



# TRADCARE® software

[COMET-ENV] Tools to predict Single Event Effects

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# Outline

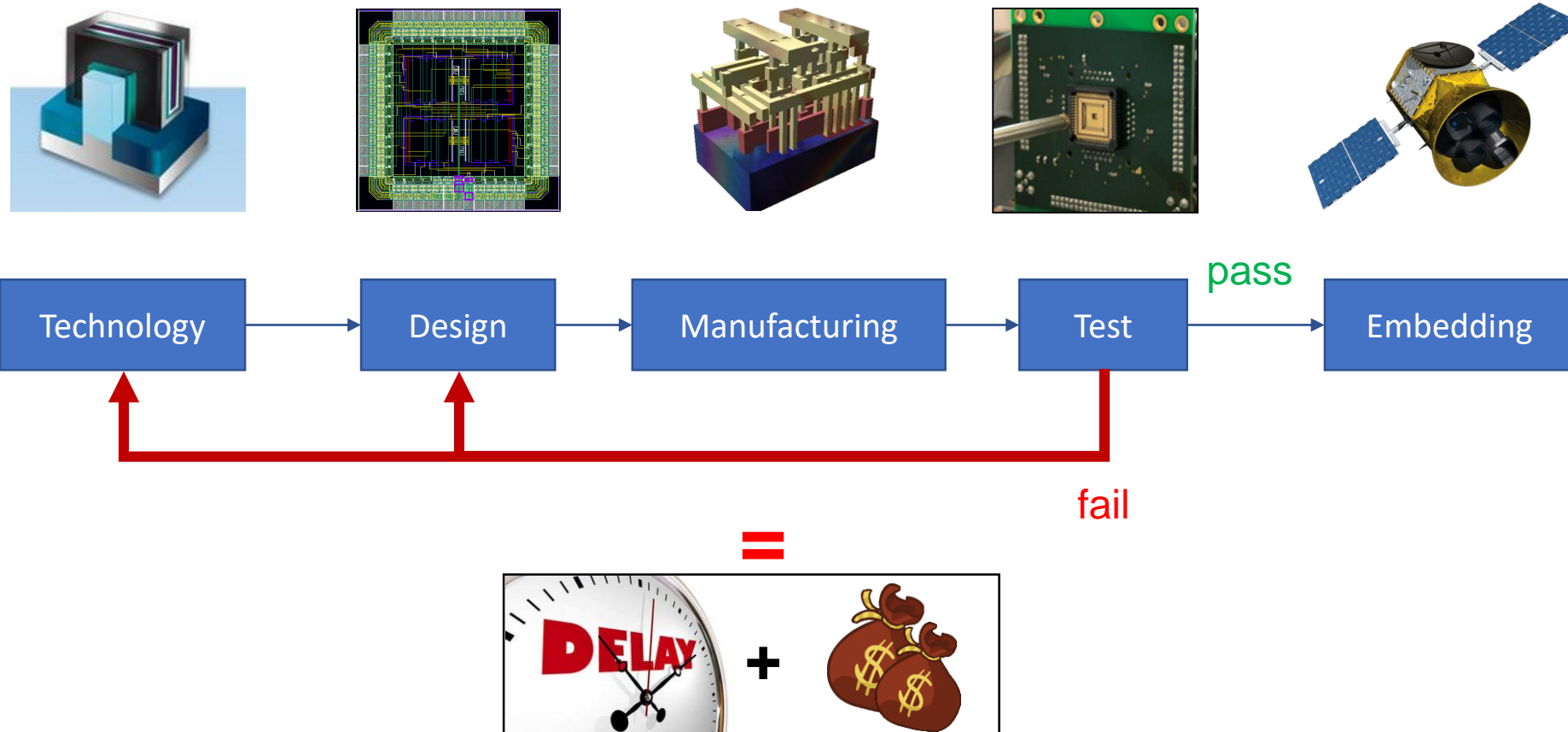
## ENGINEERING ACTIVITIES



- **Context and purpose of TRADCARE**
- History on the TRADCARE project
- TRADCARE main features
- Using TRADCARE and simulation flow
- Cases of validation
- Conclusion & perspectives

# Context and purpose of TRADCARE

- ASIC development flow



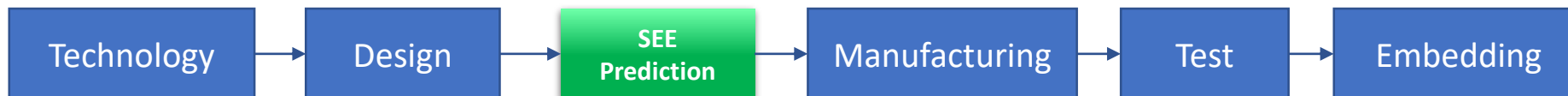
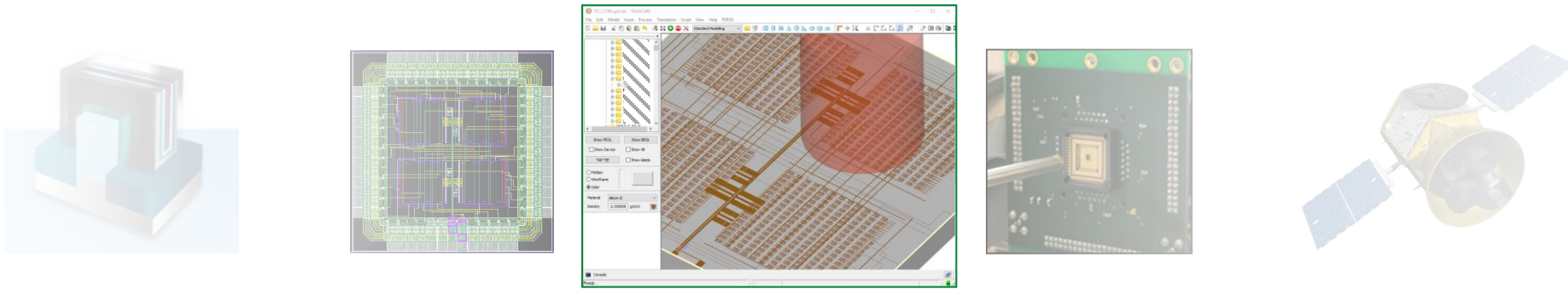
# Context and purpose of TRADCARE

- TRADCARE proposes an additional step
  - Simulate a test bench / SEE testing
  - Predict SEE occurrence before manufacturing
  - Reduce Manufacturing & Test Costs limiting iterations

Simulation needs to be realistic !  
*Realistic sensitive volumes → 3D modeling*  
*Account for physical processes*  
*Reasonable computation time*

➔ Ambitious!

TRADCARE®



Process & IP hardening

Designers  
Founders



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- Perspectives and conclusions


# History on the TRADCARE project

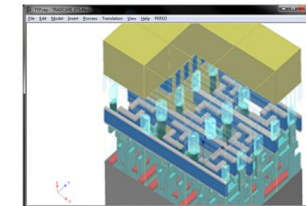
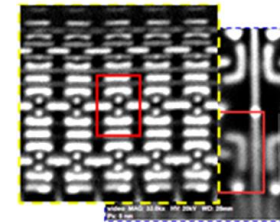


Deposited charge calculation  
inside sensitive volumes



Charge deposition and transportation needs to be more representative

- ↳ 3D modeling based on 
- ↳ Extracted from reverse Engineering
- ↳ Monte Carlo calculations →  $E_{dep}$  to compare to critical charge



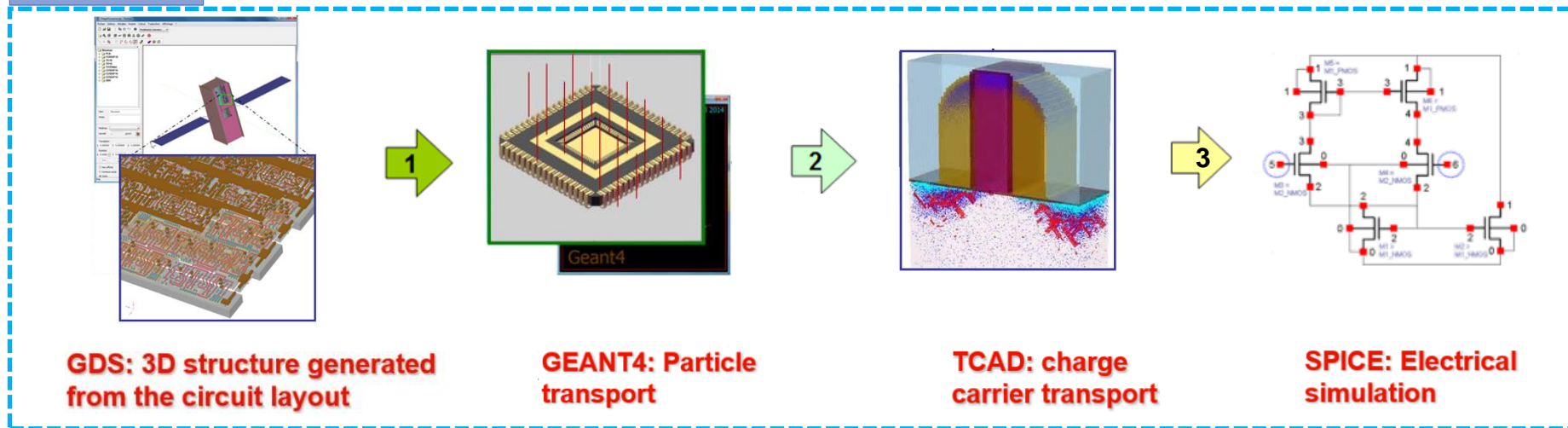
**Still needs a critical charge !**



# History on the TRADCARE project



TRADCARE



Circuit and device responses more representative



# History on the TRADCARE project

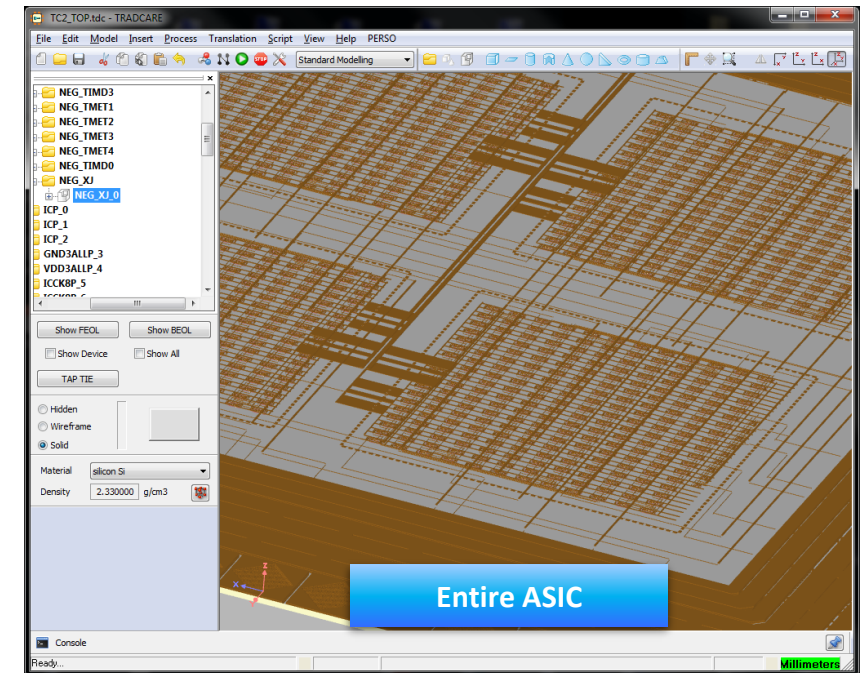
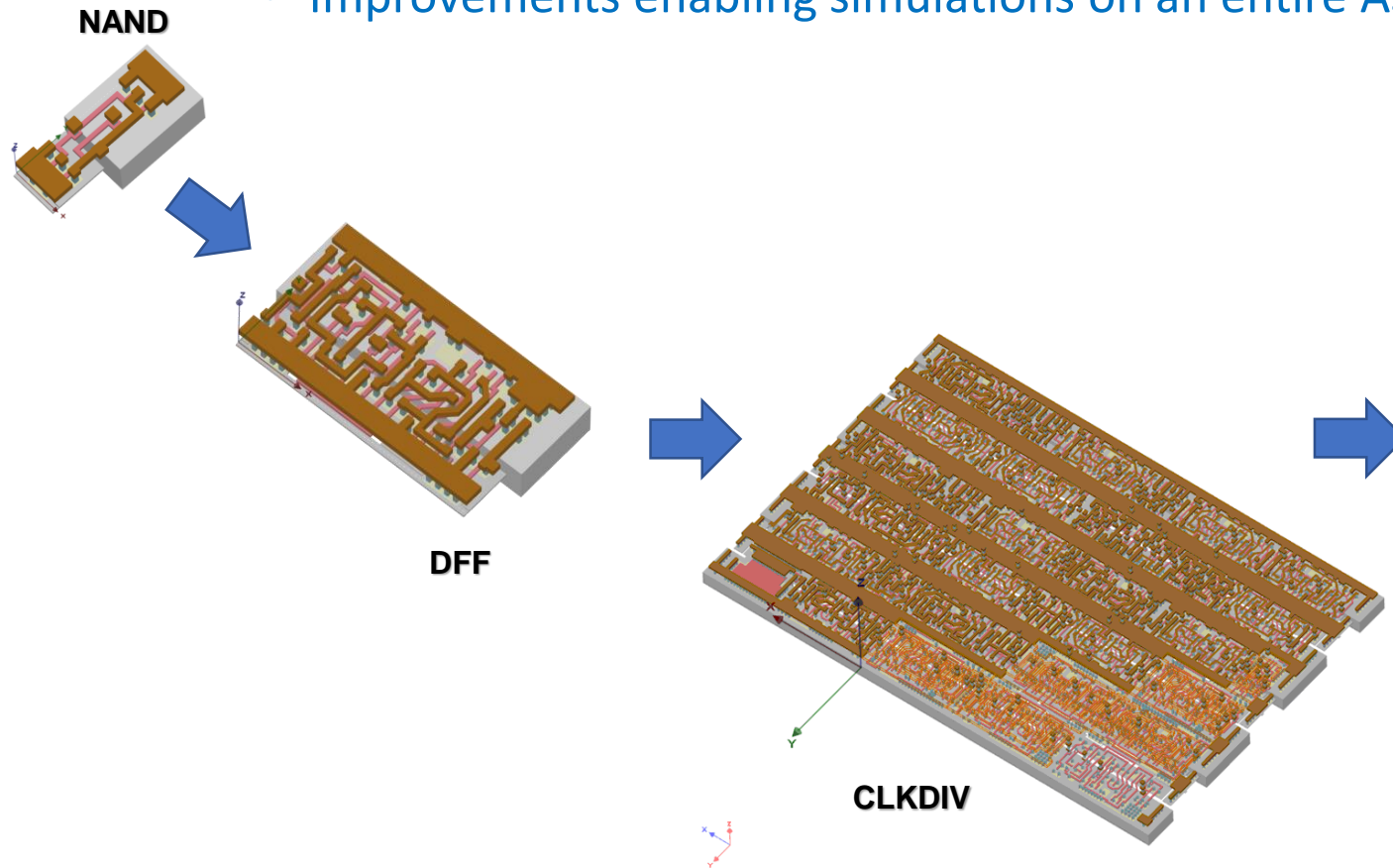
2012

2014

2016

Nowadays

- Improvements enabling simulations on an entire ASIC



# Outline

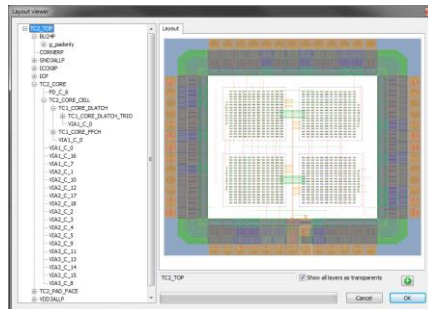
## ENGINEERING ACTIVITIES



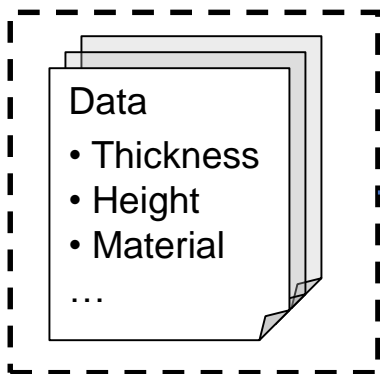
- Context and purpose of TRADCARE
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# TRADCARE main features

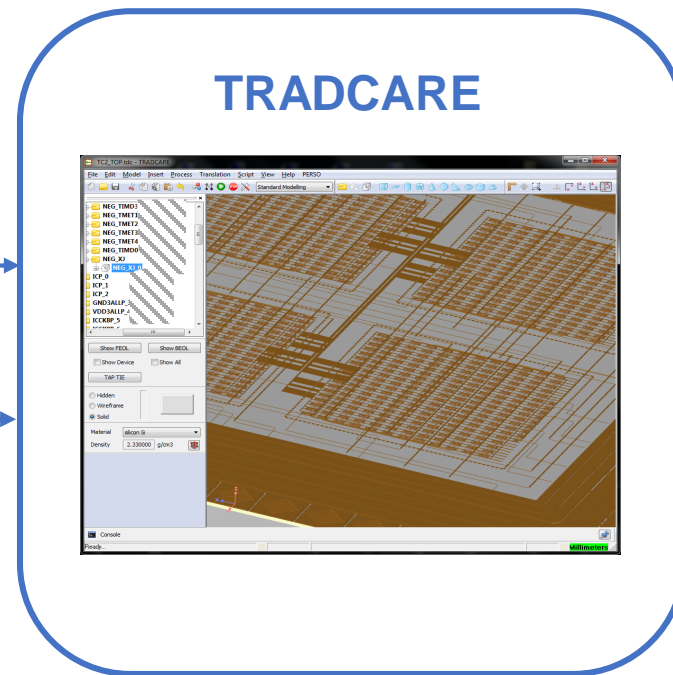
## Inputs



Layout : .gds file

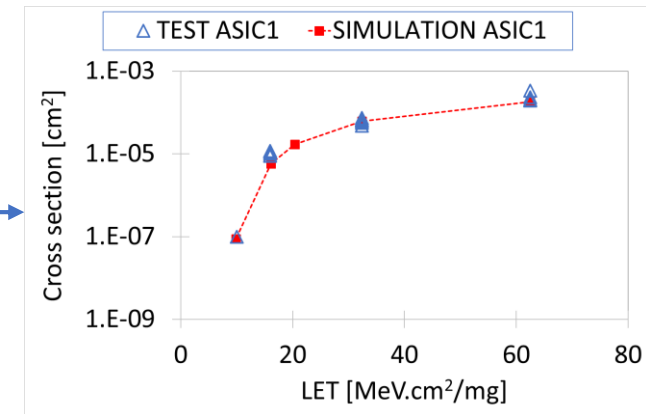


Process database

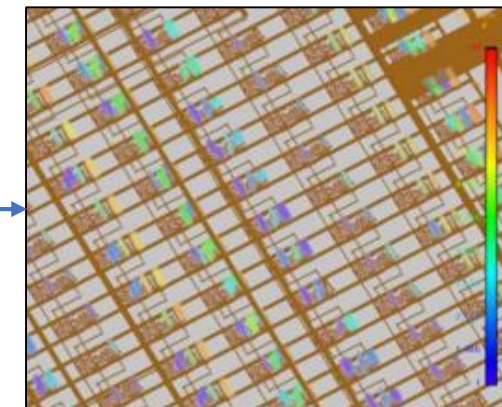


Simulate  
- test bench  
- HI cocktail, protons...

## Outputs



Simulated cross section

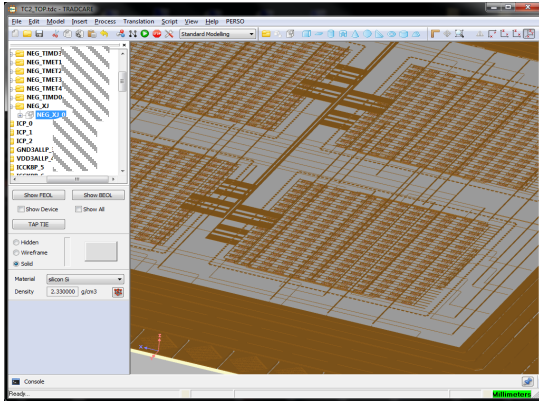


Mapping

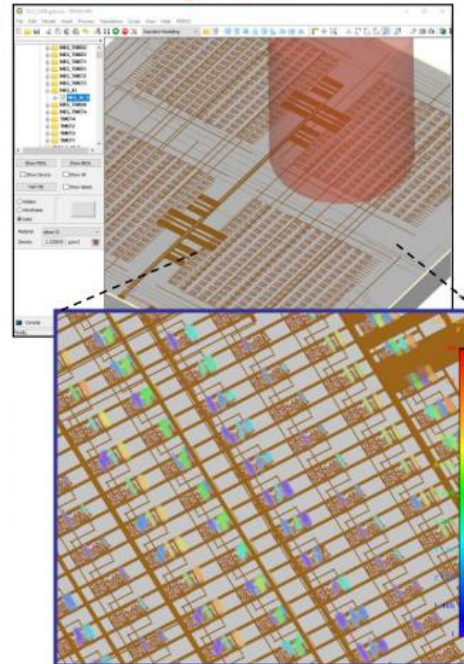


# TRADCARE main features

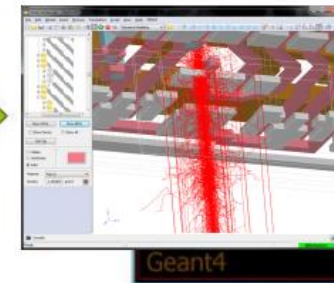
## TRADCARE



**GDS: 3D structure generated from the tape-out**



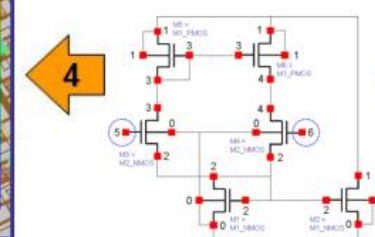
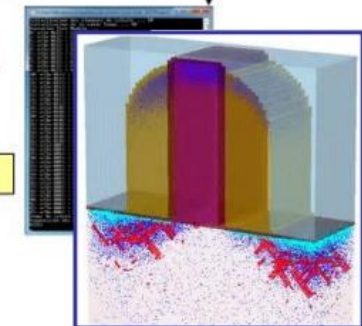
**Post-processing: hotspot mapping**



**GEANT4: particle transport**



**TCAD: charge carrier transport**



**SPICE: electrical simulation**



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# TRADCARE interface

- Similar to 

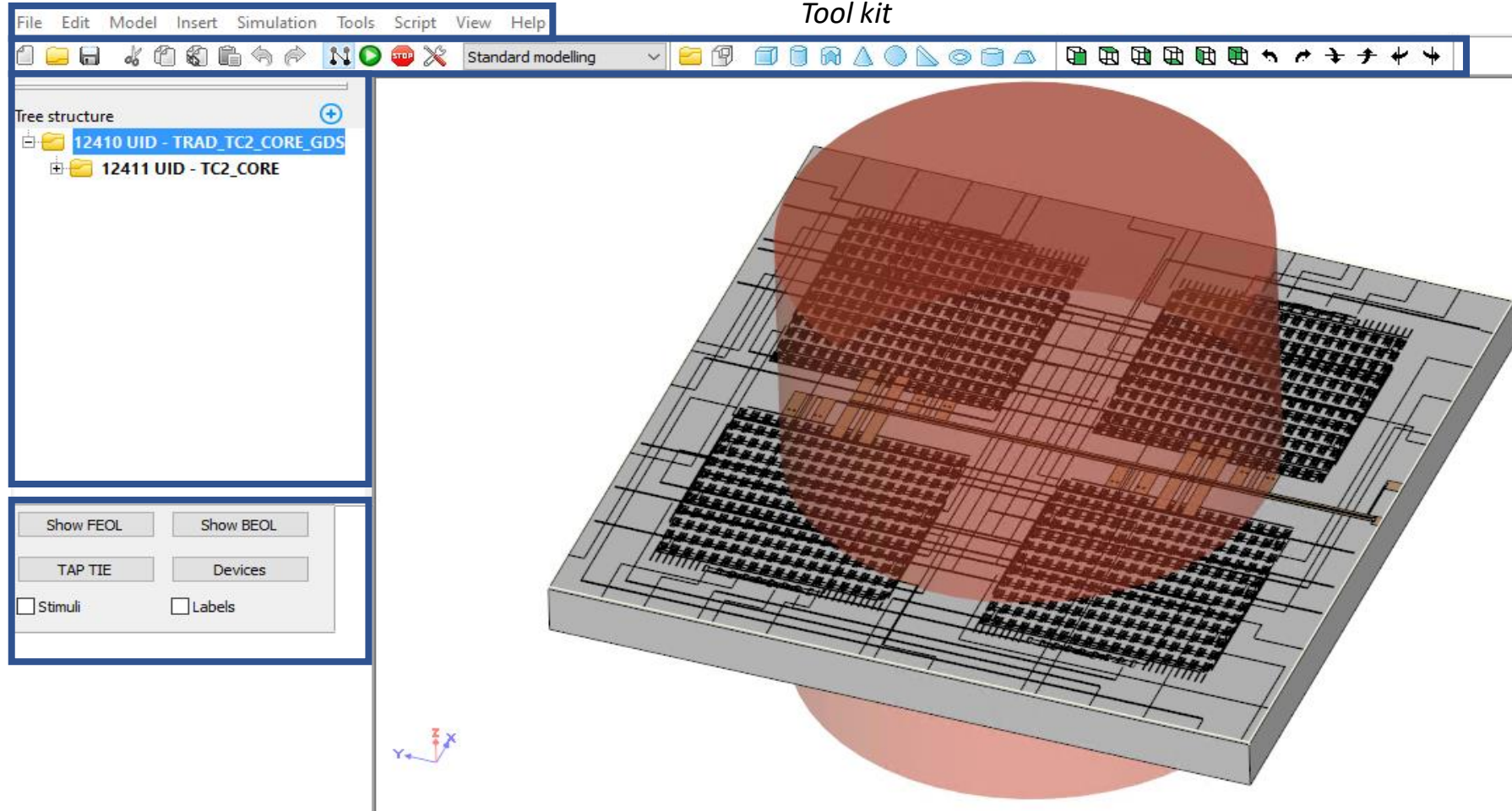
*Import GDS, launch simulations...*

*Tool kit*

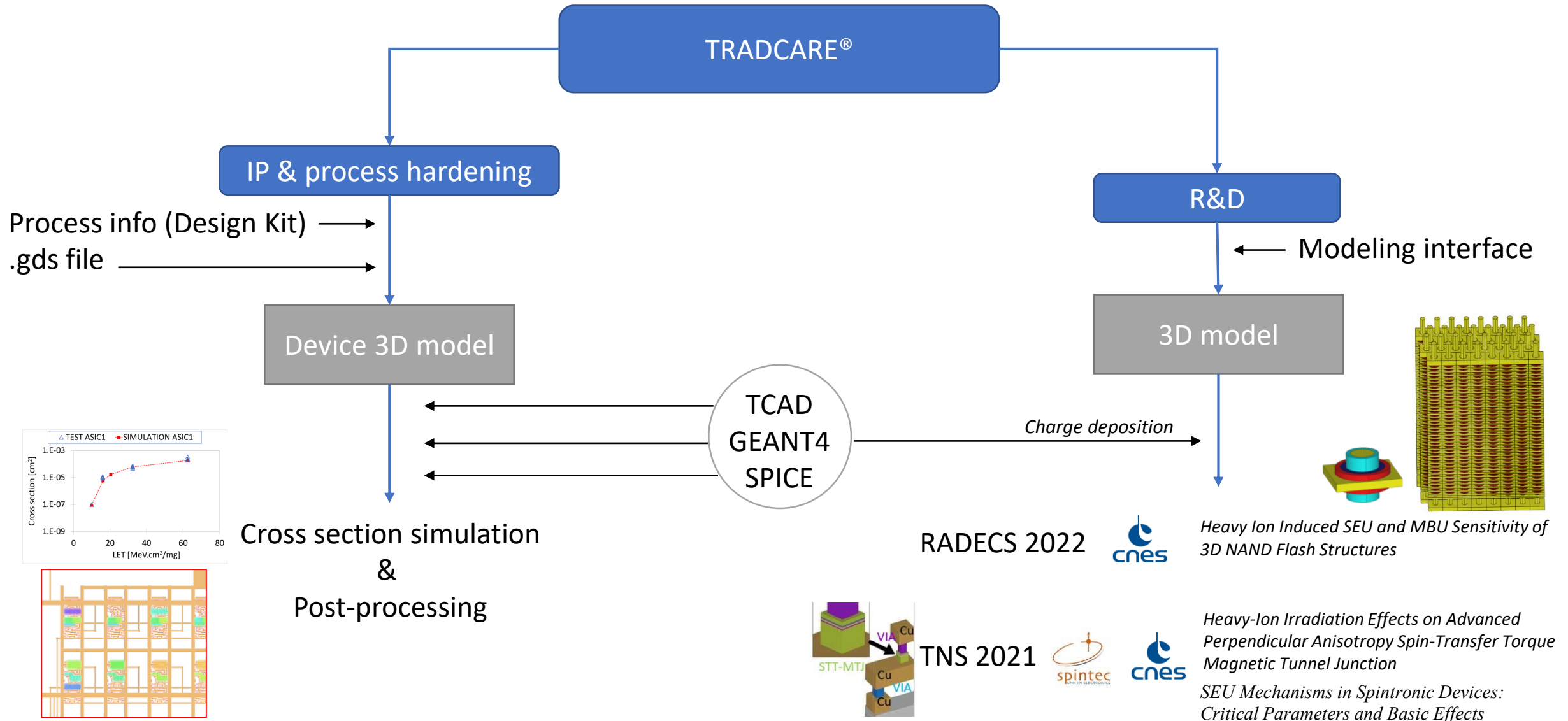
*List of recognised devices*

*Manage display*

*Visualize*



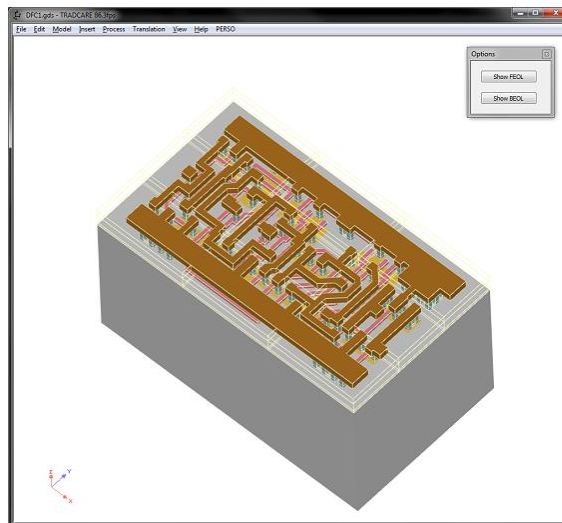
# Ways to use TRADCARE



# Simulation flow

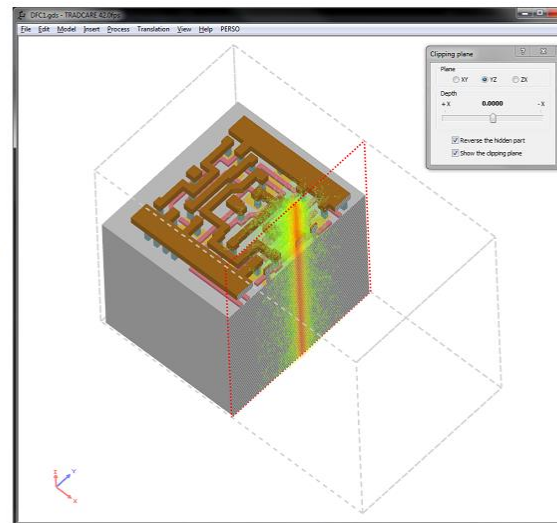
- Simulation flow for IP and process Hardening

Model



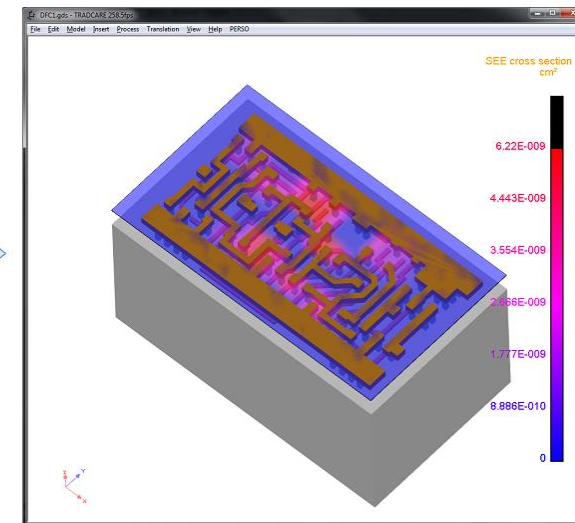
Circuit biasing

Calculate



Beam configuration

Post-process



Hotspot mapping



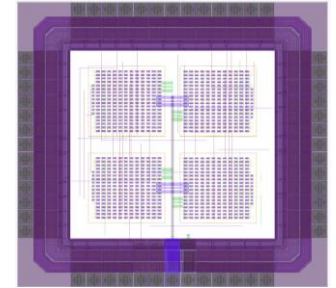
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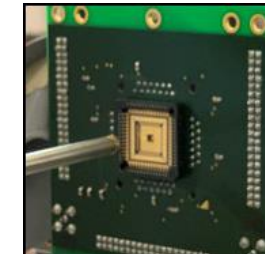
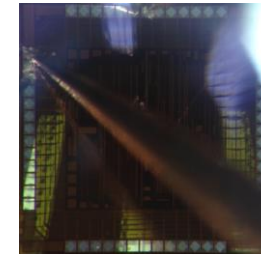
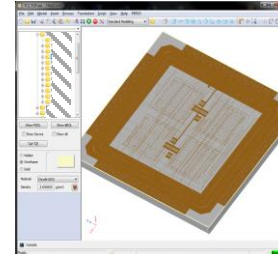
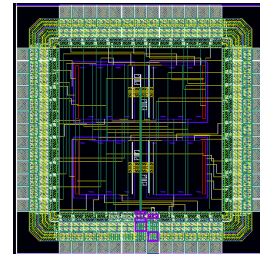
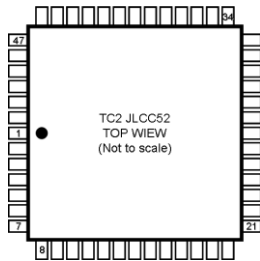
# ASIC n°1 - SEL



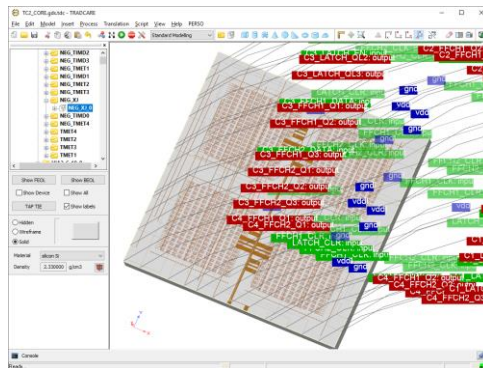
- ASIC designed from scratch with



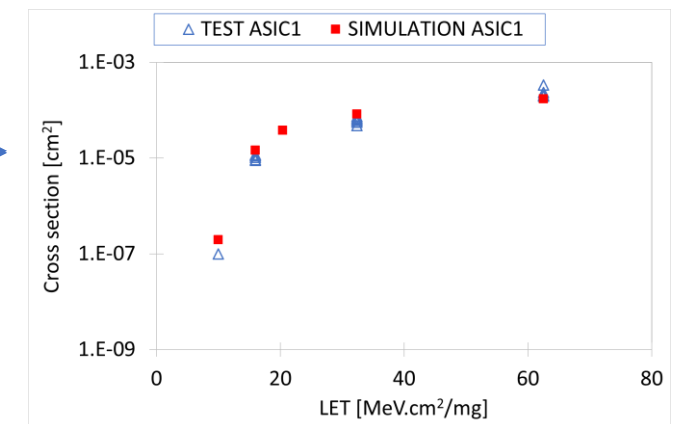
Institut Matériaux Microélectronique Nanosciences de Provence



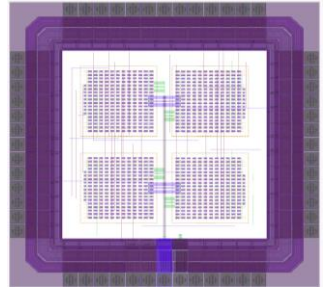
- Simulate heavy ion cocktail
- Simulate SEE test bench



## UCL facility

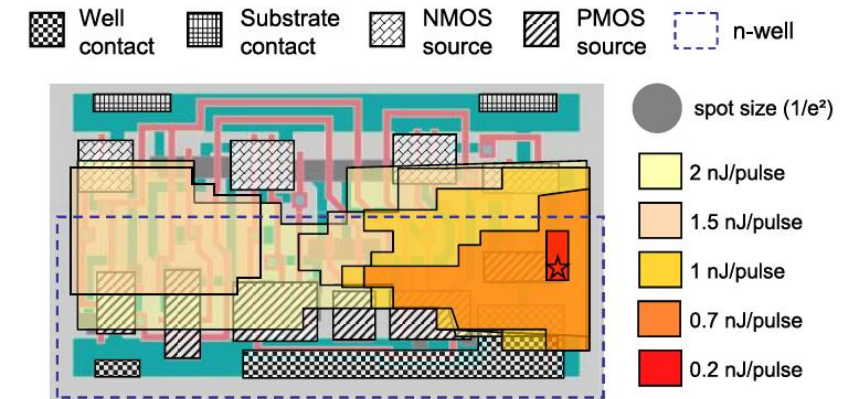
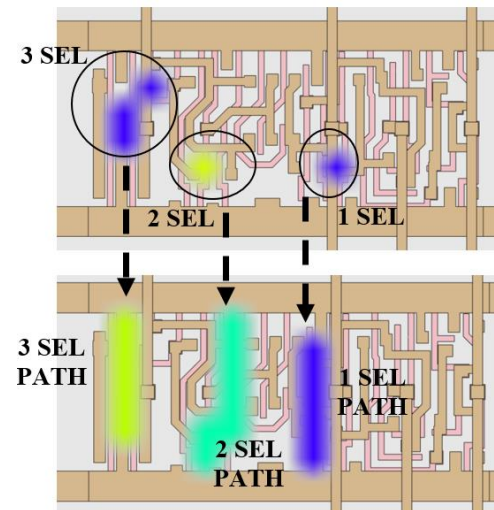
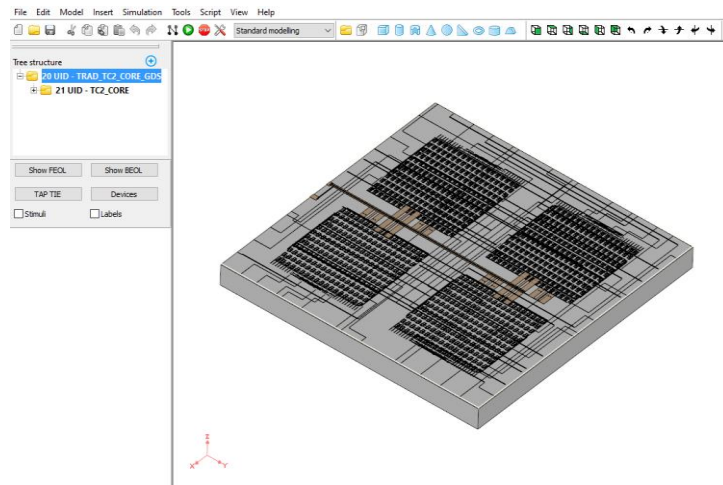


# ASIC n°1 – hot spot mapping



- Identification of sensitive areas → TRADCARE vs LASER

➤ RADECS 2019 - Single-Event Latchup in a CMOS-Based ASIC Using Heavy Ions, Laser Pulses, and Coupled Simulation

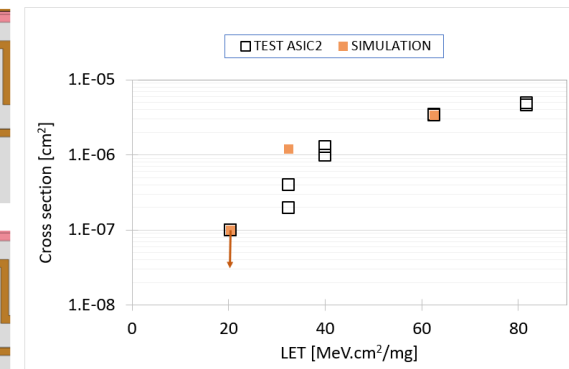
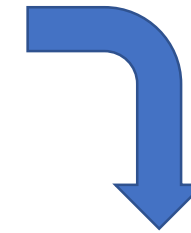
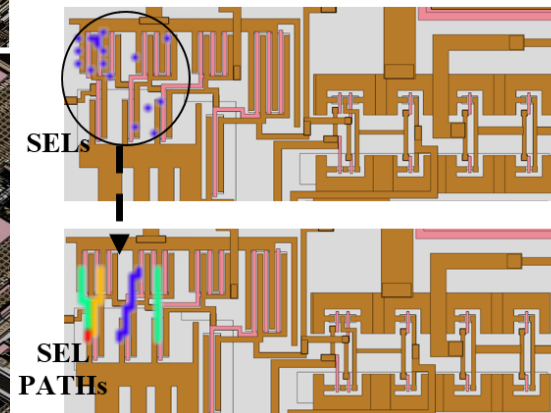
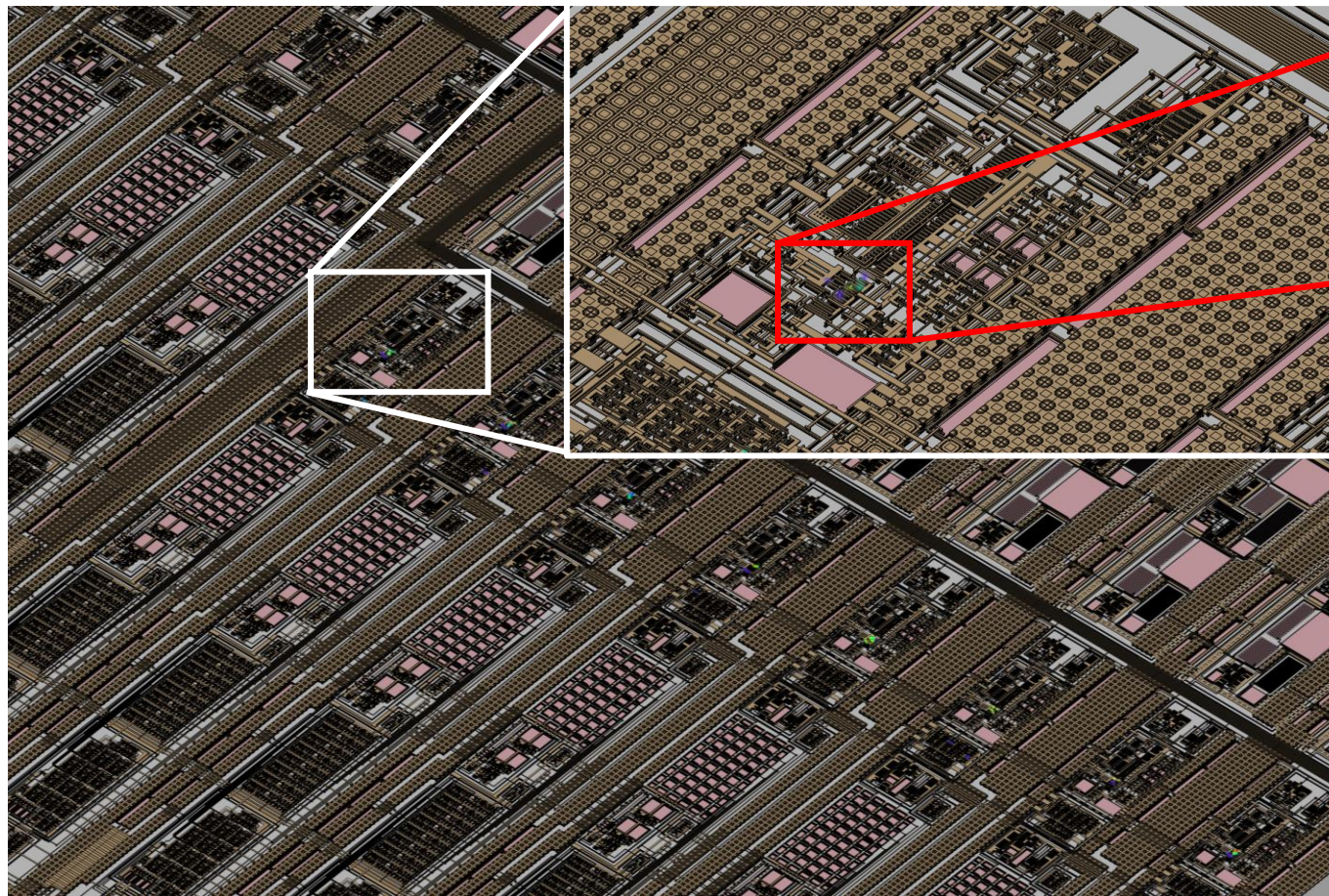
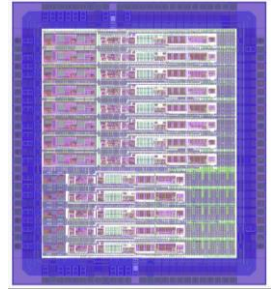


*SEL spatial sensitivity of a flip-flop using backside laser testing. The sensitive area increases with the pulse energy, varying from the SEL threshold at surface of 0.2–2 nJ.pulse<sup>-1</sup>.*



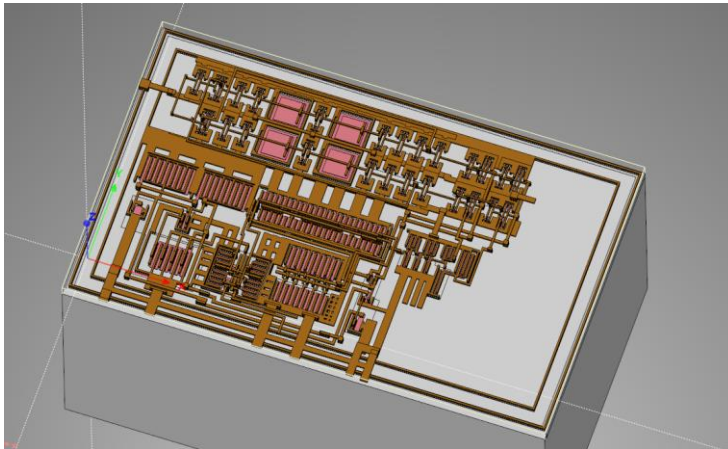
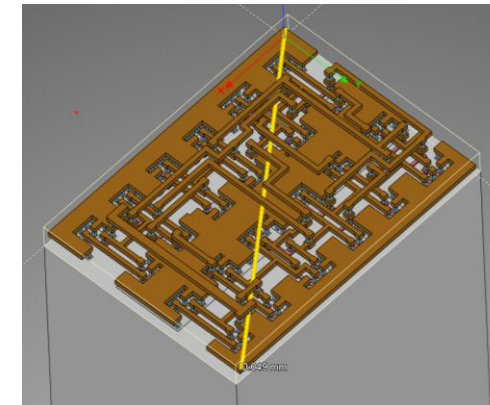
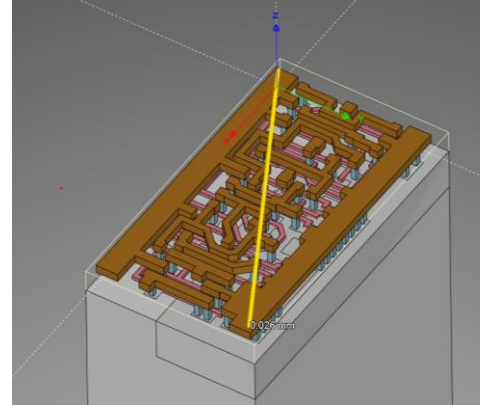
# ASIC n°2 - SEL

- Commercial mixed ASIC



# Other examples

- Digital techno - SEU
  - Std FF cell
  - Hardened FF cell
- Analog techno – SET
  - Comparator



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# Conclusion & perspectives

- **TRADCARE**

- 3D tool
- GEANT4 / TCAD / SPICE –based simulation
- Simulation of a SEE test
  - Test bench
  - Particles

- **Purpose of TRADCARE**

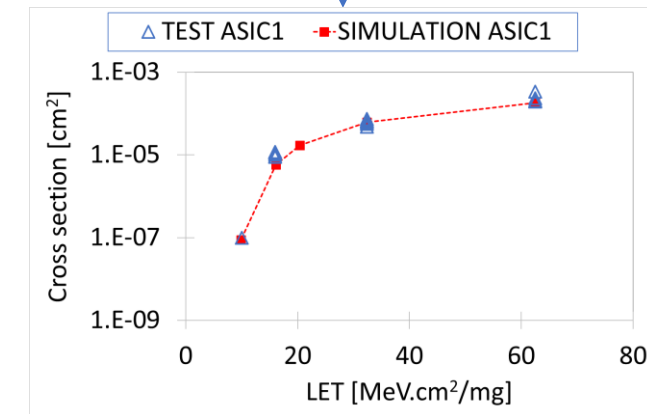
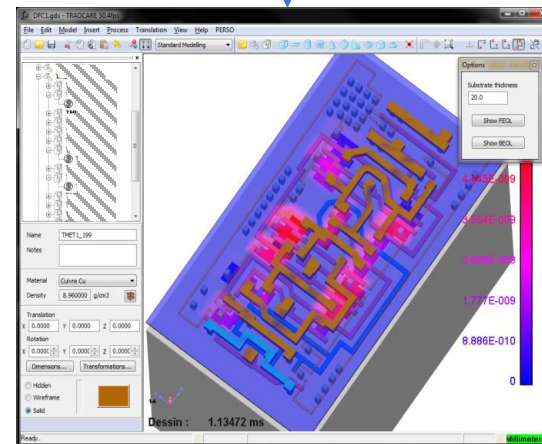
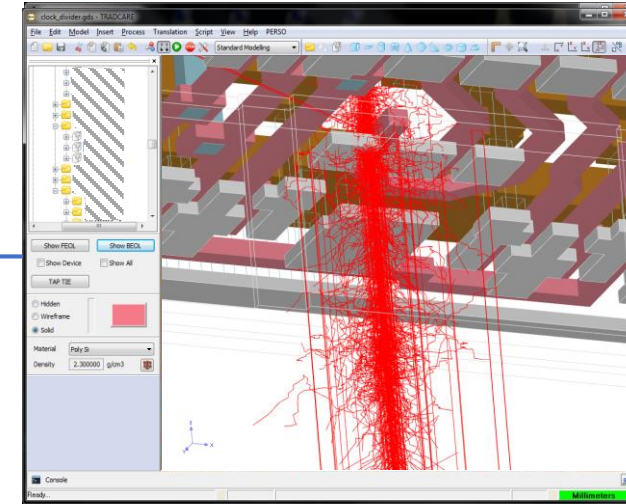
- IP & Process hardening
- R&D

- **Inputs** → gds file & process info

- **Outputs** → Cross-section & mapping

- **Perspectives**

- First version on client site in 2023



# Thank you for your attention

For further information on TRADCARE:

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