Génération de fautes par impulsions optiques dans les circuits intégrés. Etude de la SdF des systèmes complexes embarqués

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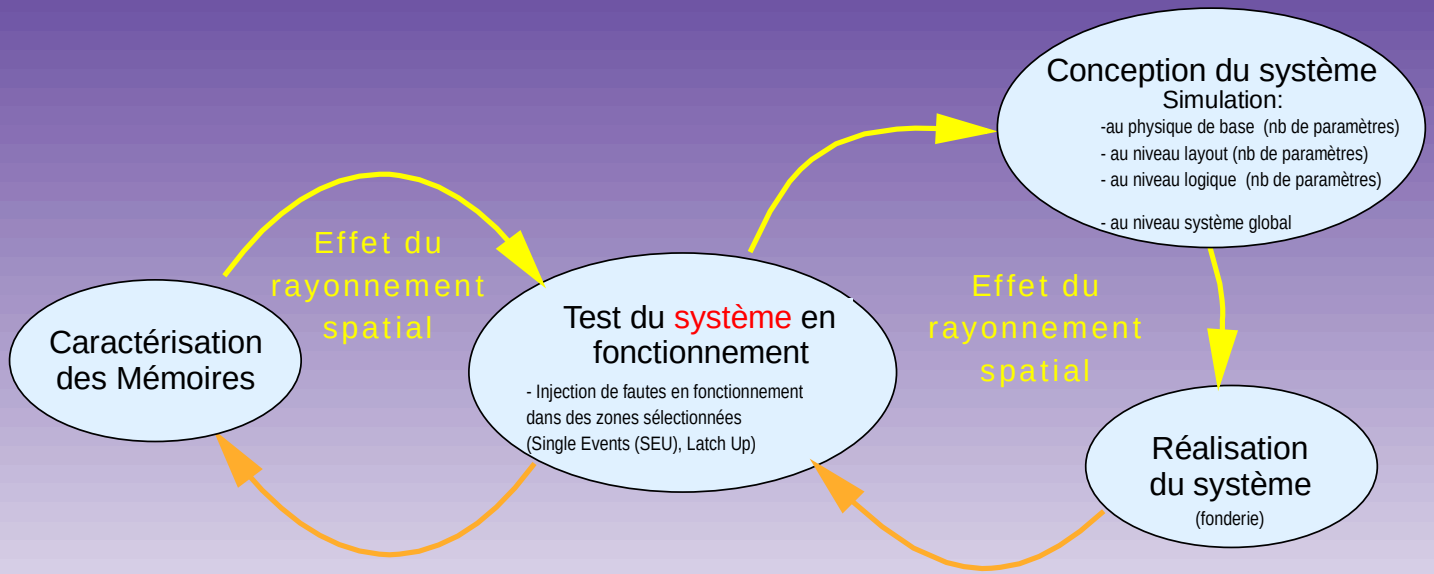
Intérêt des tests sous irradiation laser dans la conception et la réalisation des systèmes électroniques complexes embarqués?

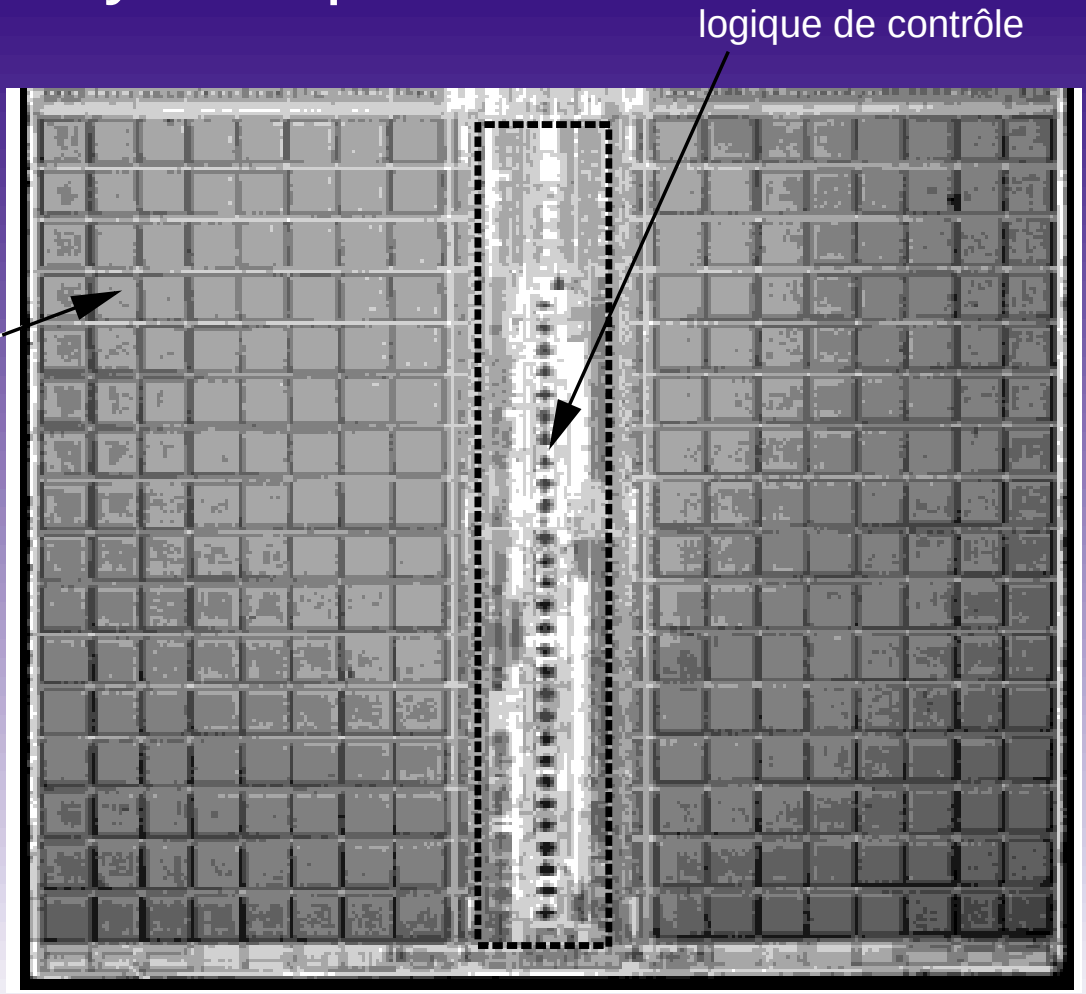


Mémoire Dynamique 64 MB

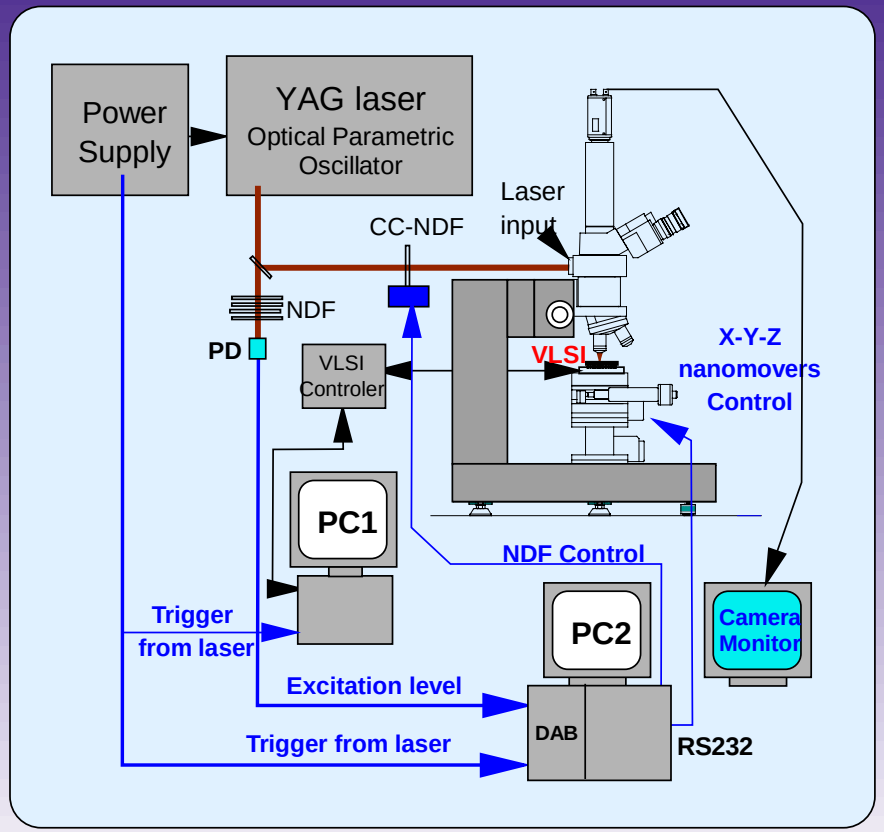
Device: SAMSUNG SDRAM
64 Mb KM41654030 CT G8

Physical organization
64 Mb= **16**x**16** blocks of 256kb

Logical organization
64 Mb= 4 bancs or 1Mb addresses with 2 bytes/address
each address: 2 bits for bank
12 bits for row
8 bits for column

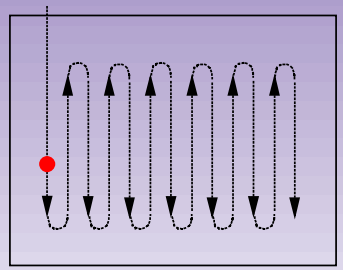


Facilities for picosecond irradiation of Silicon



main features:

- Adjustable excitation wavelength
- Picosecond pulses at 10 Hz
- Spot size slightly less than 0.5 μm
- Automatic scanning and recording



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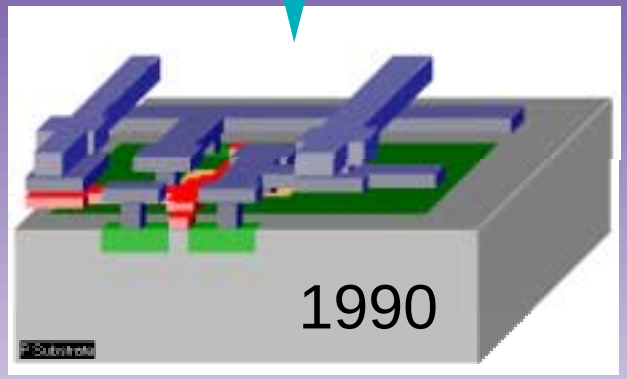
Front irradiation versus Back Irradiation

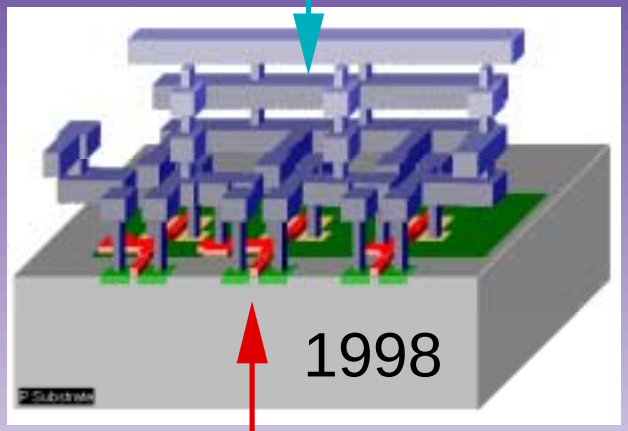
Front Irradiation

2 metal layers



Back Irradiation

4 metal layers



Back Excitation

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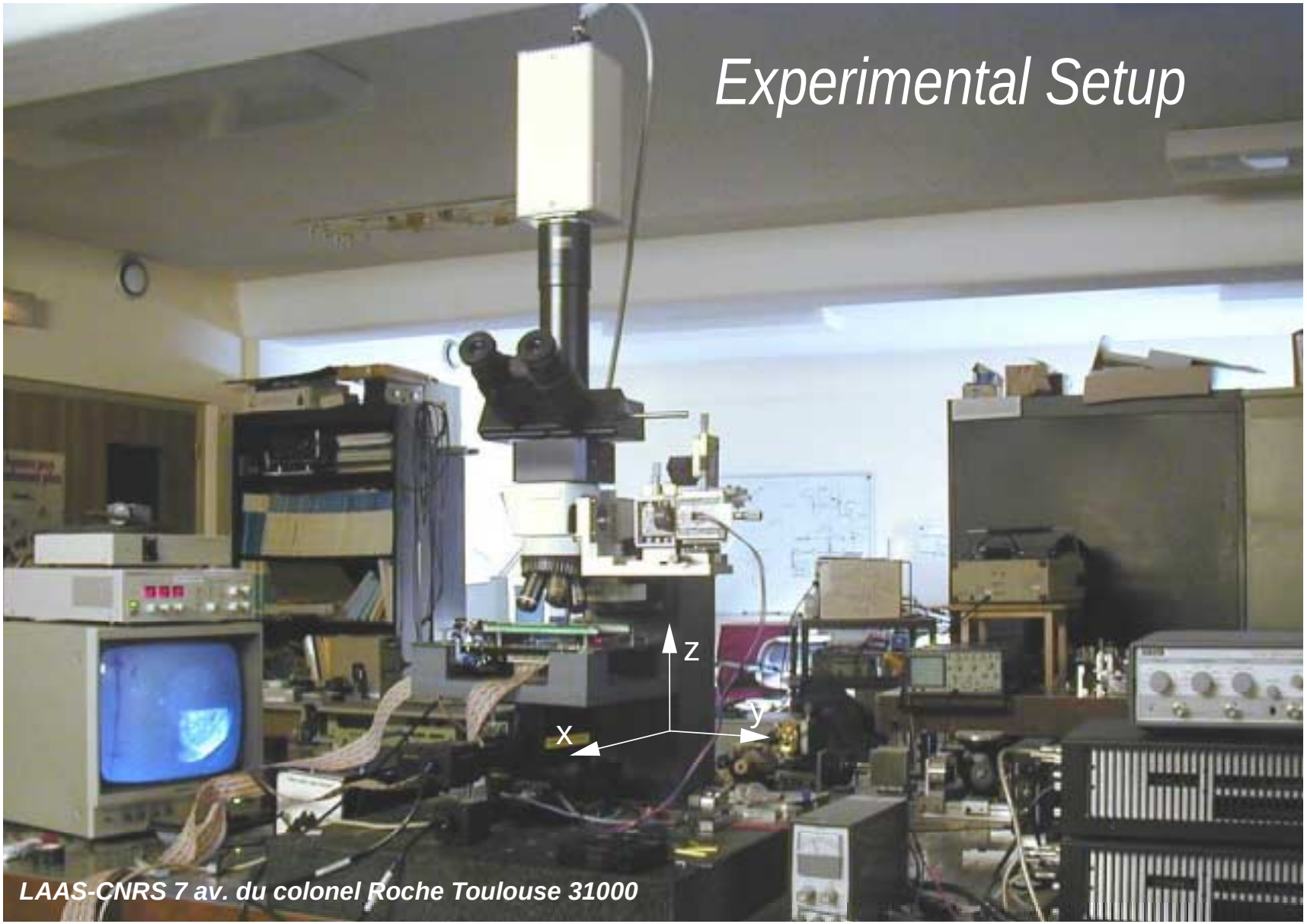
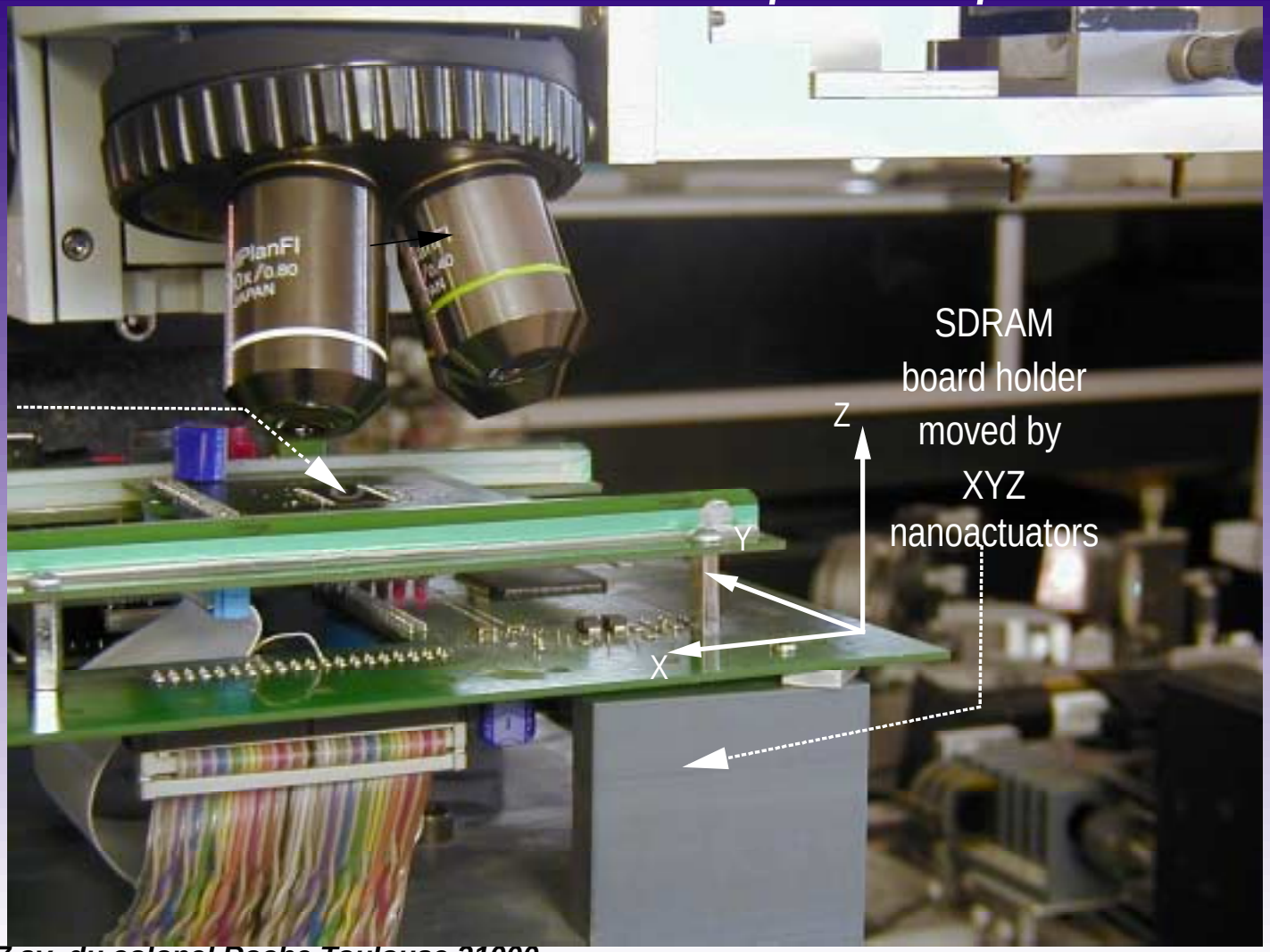
Experimental Setup

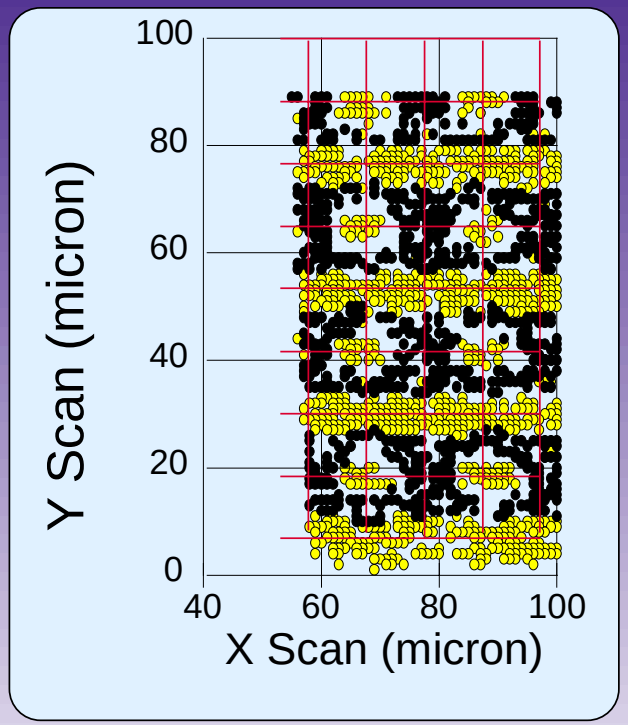


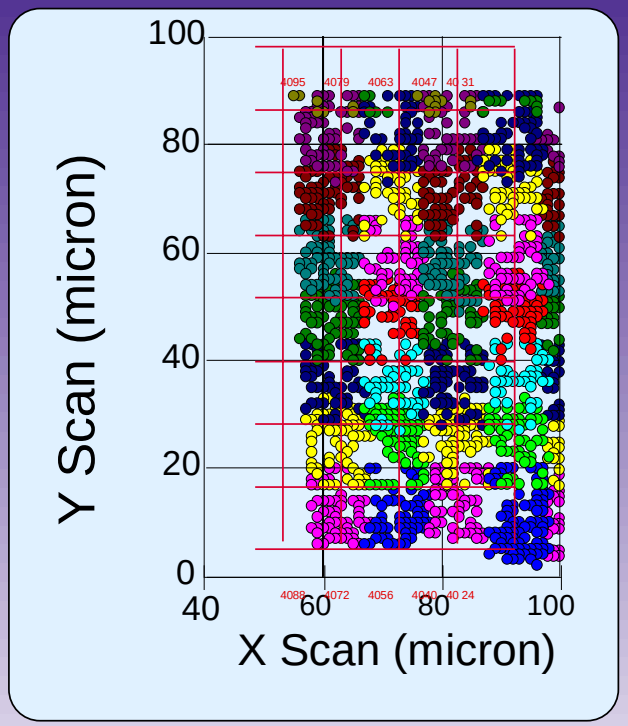
RAM holder and microscope setup



Front excitation: 1-µm-step SEU Map

Dual-port SRAM 67025 Temic





Yellow point: 1 memory bit switched from 0 to 1

Black point: 1 memory bit switched from 1 to 0

Incident energy: around 0.3 nJ
laser spot diameter: 1micron
laser wavelength= 850 nm
pulse duration: 3-5 ps

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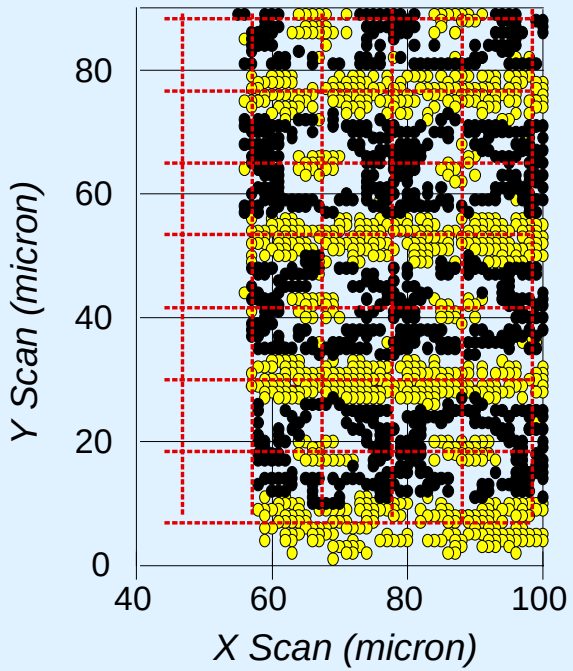
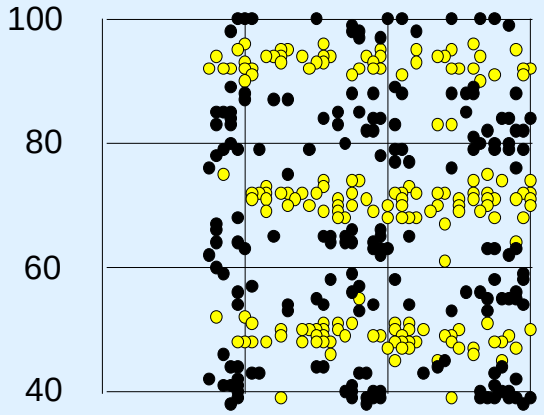
1-µm step Mapping of SEU's: Threshold energy

Dual-port RAM 67025 Temic





Incident energy: around 0.2 nJ
laser spot diameter: 1micron
laser wavelength= 850 nm
pulse duration: 3-5 ps

$$N_O = E_P T / h\nu$$

***N*O=(2.5-5)x10$_8$** EHP's are photocreated with pulse energies ranging from 0.1 to 0.2 nJ. However: ***N*P =(1-3)x10$_7$**

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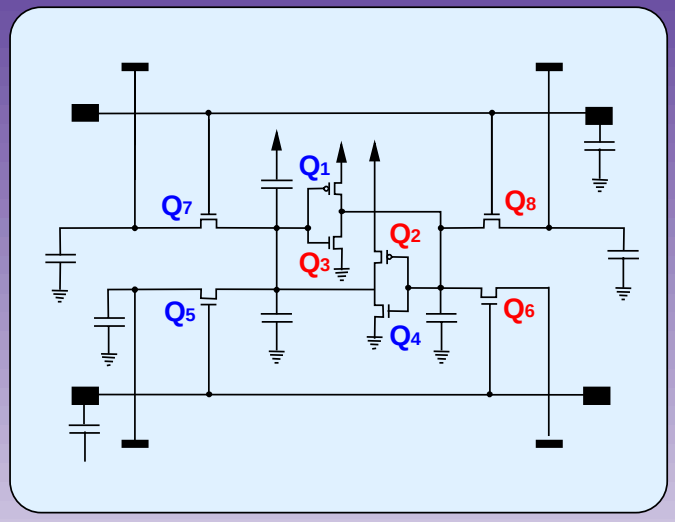
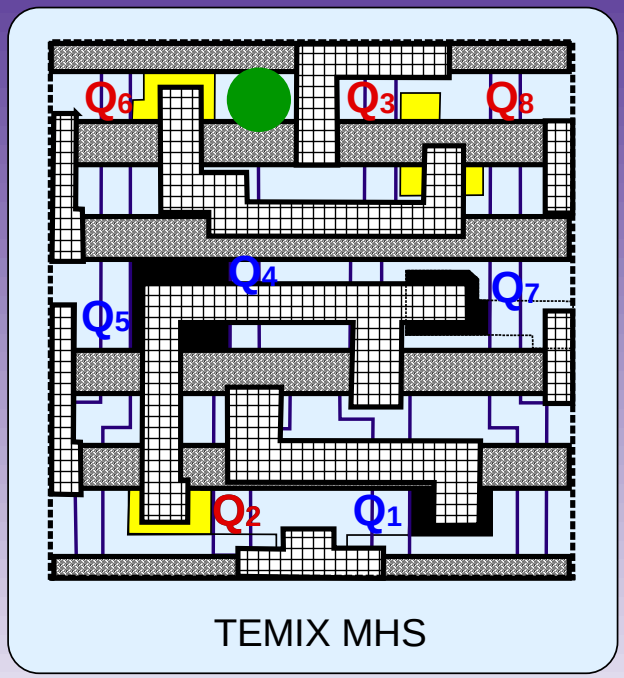
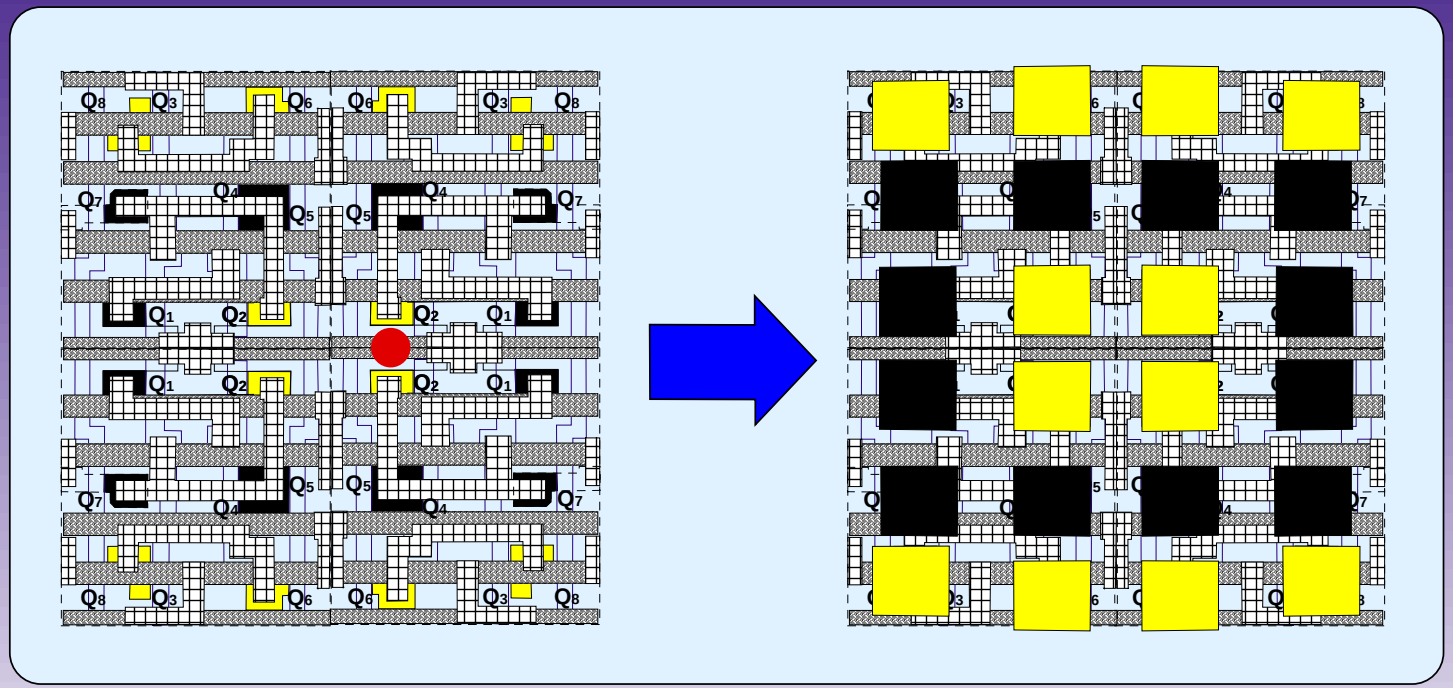
Comparison with the chip layout and identification of sensitive nodes





TEMIX MHS


Q8
Q3
Q6
Q6
Q3
Q8
Q7
Q4
Q5
Q5
Q4
Q7
Q1
Q2
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Q1
Q1
Q2
Q2
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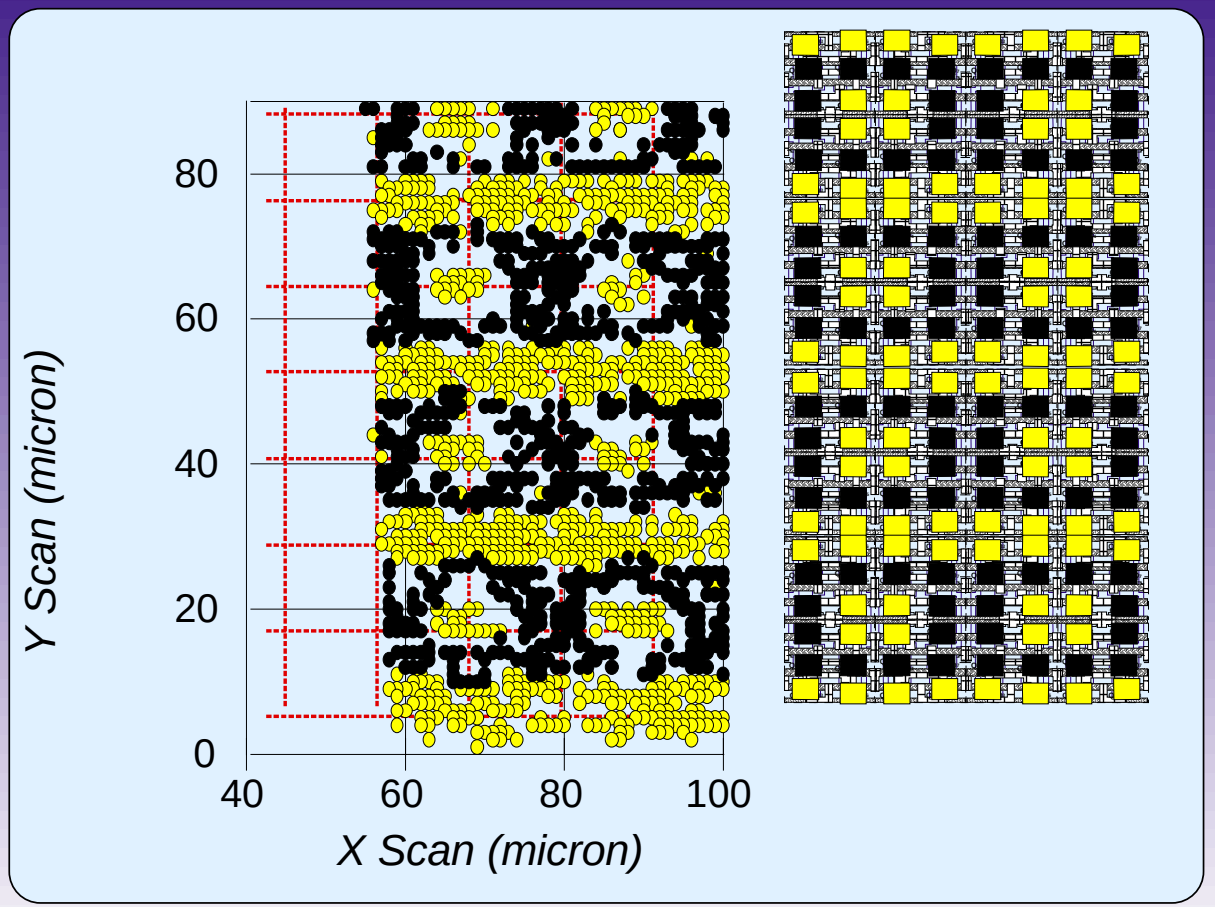
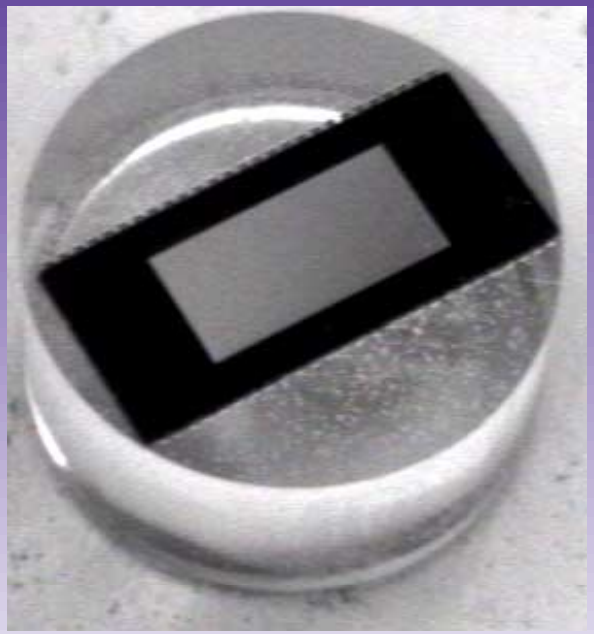
Q7
Q8
Q3
Q6
Q6
Q3
Q8

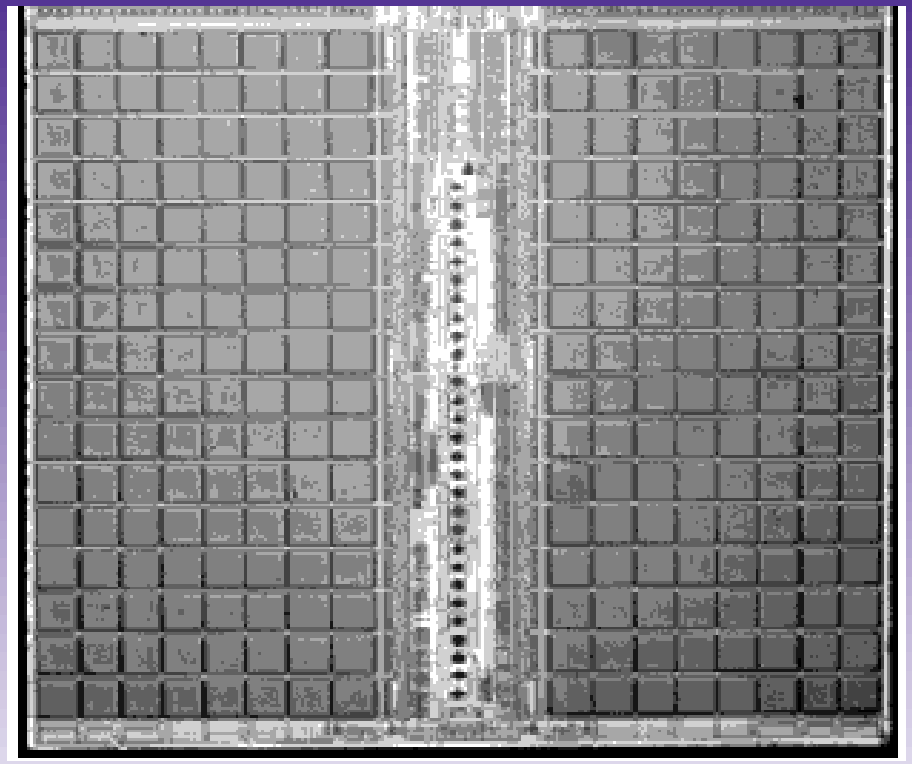
Comparison of SEU mapping with the chip layout



SDRAM substrate polishing

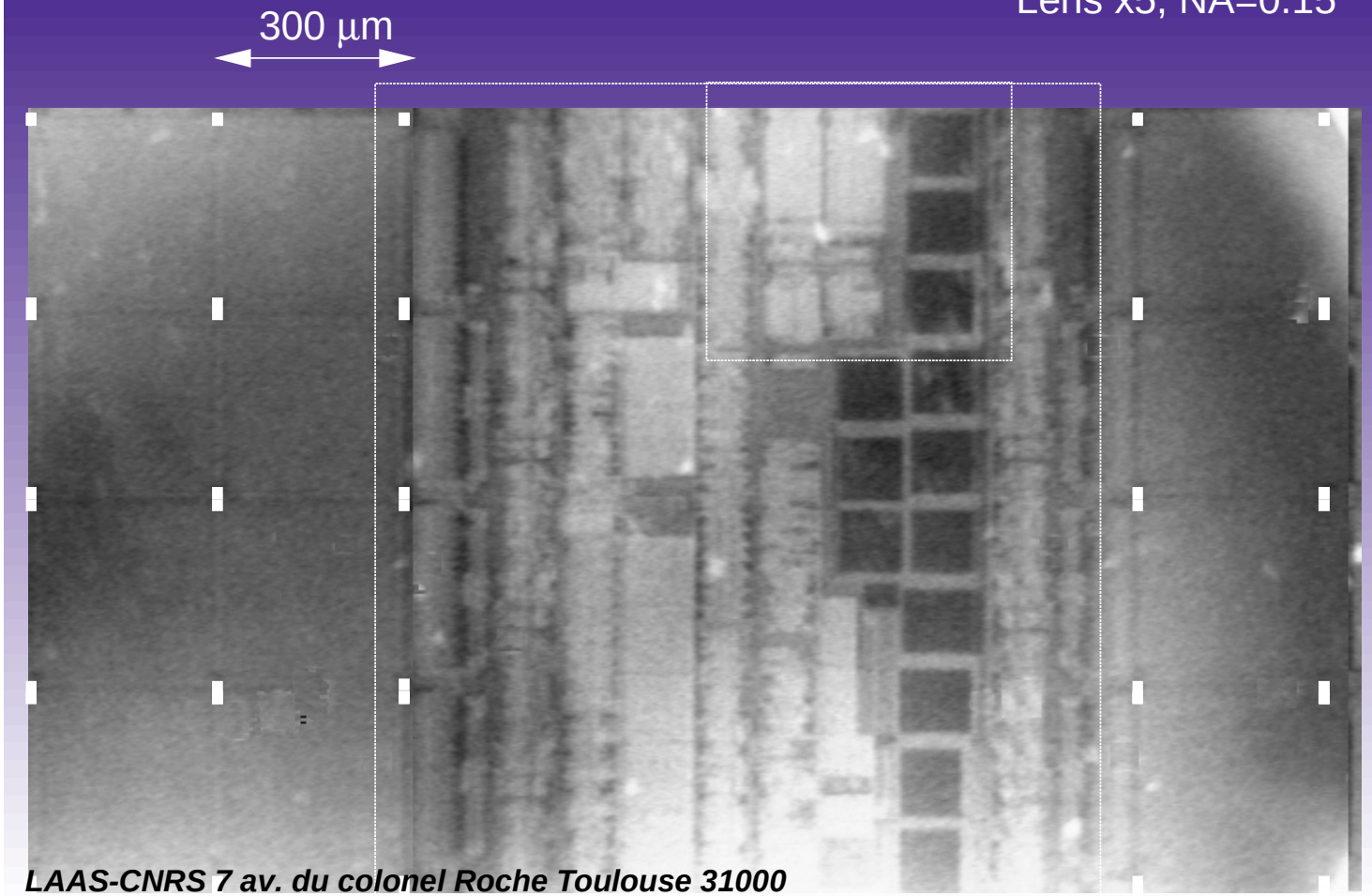
Device: SAMSUNG SDRAM
64 Mb KM41654030 CT G8





Infrared Imaging through the back side

Lens x5, NA=0.15



Processeur

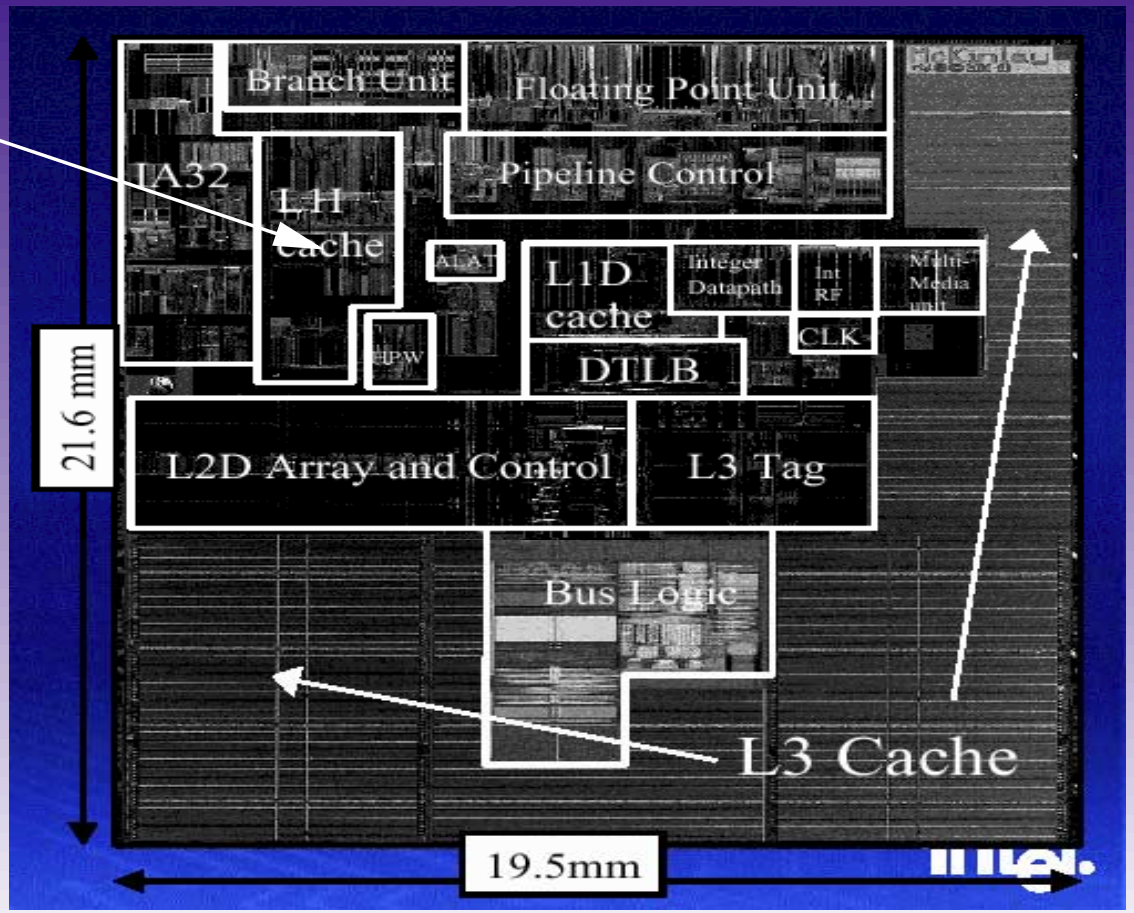
Que se passe-t-il si une faute est générée ici?

Itanium 2

- .18 µm bulk, 6 layer Al process
- 8 stage, fully stalled in- order pipeline
- Symmetric six integer- issue design
- IA32 execution engine integrated
- 3 levels of cache on-die totaling 3.3MB

- 221 Millions total transistors

- 130W @1GHz, 1.5V (source: INTEL)



Conclusion

1) Les techniques d'excitation optiques permettent d'irradier précisement des zones de systèmes complexes (Processeur: cache, registres, pipeline d'un processeur, logique de prédiction de branchement, etc..) (DRAM: Logique de contrôle, zone mémoire..)

2) On peut tester dans un cycle de validation de systèmes complexes (system on chip) la sensibilité des différentes composants au rayonnment etc...)