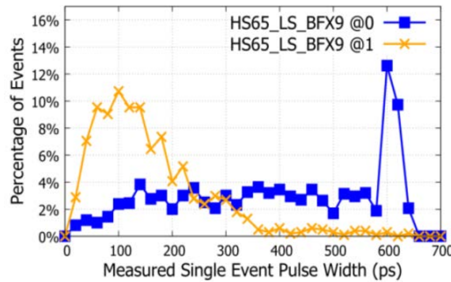
Scan of MX2 gate chain
CNES laser, 20x Lens

Legend

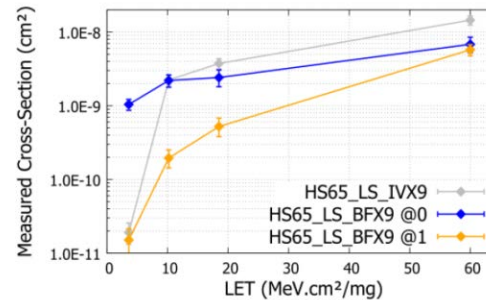
- Event produced in measurement circuit
- Maximum Width SET (≈600ps)
- Minimum Width SET (≈15ps)

- In broad-beam, significant difference in CS observed depending on state
- Broadening/narrowing clearly visible in laser scans
- Majority of detector is shown to be “insensitive” ; small sensitive area

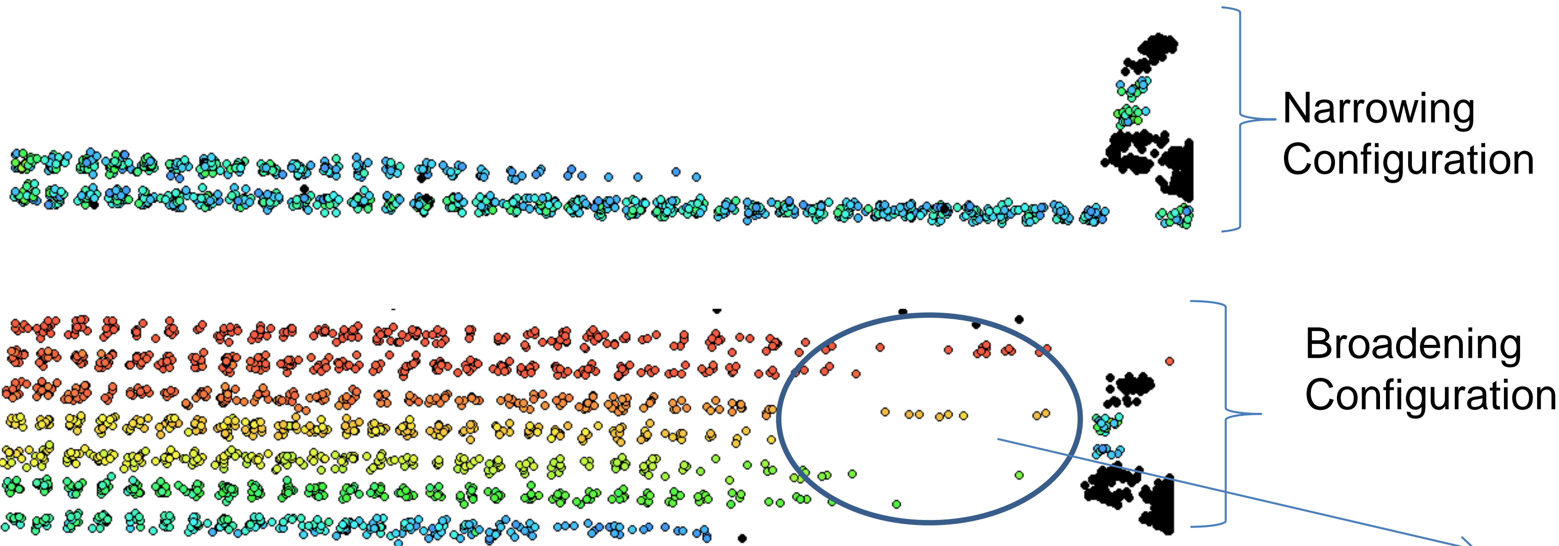
BF2 Broadening/Narrowing



HI PW Distribution



HI Cross Section

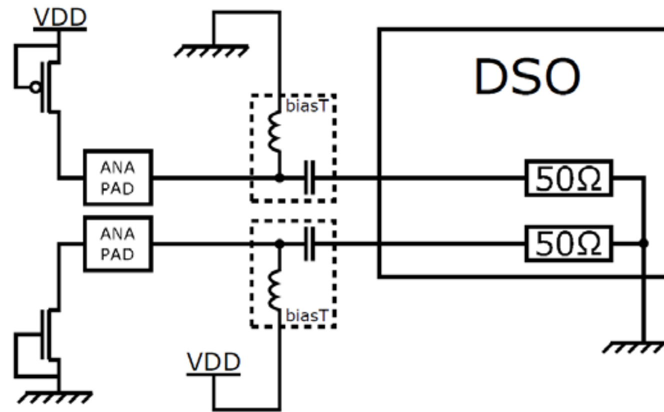


Apparent loss of focus in this region

- Broadening / narrowing can be seen in laser scans
- Peak in HI pulse width distribution due to broadening

Elementary Transistors

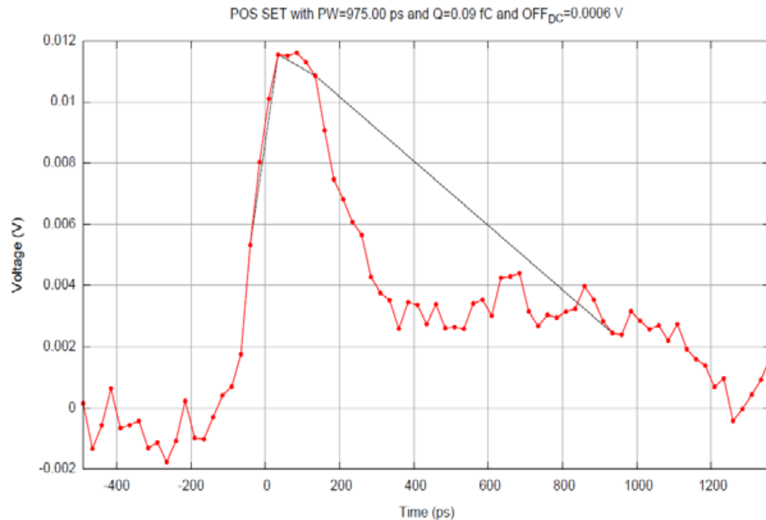
Elementary Transistors



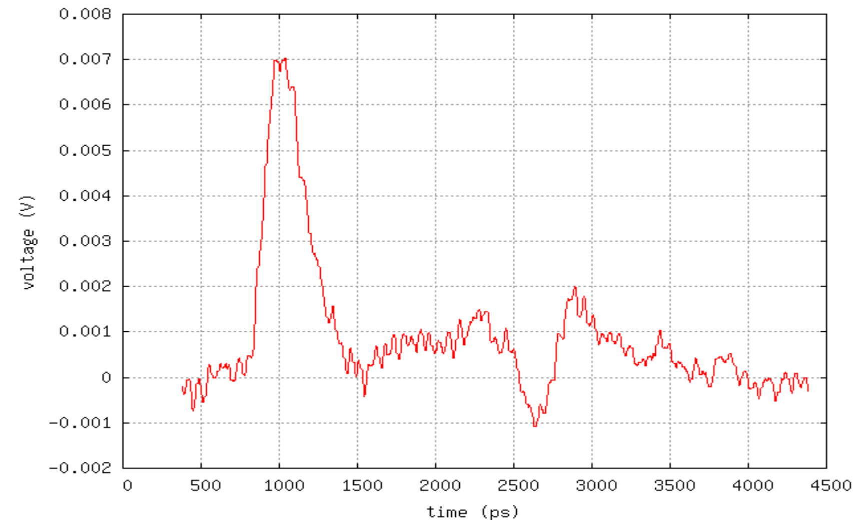
- 4 types of elementary transistors placed in small arrays
  - NMOSX9, NMOSX27, PMOSX9, PMOSX27

- NRL facility has support for advanced scope triggering
  - Scope is triggered by laser
  - Waveform acquisition is automated
  - Waveform processing (averaging, peak, etc) automatic

Individual SET Captures



CNES : PMOS X27, 70% energy

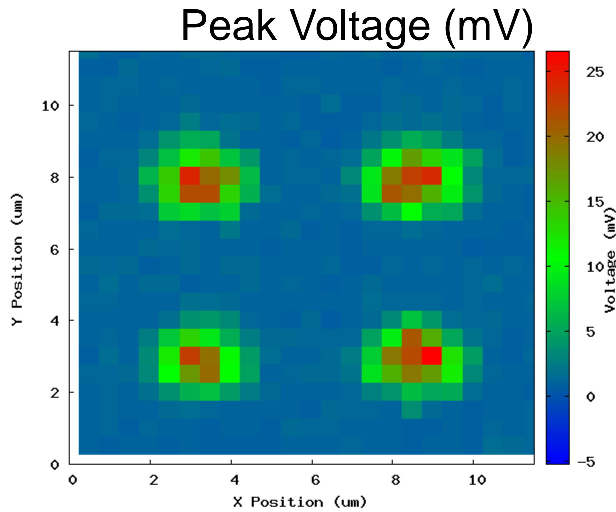


NRL : PMOS X27, 363pJ (average of 10 captures)

- Laser induced SETs in transistors
- NRL
  - Automated scope interface
  - Data recording, averaging and on-line analysis

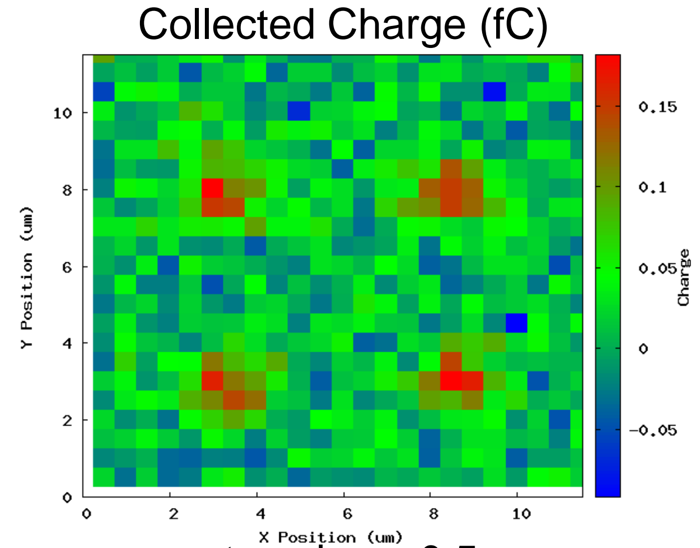
NRL : XTOR Scan (PMOS X27)

Peak Voltage (mV)

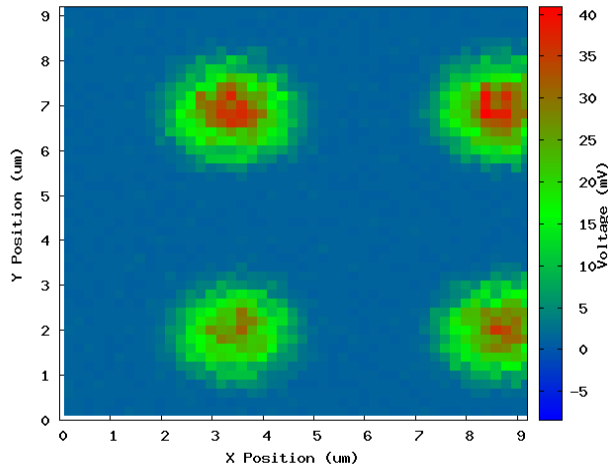


step size = 0.5µm

Collected Charge (fC)



step size = 0.5µm

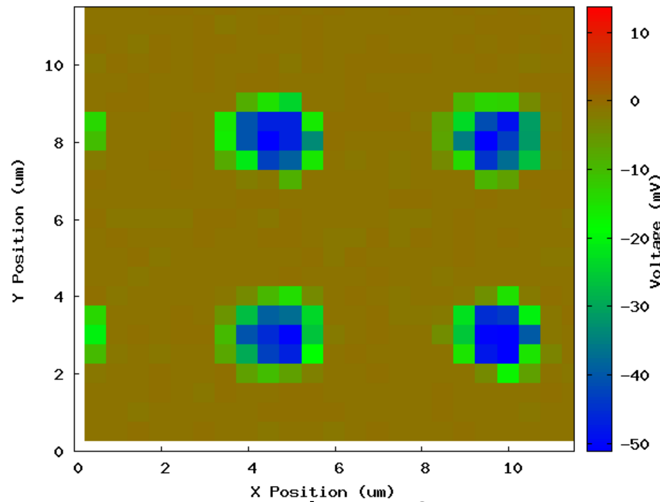


step size = 0.2µm

XY scan of PMOSX27 xtor
Pulse energy = 363 pJ

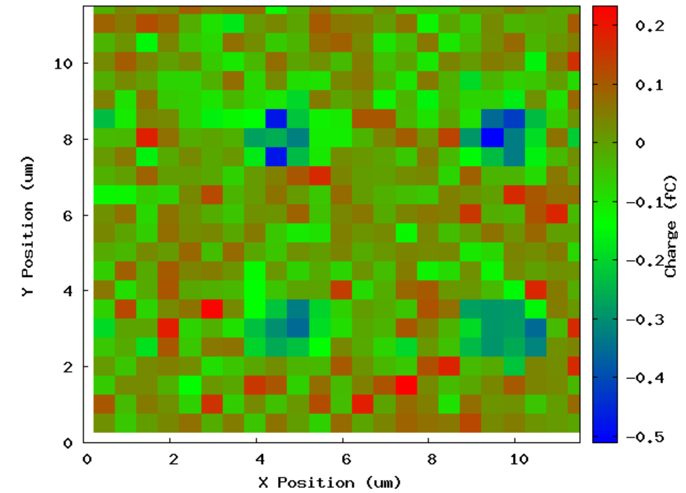
NRL : XTOR Scan (NMOS X27)

Peak Voltage (mV)

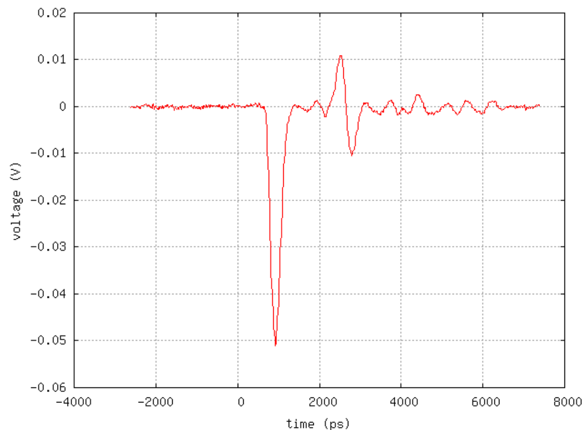


step size = 0.5μm

Collected Charge (fC)



step size = 0.5μm



Example SET in NMOS

XY scan of NMOSX27 xtor
Pulse energy = 363 pJ

Conclusions

Conclusions

- Pulsed laser is effective for understanding circuit behaviours
  - Both SPA and TPA performed well
  - Transistors, gates and full digital circuits
- At 65nm, individual gates and xtors can be targeted
- CNES system
  - Scan speed is fast
  - Direct imaging from actual laser
- NRL system
  - Good support for interface with scope
  - Scanning, data-acquisition highly automated