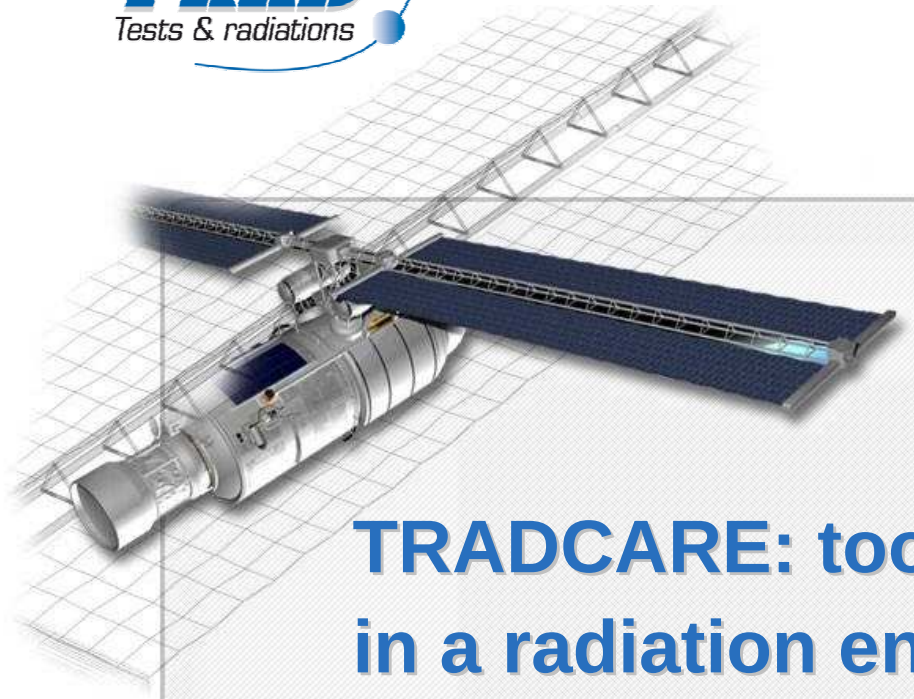

# TRADCARE: tool for SEE prediction in a radiation environment

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# Context

- **Study started in 2012**

- **Most of the SEE rate estimation tools limited to RPP methods:**
  - Not considering shielding surrounding the sensitive area,
  - Charge deposition based on mean LET

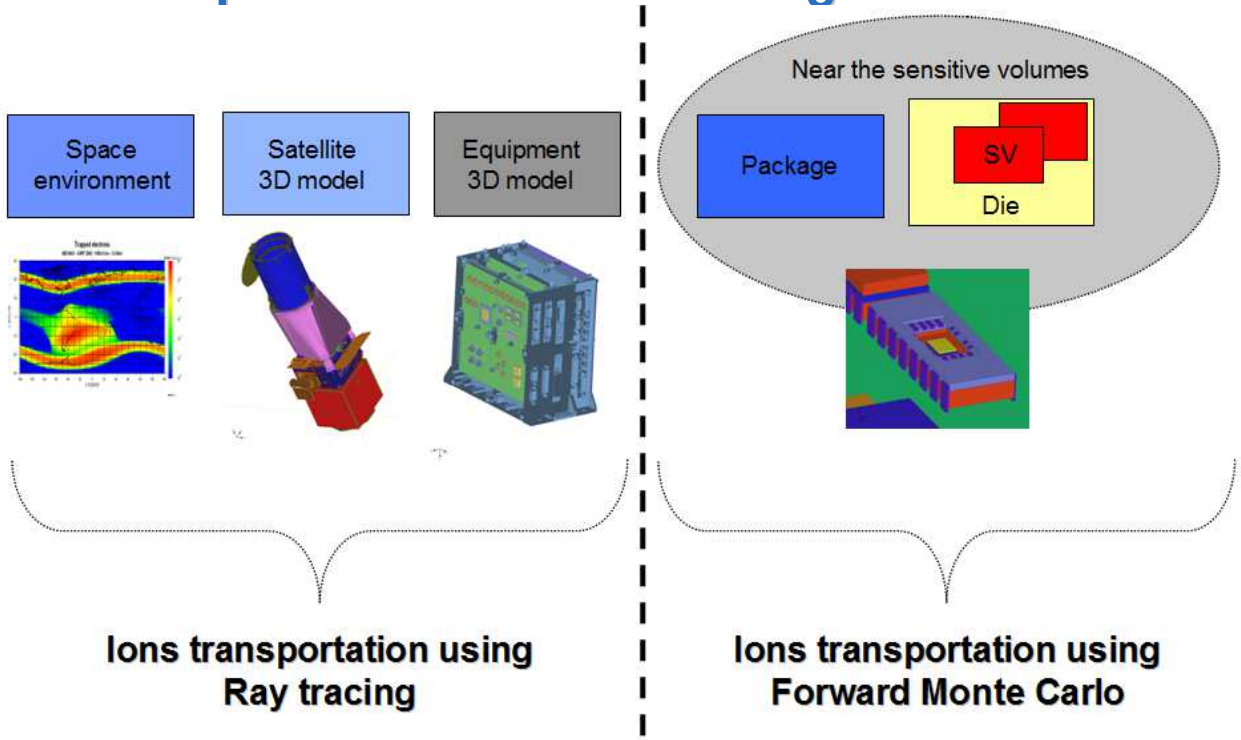
- **Need to create a prediction tool using Monte Carlo capabilities:**
  - Considering the shielding/materials around the sensitive area,
  - Charge deposition based on deposited energy through realistic particle interactions

- **Others characteristics:**
  - Generalist regarding the IC type and the SEE type to predict,
  - Allowing to study isotropic environments (SEE rate prediction) and also irradiation beams (cross section analysis)

# First generation

- **2012 - 2013 :**

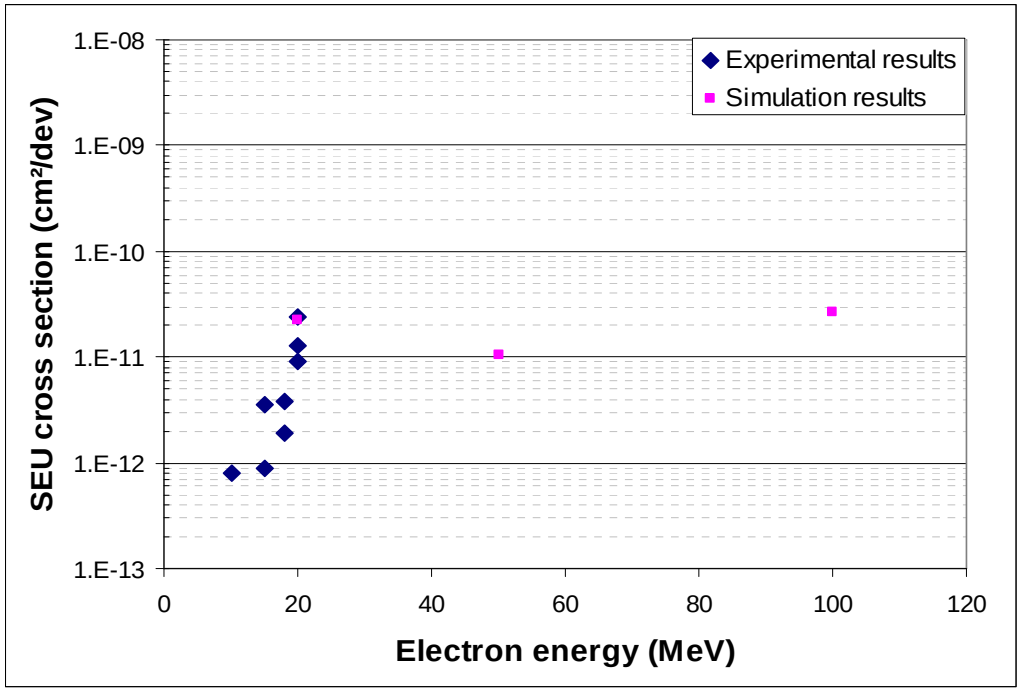
**SEE rate estimation tool taking into account physical interaction processes and shielding**




**Deposited charges in the sensitive volumes are calculated**

# First generation

- **E.g. Cross section simulation vs tests (electrons)**

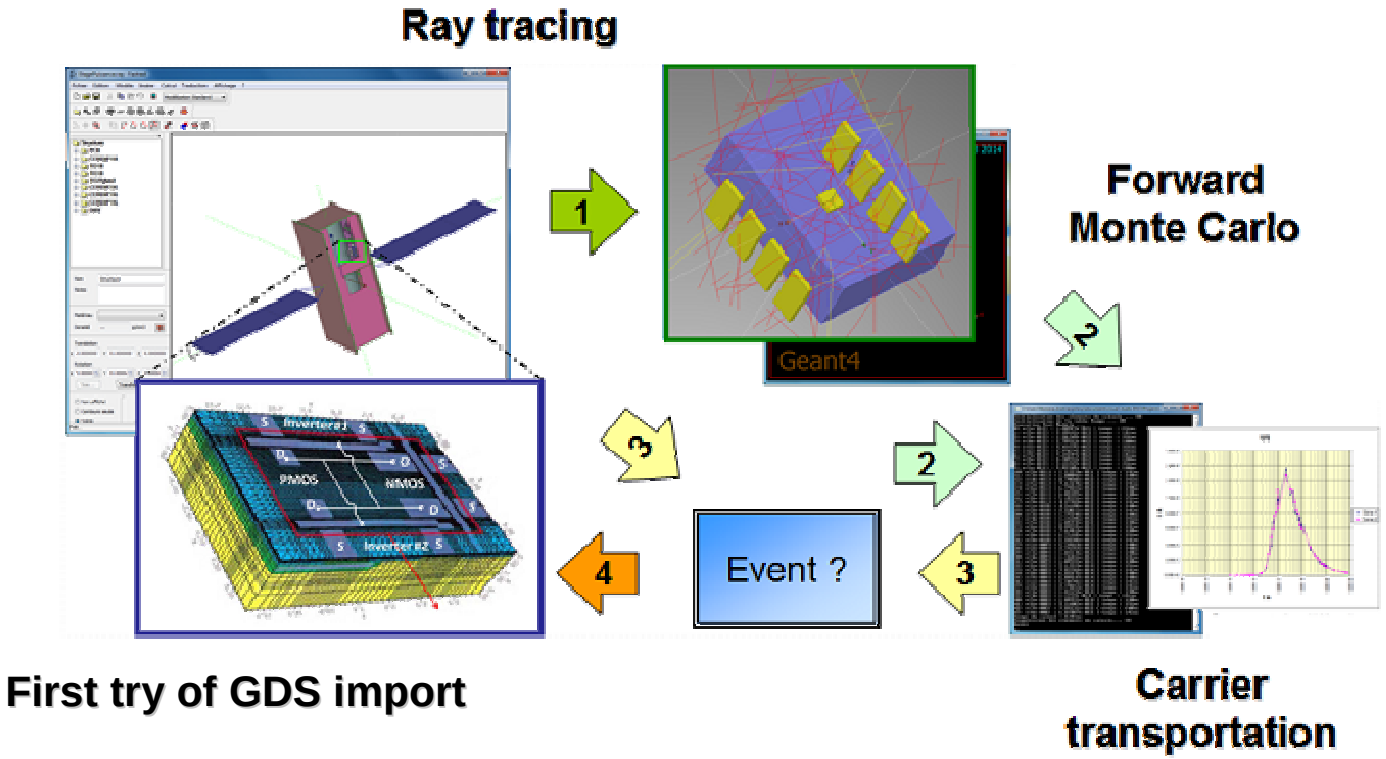



**Calculation parameters (critical charge, sensitive volume thickness and area) were defined using test data**

# Second generation

- **2014 :**

## 2nd generation of the SEE rate estimation tool




**Carrier transportation models were introduced to take into account the carrier diffusion to collection area through substrate**

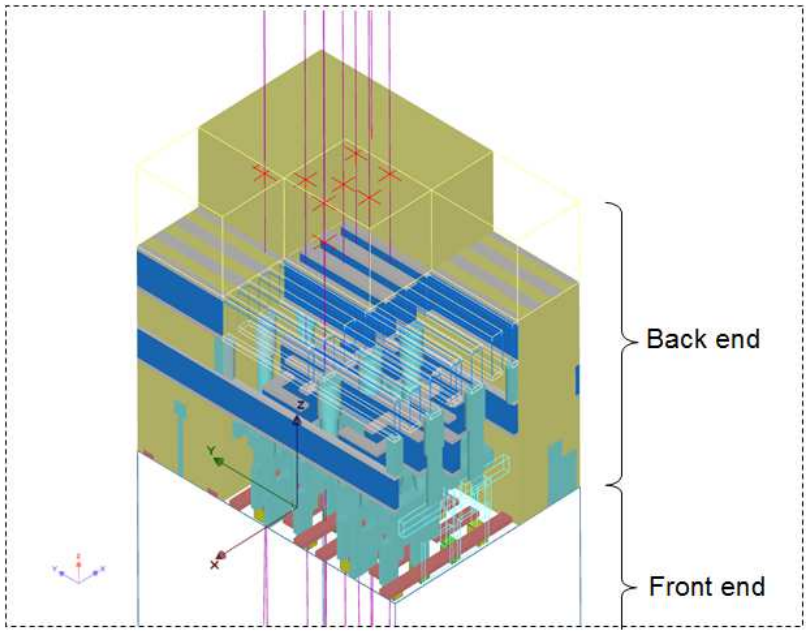
# Second generation

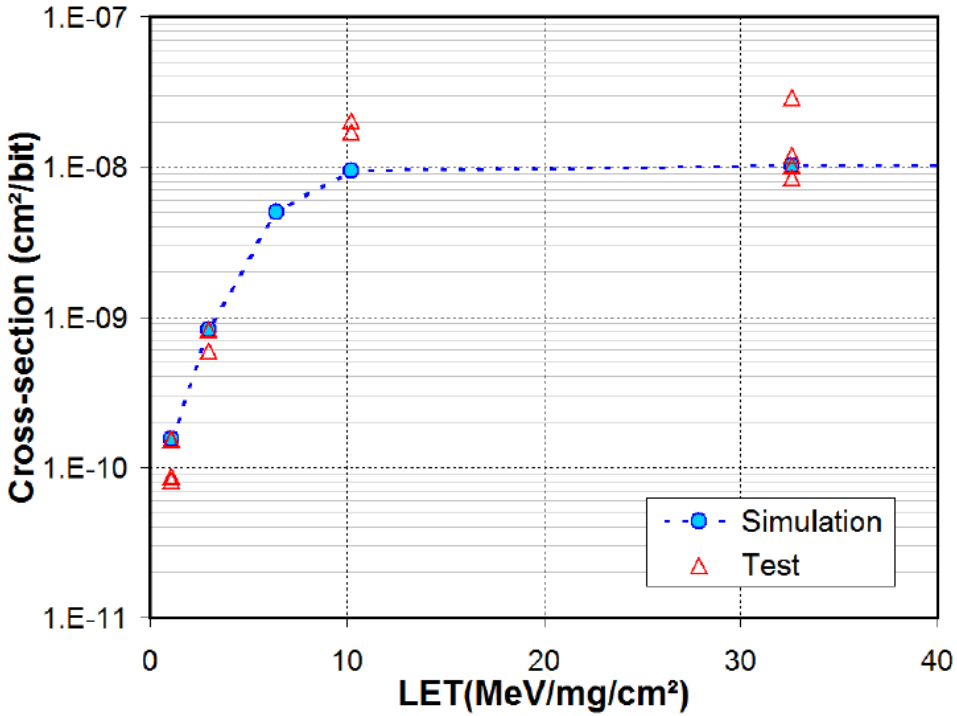
- **E.g. Cross section simulation VS test (cocktail of ions)**

**SRAM matrix of 9 cells built in the tool using its modeler**

ions

$^{84}Kr$ $^{40}Ar$ $^{20}Ne$ $^{13}C$



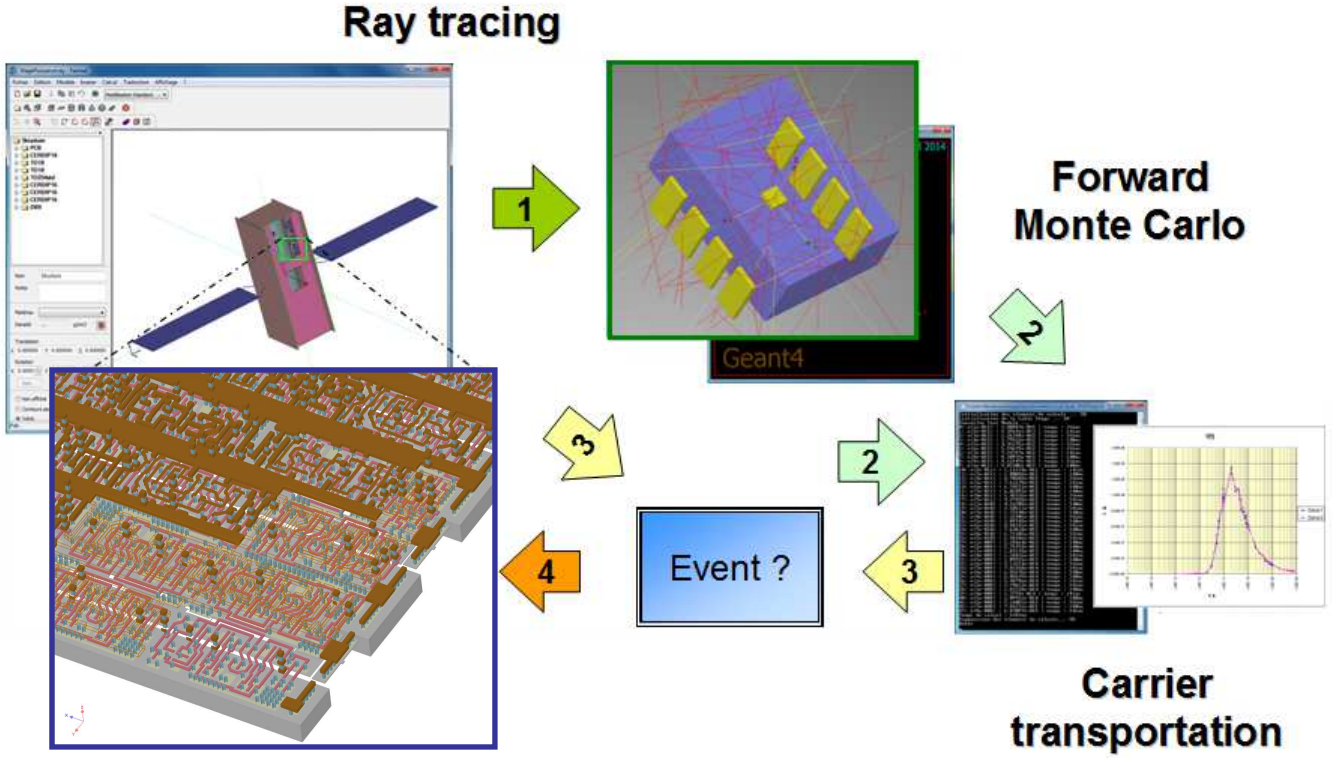




**Only critical charge had to defined using test data**

# Third generation

- **2015 - 2017 :**

  **Several enhancements based on GDS, TCAD, and SPICE**



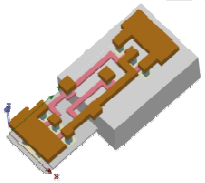

**Integrated Circuit design from GDS**

**From now on, the IC model can be automatically built**

# Third generation

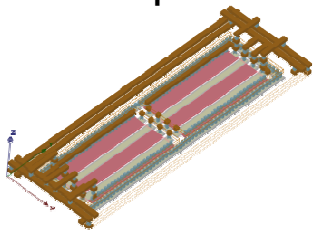
- **2015 - 2017 :**

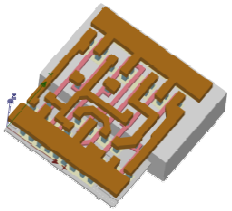
## GDS import examples



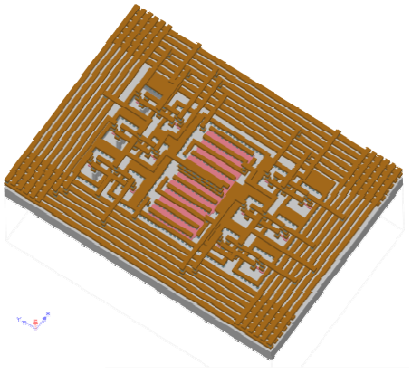
NAND gate 4T

Differential amp 4T

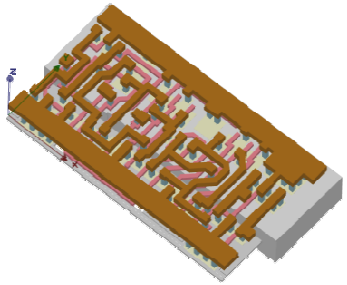




Adder 12T

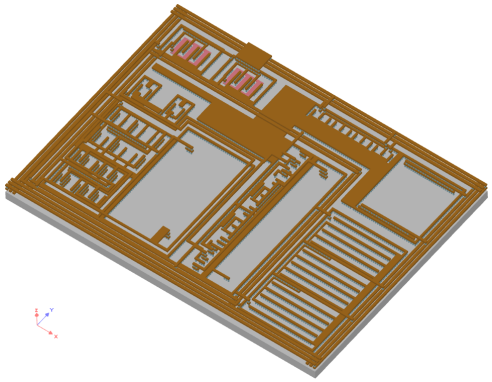


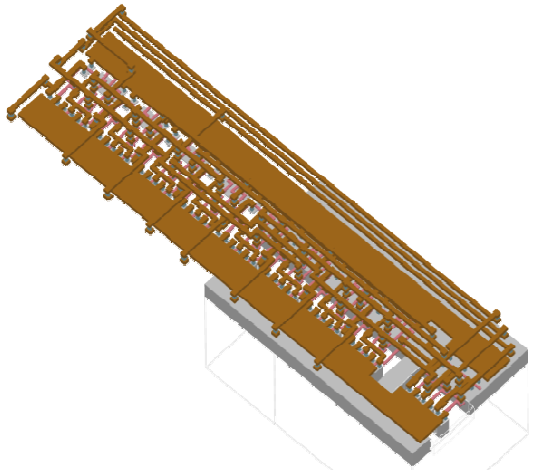
Current mirror 16T



Flipflop 30T

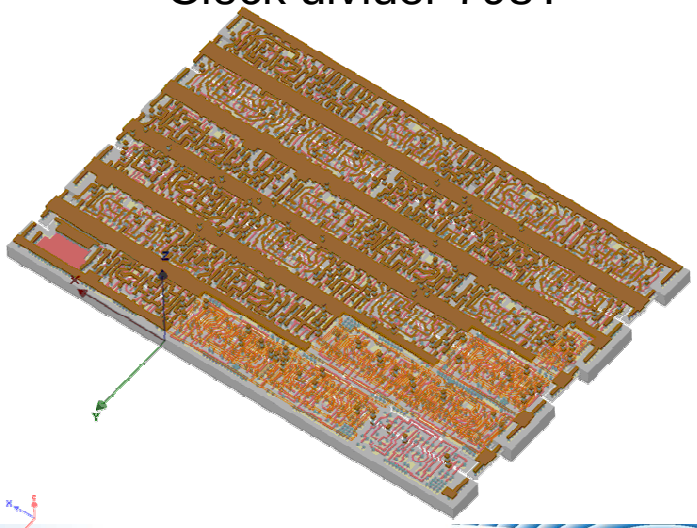
Recopy amp 54T





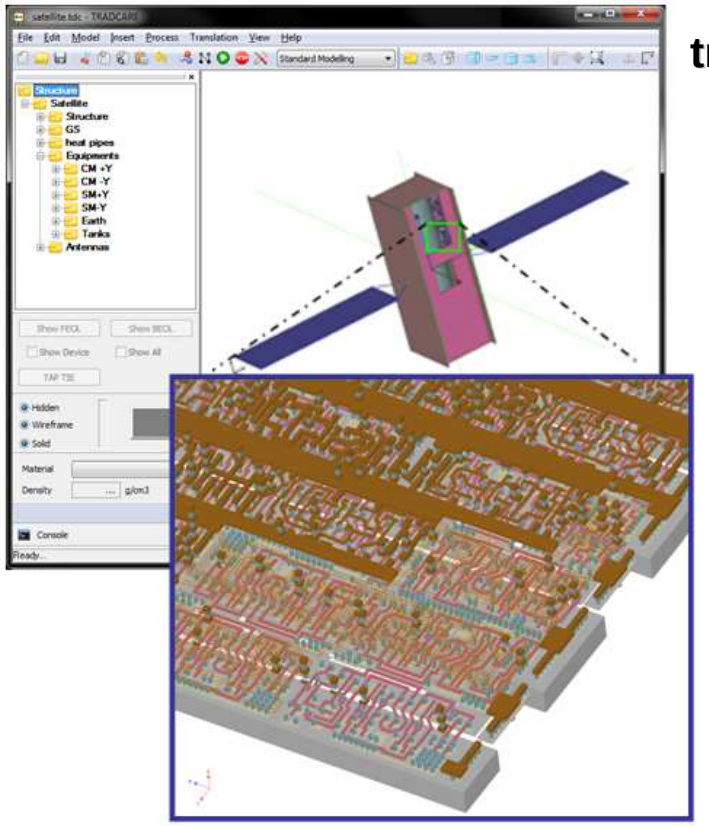
3to8 decoder 70T

Clock divider 798T



# Third generation

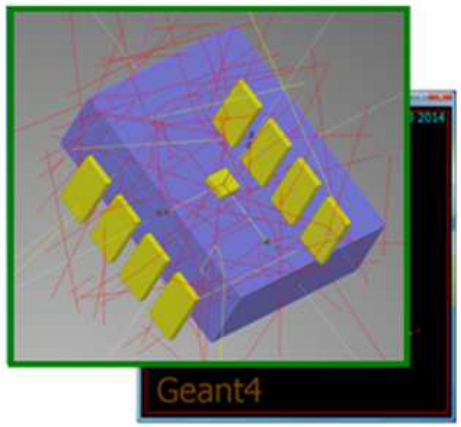
- Carrier transportation based on device simulation (TCAD tool)



IC design from GDS

Ray tracing

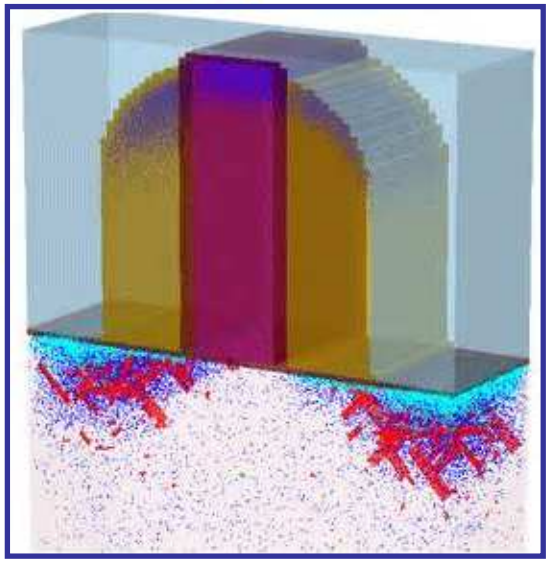
1




Forward Monte Carlo

2

Device simulation



3

2

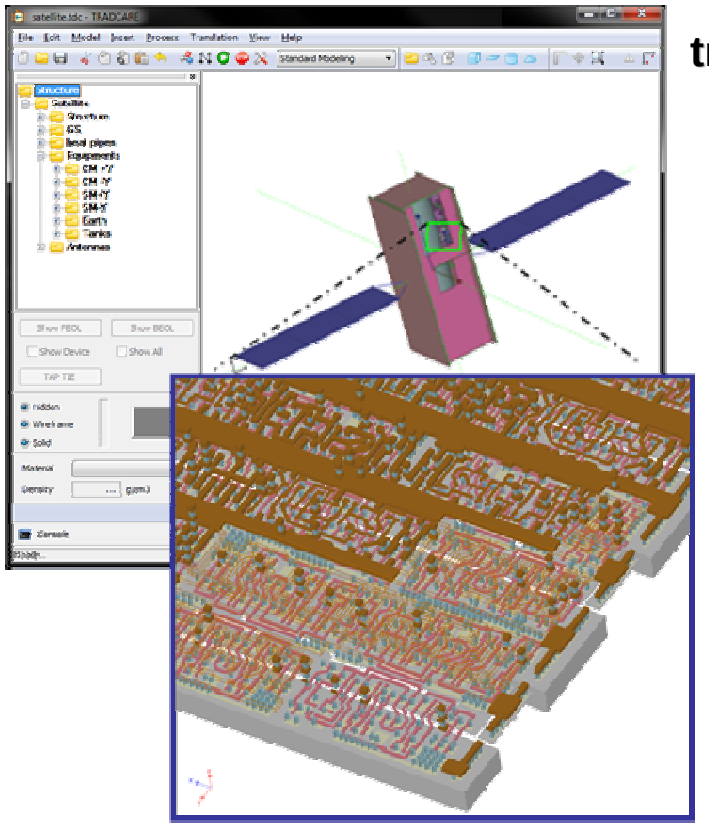
4

Event ?

3

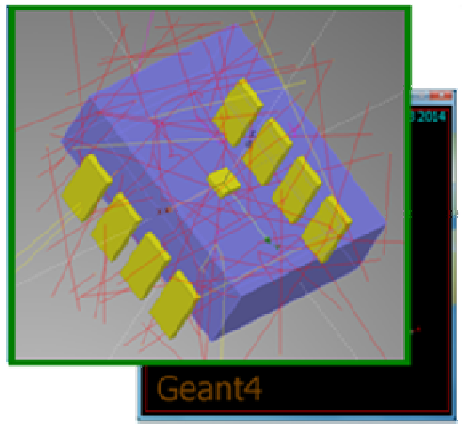
# Third generation

- Event detection based on electrical simulation (SPICE-like tool)



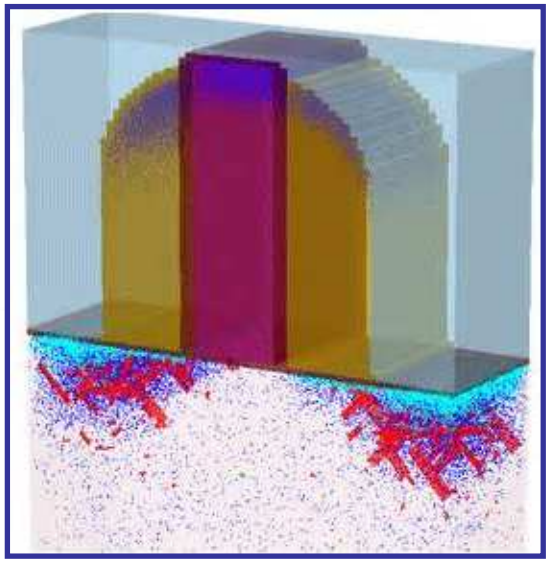
IC design from GDS

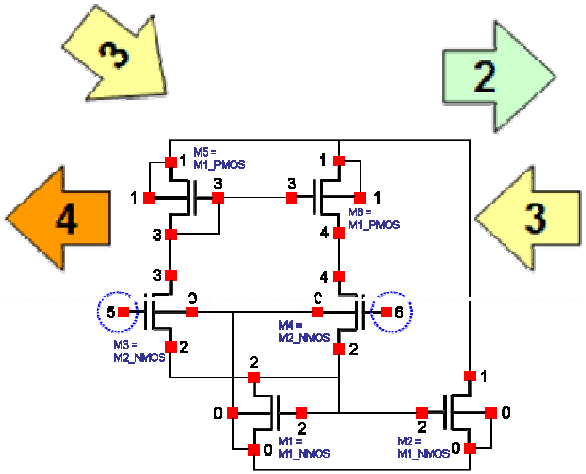
Ray tracing




Forward Monte Carlo

Device simulation

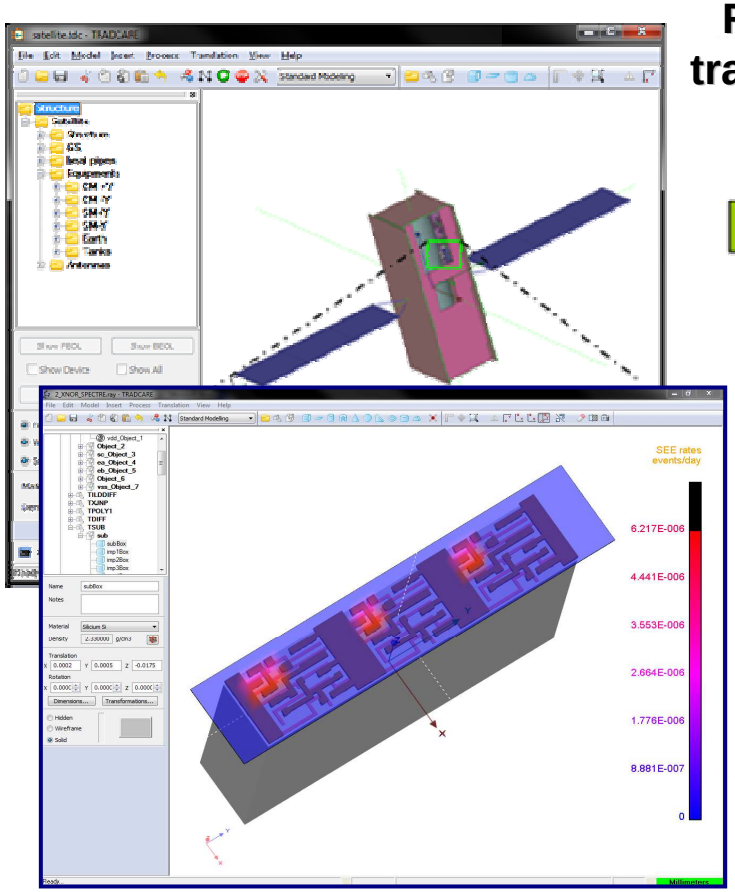





Electrical simulation

# Third generation

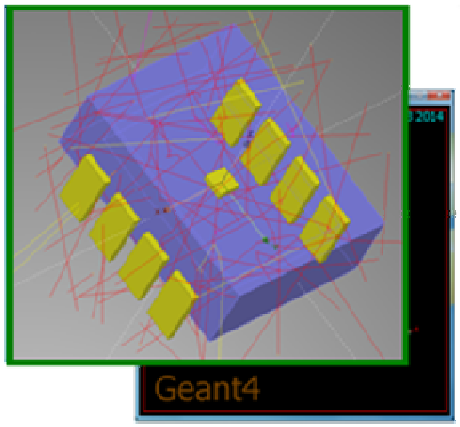
- **Graphical representation of the IC sensitivity**




**Post-processing**

**Ray tracing**

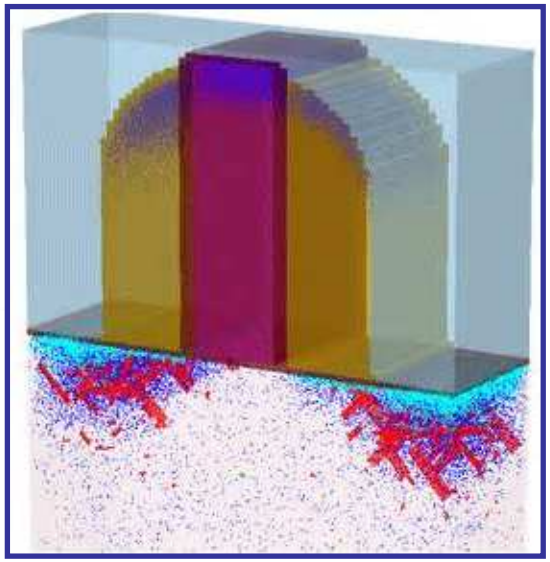
1




**Forward Monte Carlo**

2

**Device simulation**

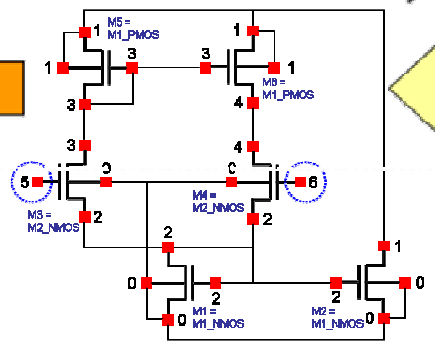


3

2

4

3




**Electrical simulation**

# To recap

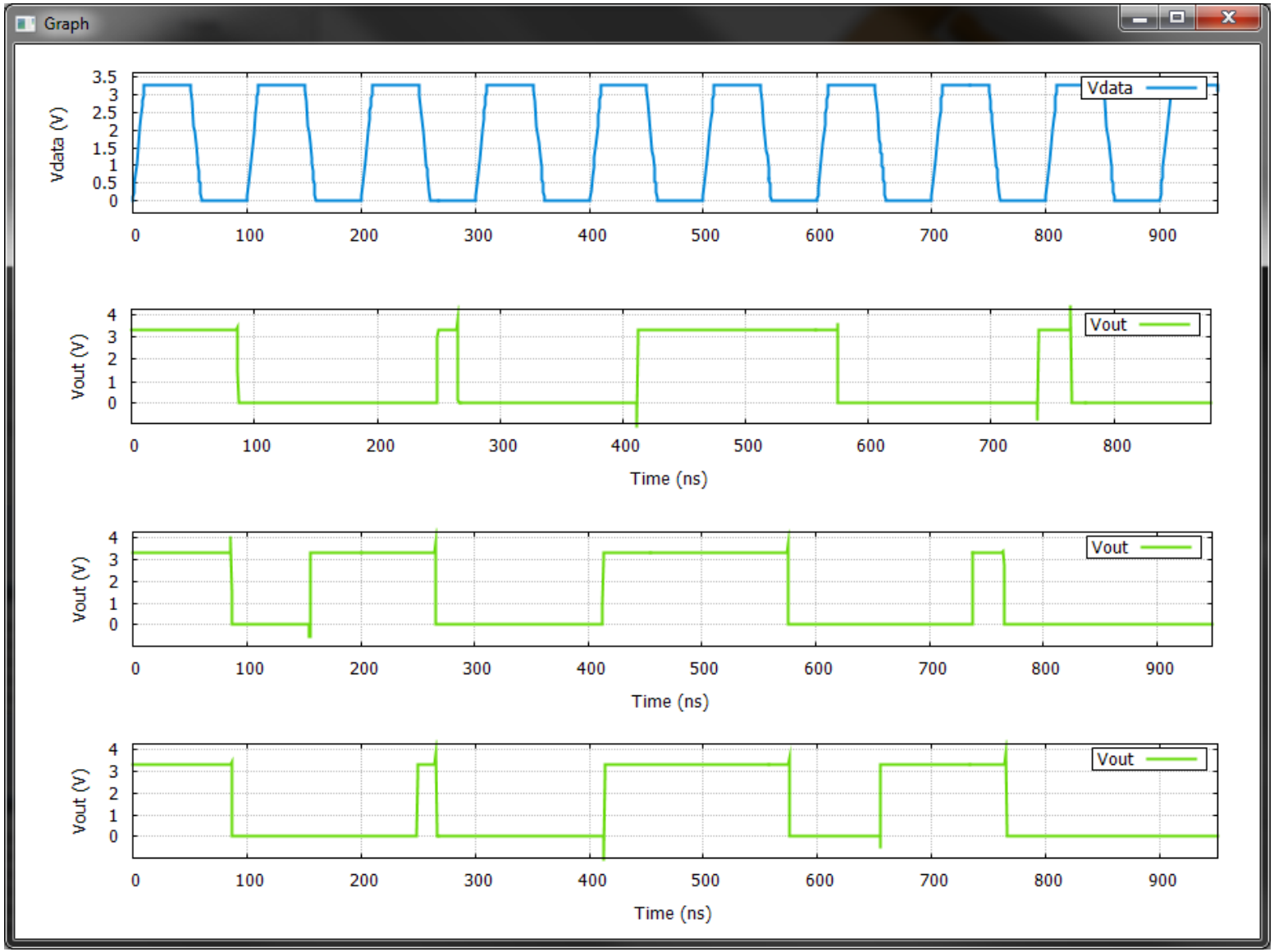
## Prototype in a validation phase

- **Including**:
  - IC model from GDS
  - Ions transportation based on Ray Tracing and Forward Monte Carlo
  - Carrier transportation based on device simulation (TCAD tool)
  - Event detection based on electrical simulation (SPICE-like tool),
  - IC sensitivity mapping

- **Generalist tool**
  - Predictions possible for different types of SEE : SEU/MBU, SET, SEL
  - Prediction method not specific to a certain IC technology
  - On-going validation with CMOS technology
  - Open to expand the validation to other technologies

# TRACARE Demonstration

# Event detection



# Actual version

- **From system to circuit**
  - → Taking into account the satellite shielding