Development of Predictive Single Event Latchup Model

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Laurence Montagner

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SELEST

- **Development of internal SEL prediction tool funded by the CNES, French space agency**

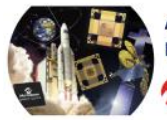
- **2 posters presented at RADECS (2019 and 2021)**

New Approach of Single Event Latchup Modeling Based on TCAD Simulations and Design of Experiment Analysis

D. Truyen, L.Montagner

A Neural Network Approach for Single-Event Latchup Prediction Based on TCAD Simulations in CMOS Technology

D. Truyen, E Leduc, L.Montagner, M.Briet, A. Collange



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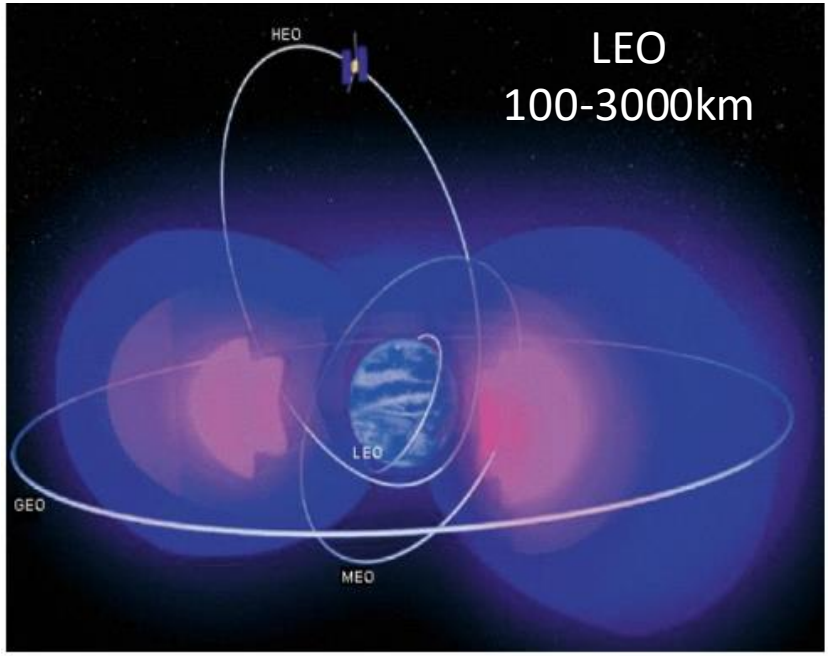
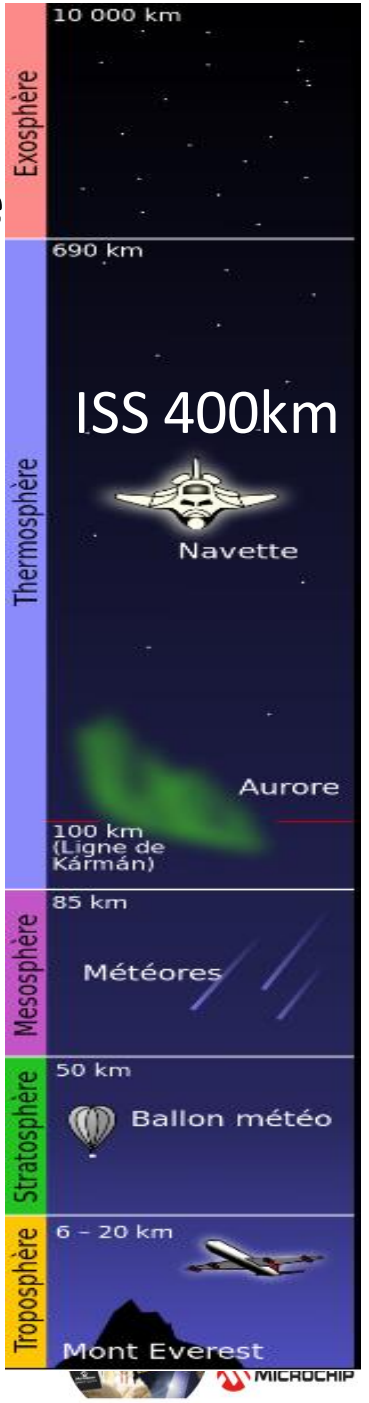
Context

- **To address the new space market “low cost”, COTS (circuits on the shelves) are evaluated and “hardened” to radiation to meet space agency specifications.**

→ Need to analyze of a lot of products to estimate quickly their radiation behaviour and their ability to be hardened before any expensive experimental test.



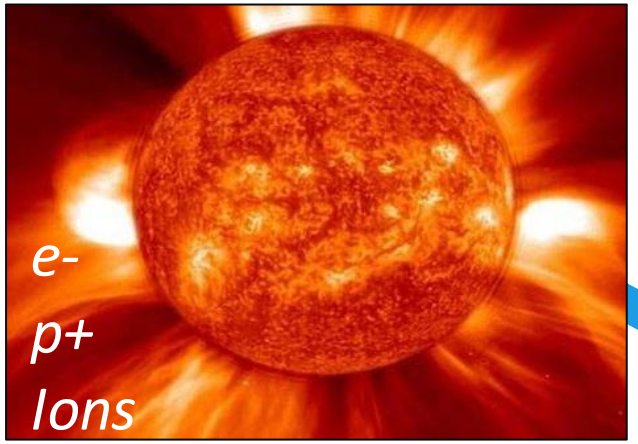
GEO : Geosynchronous Earth Orbit
MEO : Medium Earth Orbit
LEO : Elliptica Low Earth Orbit
HEO : Highly l Orbit



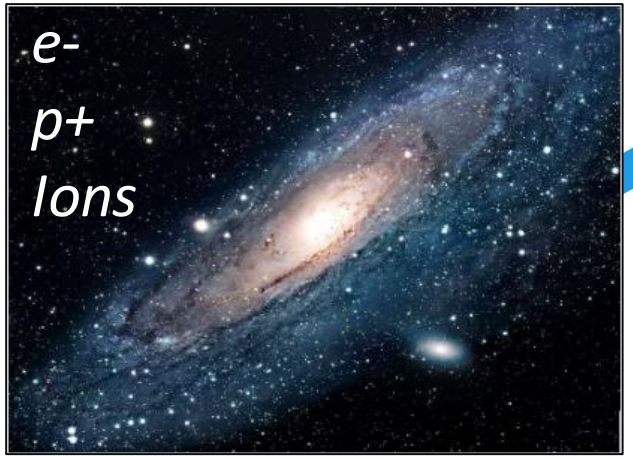
Context

Radiations impact on Electronic Circuits

1- The sun

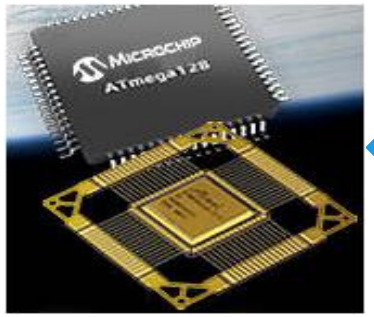


2- Cosmic Rays

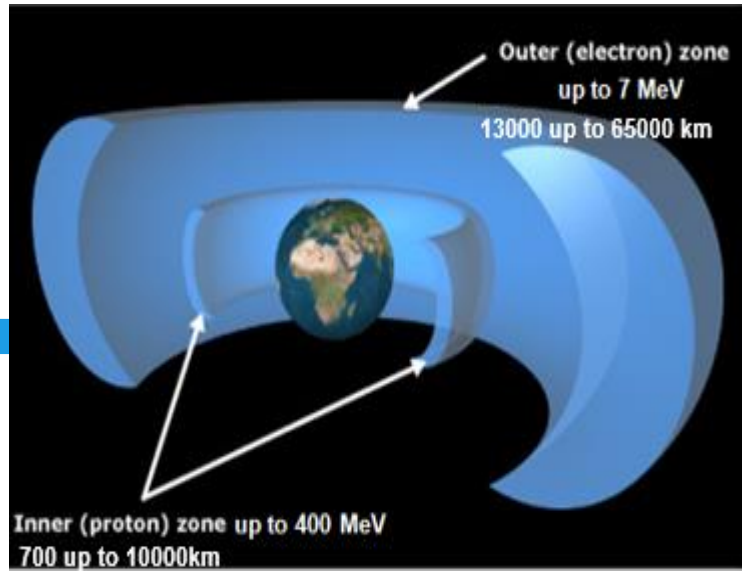


Radiation effects

SEE / TID



3- Van Allen Belts



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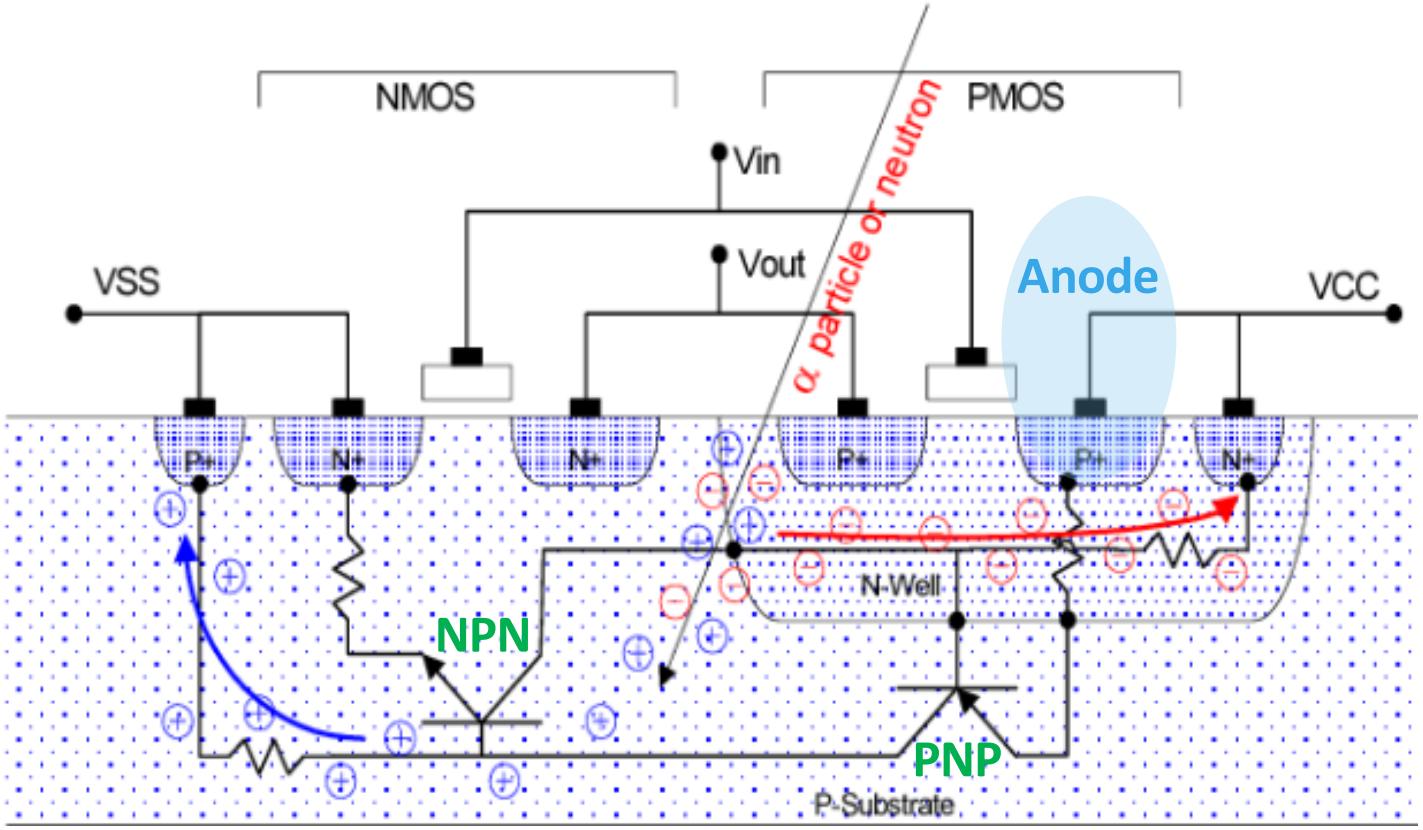
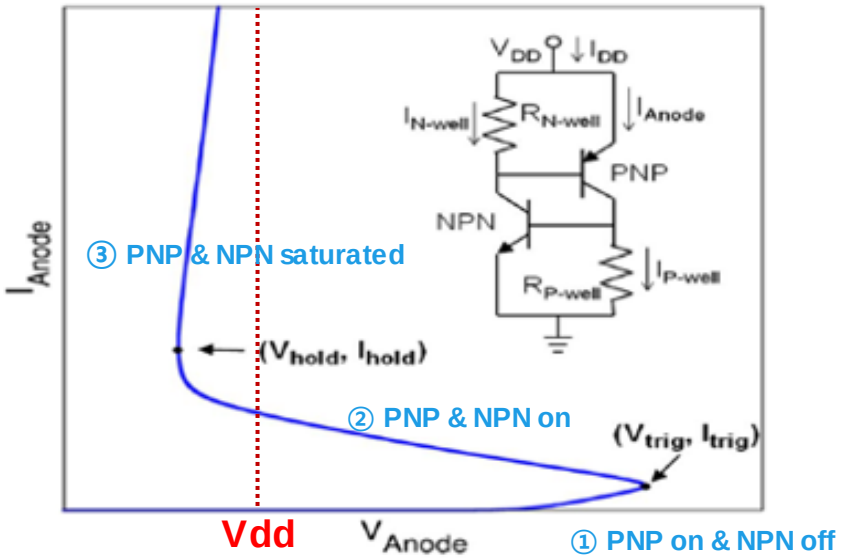
Focus on Single Event Latchup (SEL)

Mechanism

- SEL is a critical effect with catastrophic impact on space craft systems
- SEL is a triggering of the parasitic thyristor (2 parasitic bipolars: NPN & PNP)





If an energetic particle produces:

- $I_{Anode} > I_{trig}$
- $\beta_n . \beta_p > 1$
- $V_{DD} > V_{hold}$

} **SEL will occur**

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Single Event Effects – Charged Particles

Linear Energy Transfer - LET

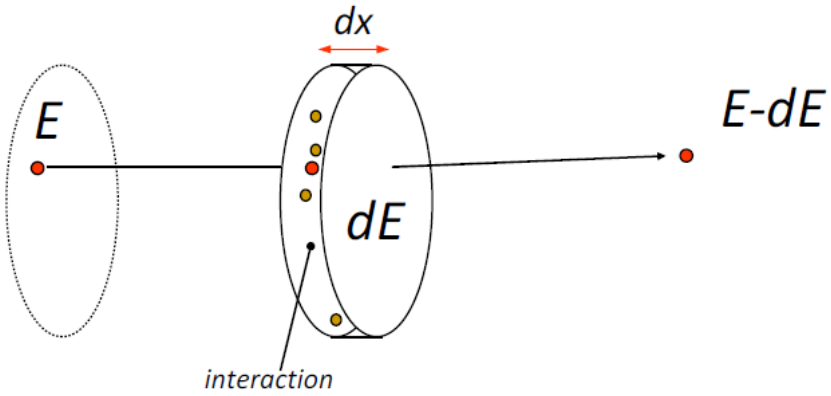
- **Direct ionization (ions): Linear Energy Transfer electronic (LET)**

Heavy-ions are described by amount of energy lost in the matter per unit track length in the considered material

LET:

- dE/dx= MeV/cm
- Material density = mg/cm^3

$$LET = \frac{dE}{dx} \times \frac{1}{\rho} \Rightarrow \frac{MeV}{cm} \times \frac{1}{\frac{mg}{cm^3}} \Rightarrow MeV.cm^2/mg$$



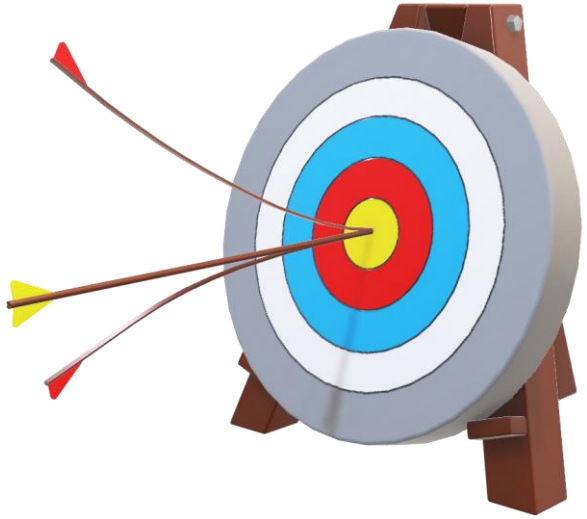
- The parasitic currents increase with the LET
- 100 MeV.cm2/mg = ~ 1pC/µm in the Silicon

ESA Criteria: immune to latchup >60MeV.cm²/mg

Objective

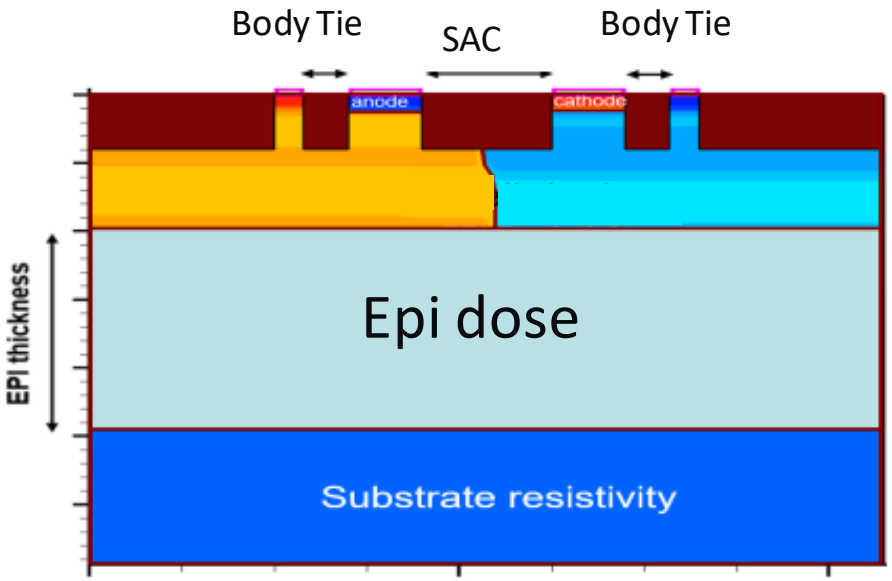
- Implementation of an analytical prediction model based on calibrated simulation

- Prediction of SEL sensitivity :
  - Vhold
  - LETth



Input and Output definition

- **TCAD Sentaurus view of inverter**



Input	Output
SAC	Vhold
Body Tie	LETth
Epi Thickness	
Epi dose	

LET_{th}, V_{hold}

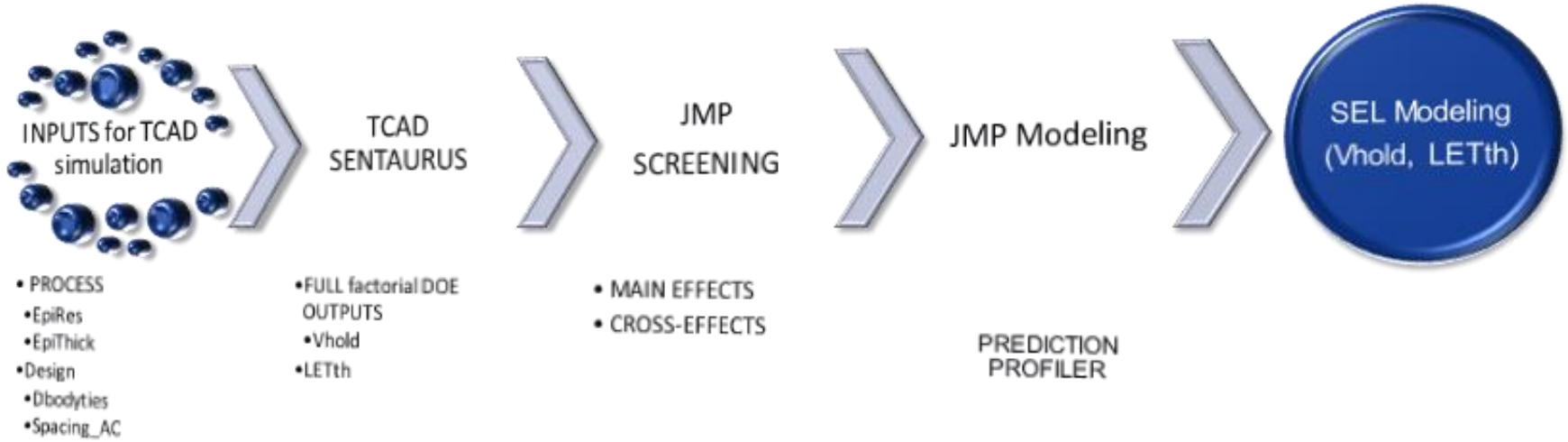
$V_{hold} > Vcc \rightarrow$ No SEL, $LET_{th} > 60$ MeV.cm^2/mg

$V_{hold} < Vcc \rightarrow$ SEL possible, LET_{th} ? $\rightarrow$ LET_{th} Model

SEL Modeling Flow

Model for SEL prediction:

- LETth and Vhold Versus Input parameters



Model validation with experimental results

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SUMMARY OF HEAVY ION SEL, AND COMPARISON WITH PREDICTIVE MODEL

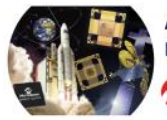
Products	Tech. node (µm)	SEL LET_{th} (MeV.cm²/mg)	
		Pred. Model *SELEST*	Exp.
16-Bit Microcontroller Dual Core	0.09	12.06	< 3.3
16-Bit SPI I/O Expander with Open-Drain Output	0.6	0.34	4.2
16-Bit digital Signal Controller for digital power Applications	0.18	2.64	< 3.6
64-Mbit Serial Quad I/O (SQI) Flash Memory	0.07	62.3	> 78
Ethernet physical layer transceiver	0.065	65.6	64
8-Bit Microcontroller	0.18	33.5	39

Modification of DOE by adding inputs per technology node for better accuracy

Use of neural network models

ELEST Version 2

Thanks for your attention



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