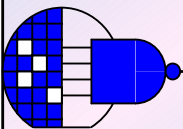


Characterization , simulation and modeling of PLL under irradiation using HDL-A

I.Martínez, P.Delatte and D.Flandre

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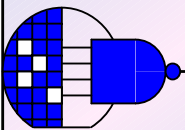


Microelectronics Laboratory

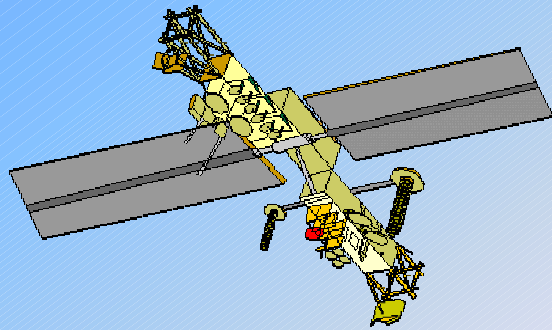


Outline

- Introduction.
- Simulation of transient currents in transistors.
- VCO characterization and simulation.
- PLL block simulation.
- Conclusions.

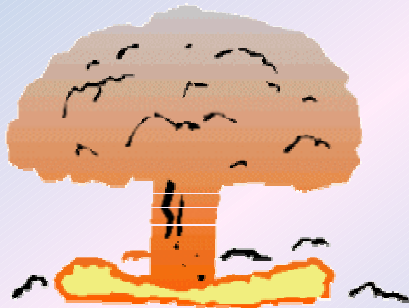
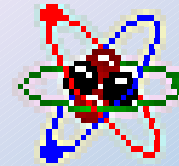


Introduction : Radiative environments

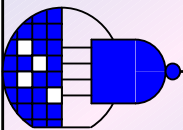


- Space environment.

- Power Plants & accelerators.

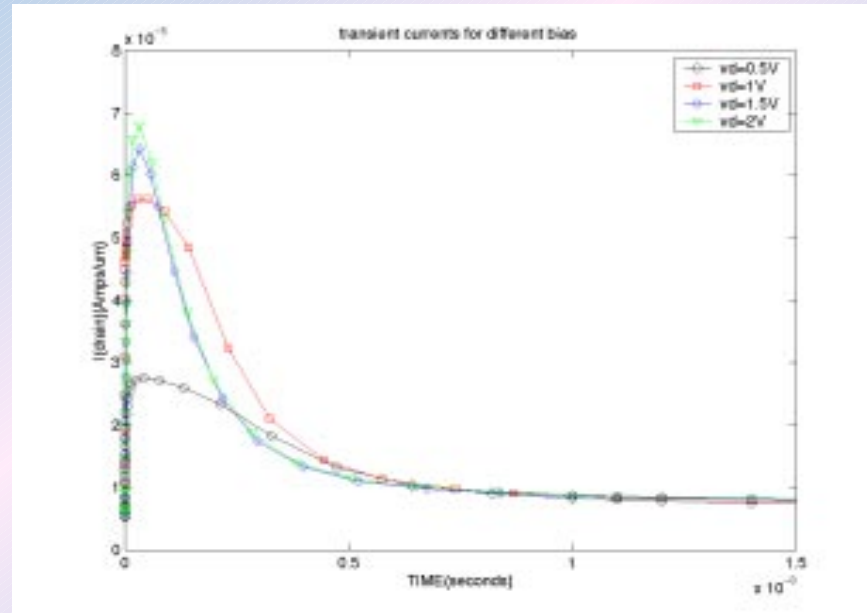
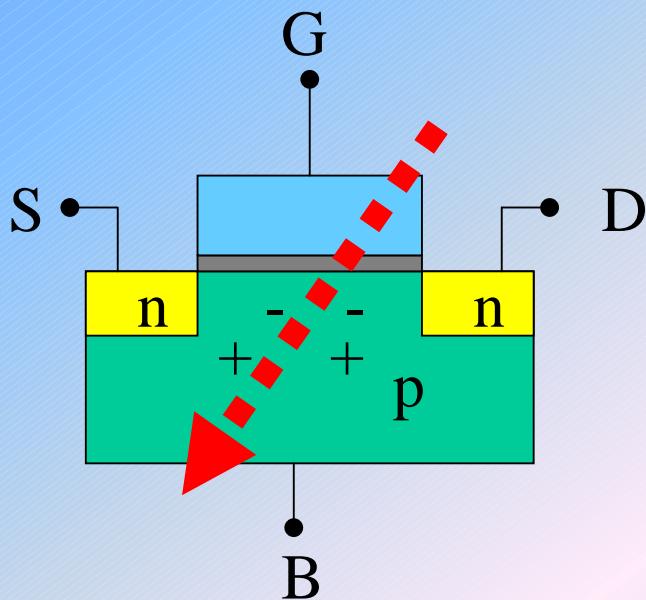


- Military applications.



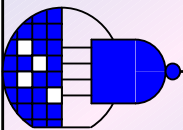
Introduction :

Ionization transient currents

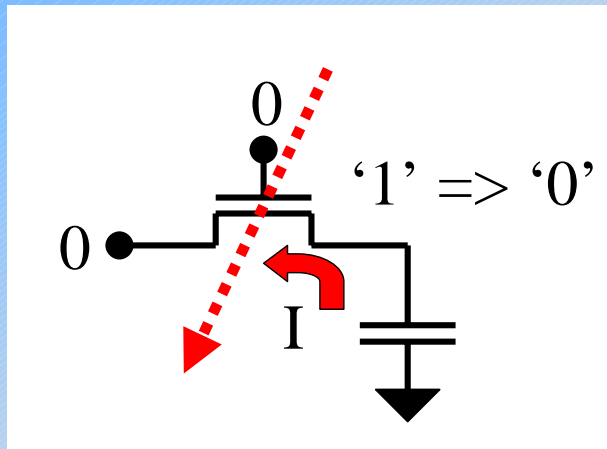


- The high energy particles generates free charges into the Silicon.

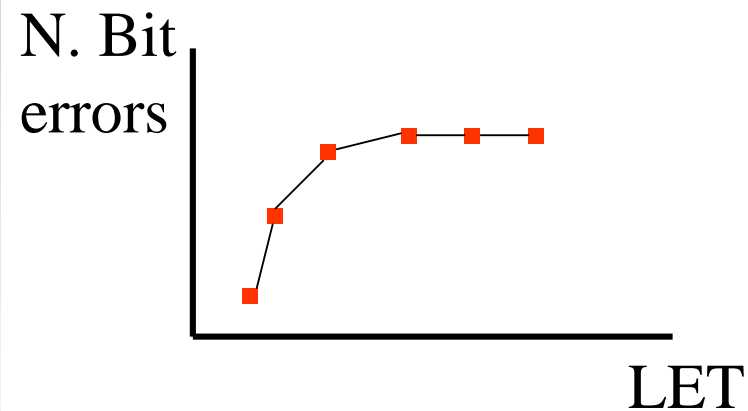
- Ionization currents depends on bias and transistor characteristics.



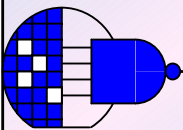
Introduction : Single Event Upsets (SEU)



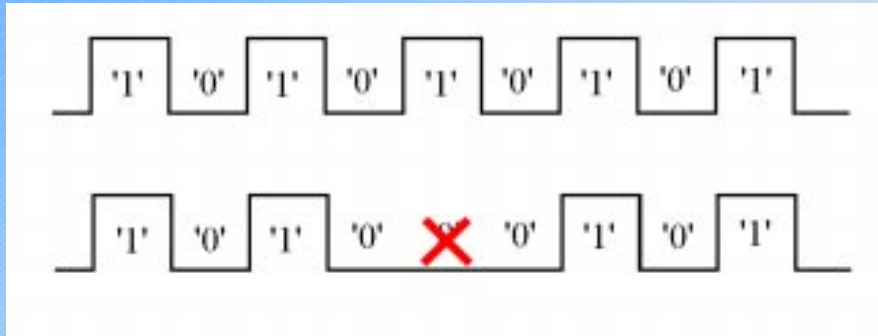
- Transient currents changes the information in the nodes in digital parts.



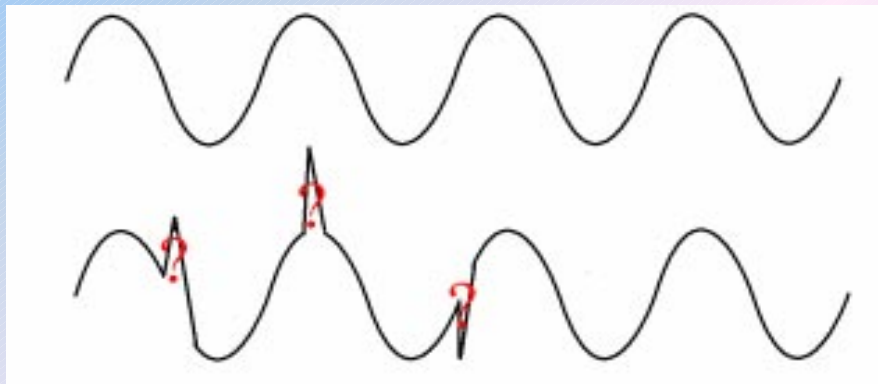
- In digital circuits, the number of bit errors are represented in function of the Linear Energy Transfer of the particles.



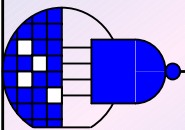
Introduction: Single Event Upsets (SEU)



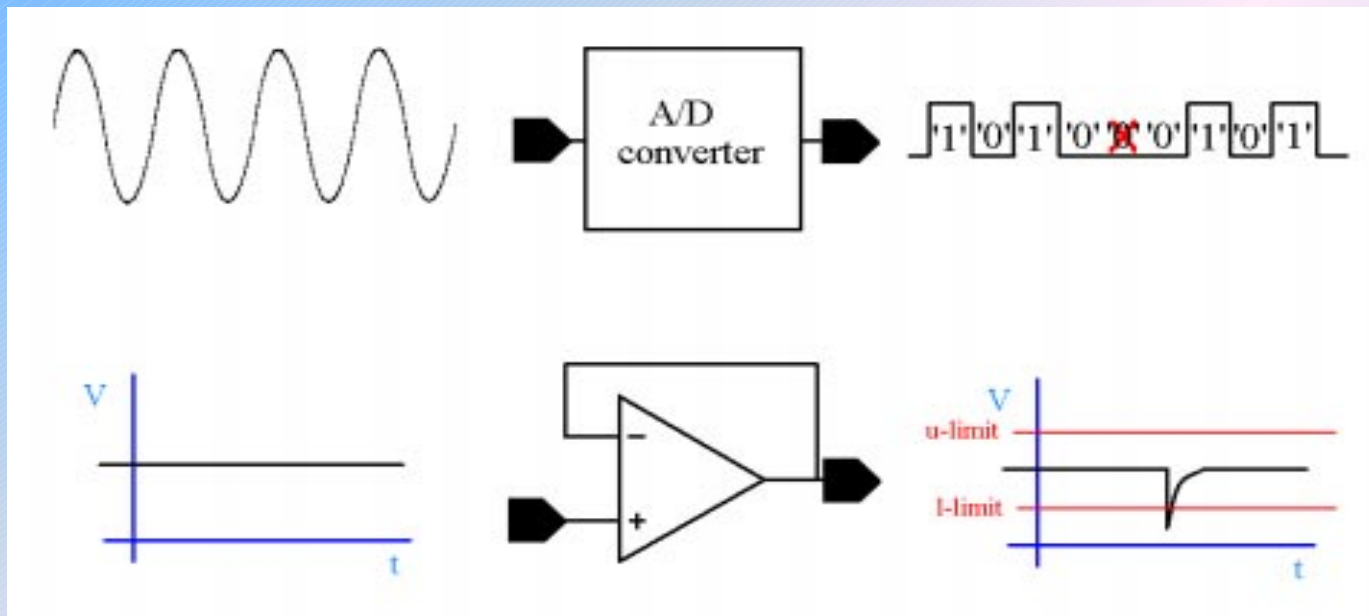
- Digital parts : Information contained in bits \Rightarrow Upset defined by bit changes.



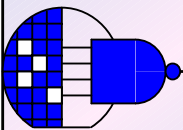
- Analogue parts : Information contained in continuous signal \Rightarrow We must consider continuous changes in waveforms.



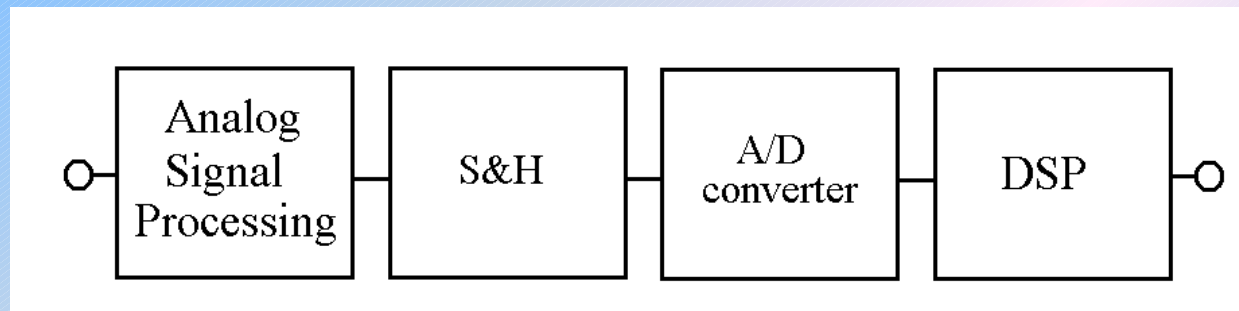
Introduction : Mixed/Analogue SEU def.



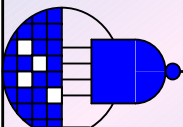
- In A/D converters (mixed circuits) the SEU are defined by changes in the digital output.
- In OPAMPs, SEU are defined by the use of a 'Threshold' Value.



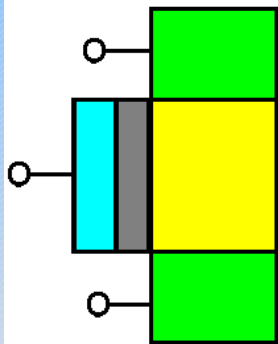
Introduction : Rad-Hard in SoC?



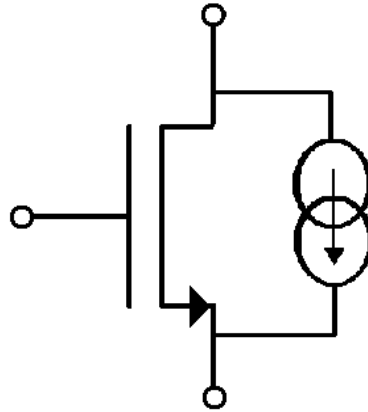
- In digital parts: LET concept can be adopted.
- In M-A parts: perturbation can be propagated or not depending on circuit system.
- Methodology : system simulation to study propagation of perturbation => We must introduce the transient currents in simulator.



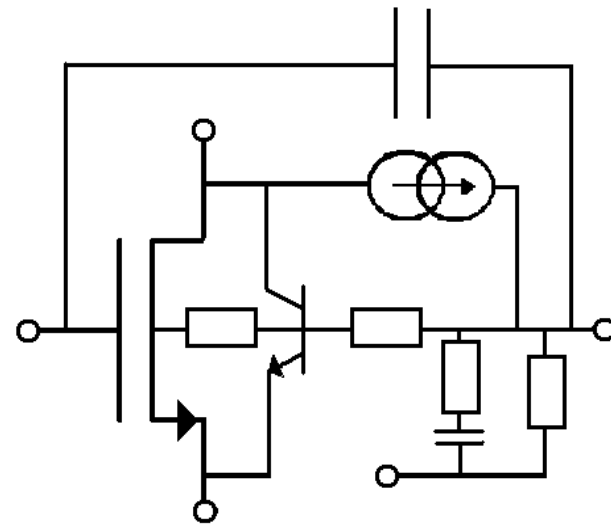
Transient currents in electrical simulators



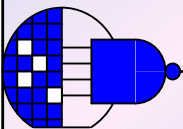
1. Device simulator
in mixed mode



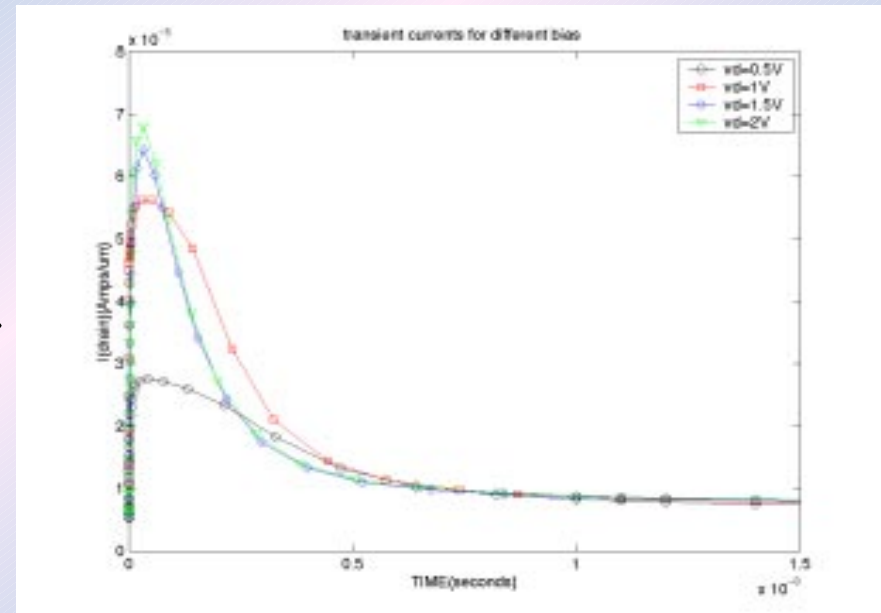
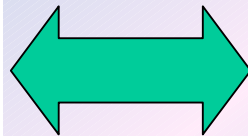
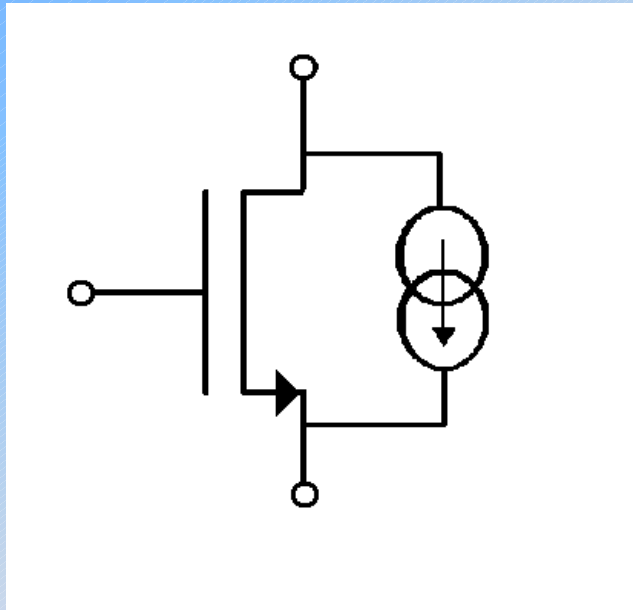
2. PWL current source



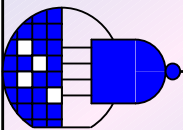
3. Complet transistor
model



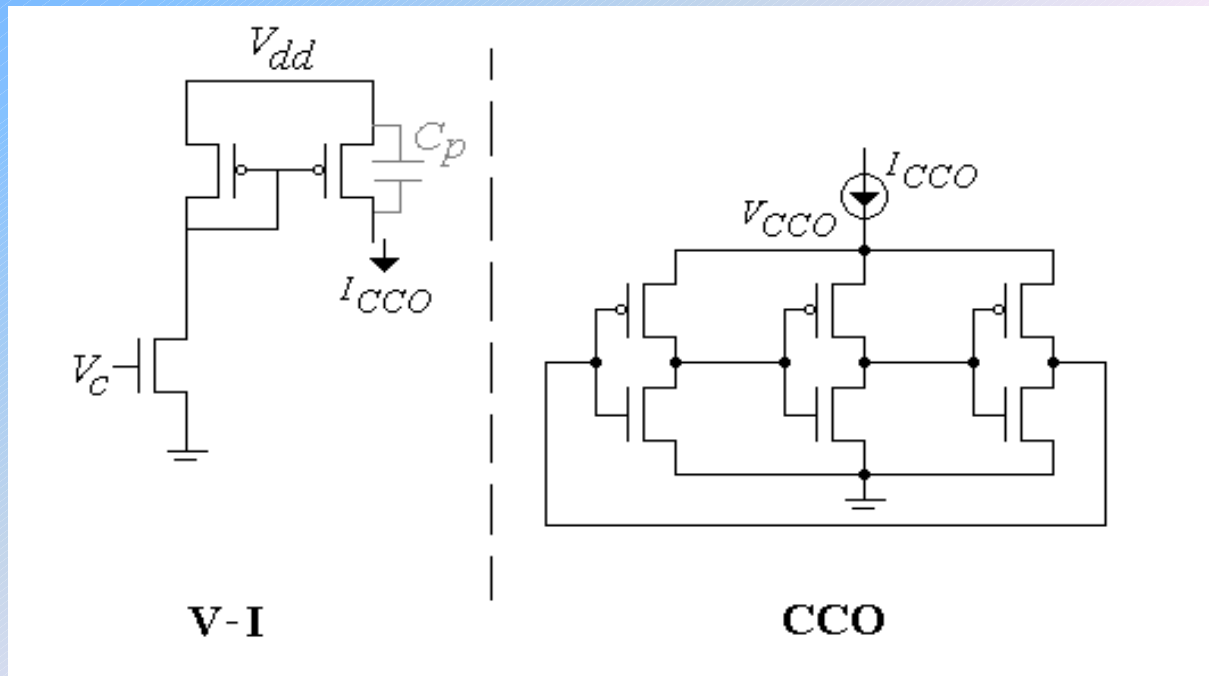
HDL-A transient current source



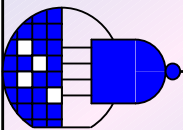
Use of HDL-A as interface between data archives and SPICE



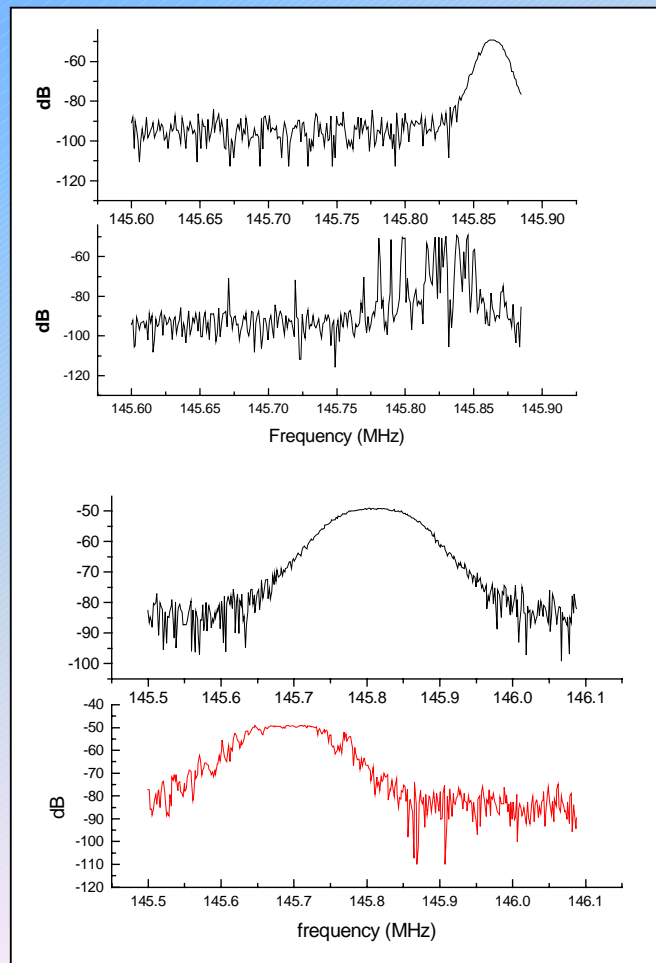
Study of VCO: schematic



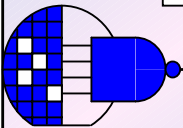
- VCO based in CCO architecture.
- SOI Fully-Depleted $1\mu\text{m}$ -UCL technology.



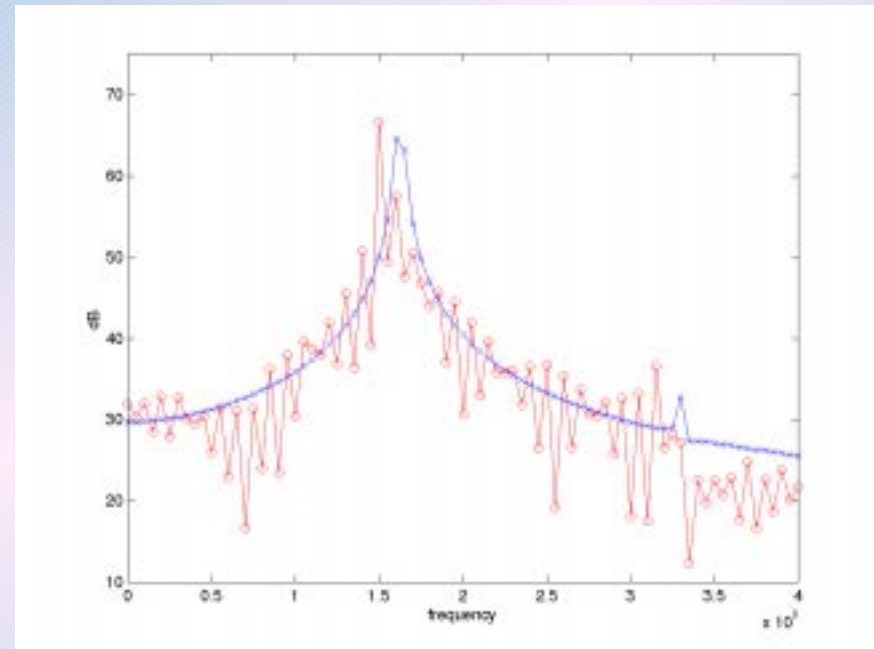
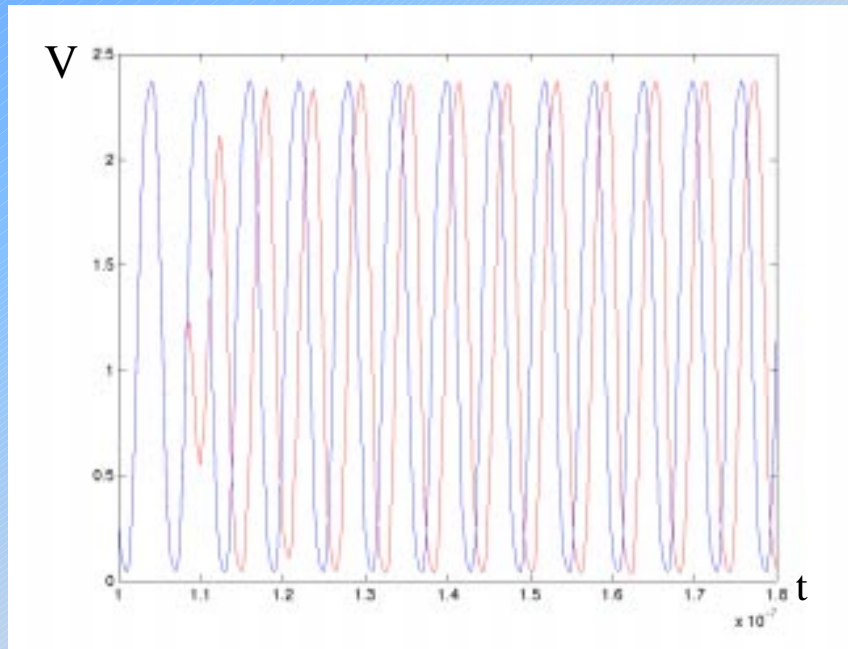
Study of VCO : experiment results.



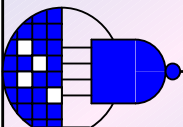
- Experiment carried out in the CRC.
- Heavy Ions ($^{132}\text{Xe}^{26+}$ (LET=55,9 MeV/mg/cm²) .
- Peaks in the Spectrum.
- Average frequency changes.



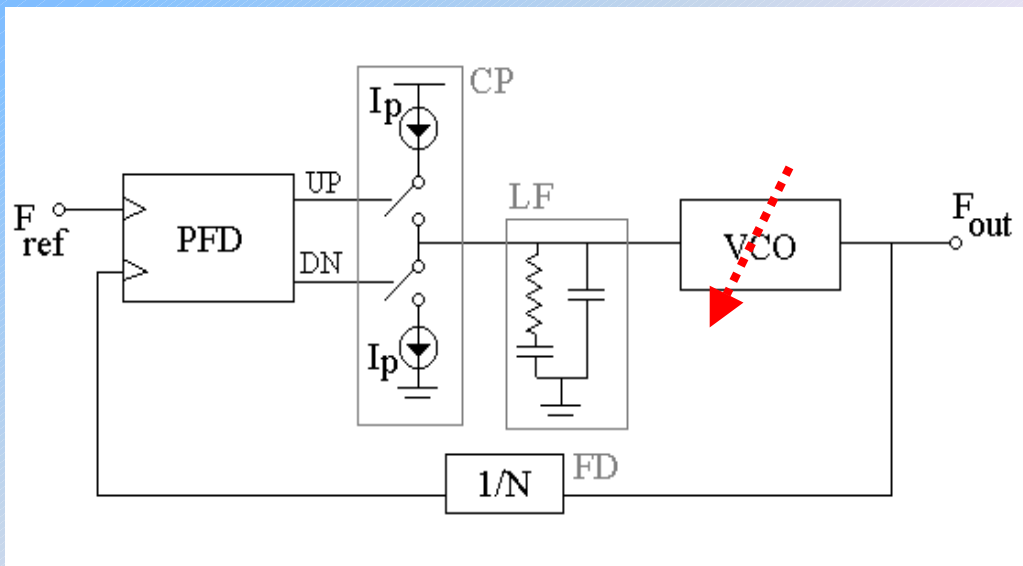
Study of VCO: simulation with transient current sources



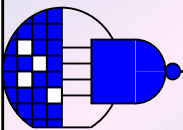
- Phase changes in time domain (jitter).
- Peak apparition.
- Change in main frequency.



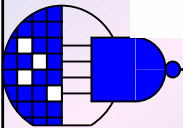
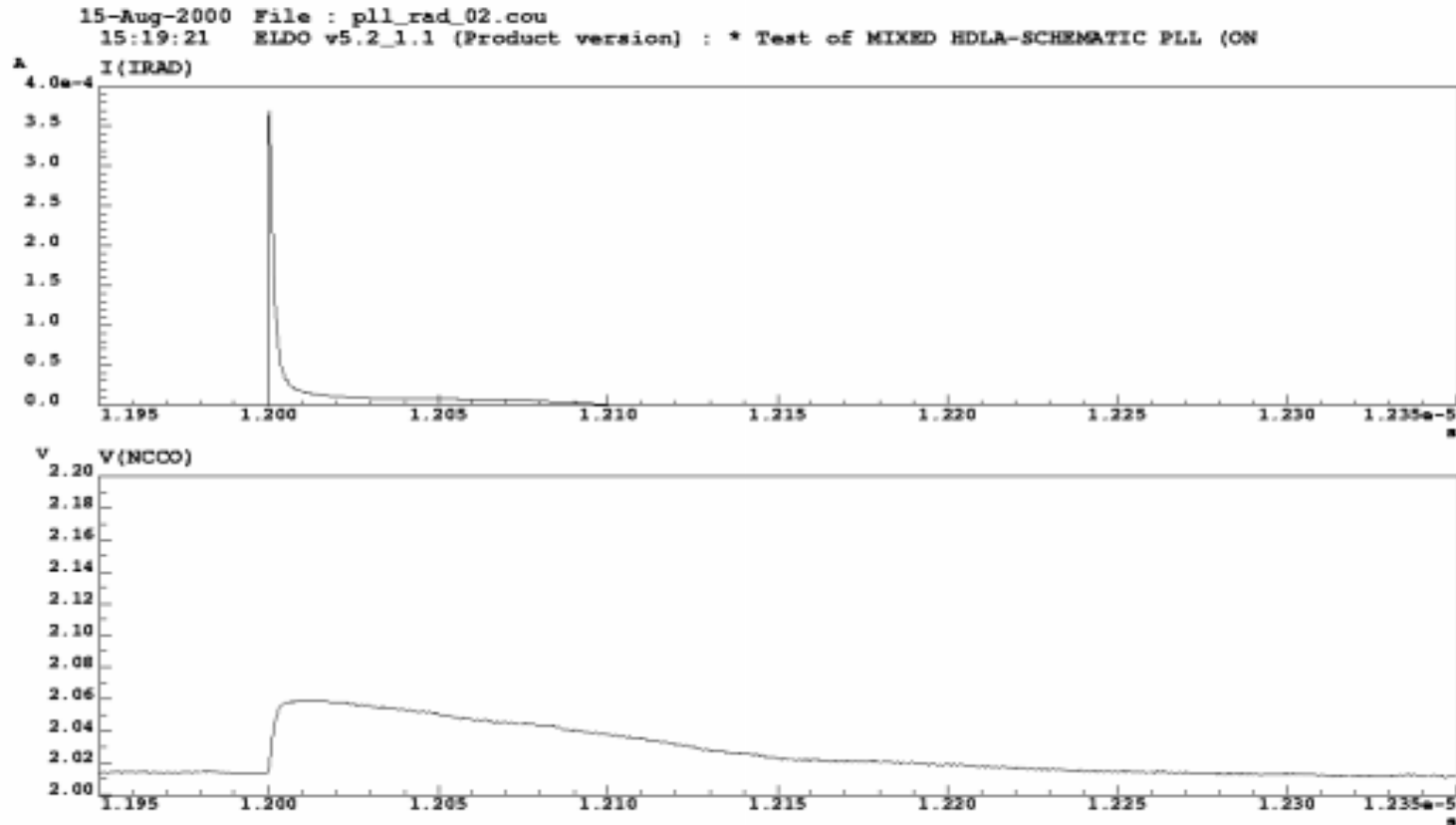
Study of PLL: characterization under irradiation



- The overall PLL is simulated to obtain the response to irradiation.
- VCO is simulated like schematic with transient currents.
- The rest of PLL blocks are implemented in HDL-A.

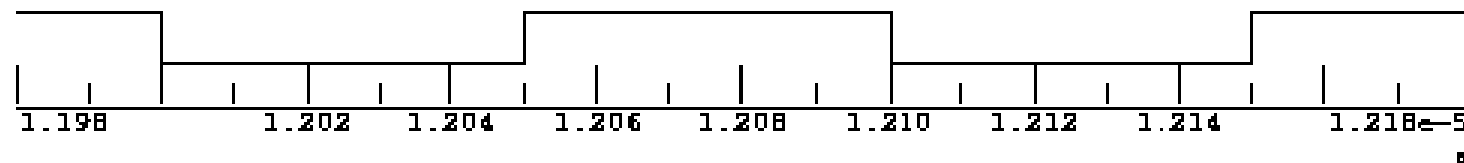


Study of PLL : Simulation results

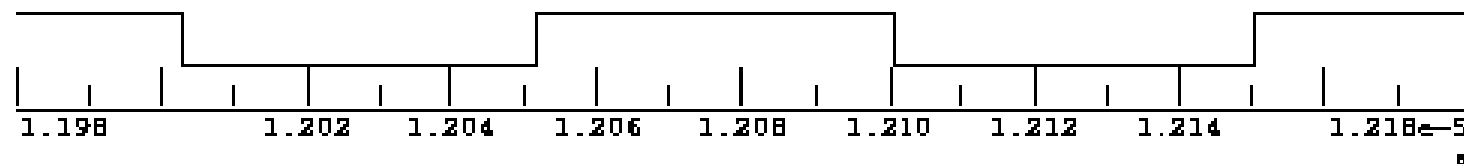


Study of PLL: Simulation results

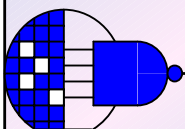
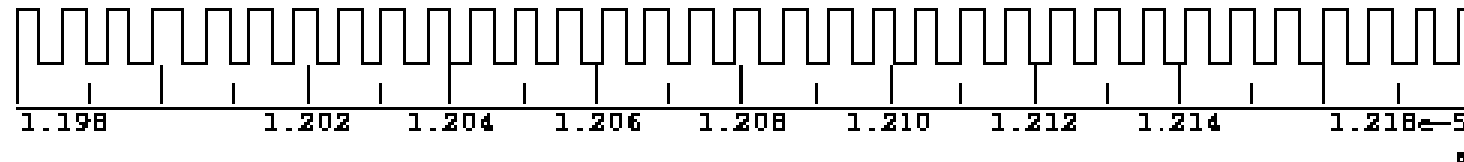
SG (NREF)



SG (PORTDIVOUT)



SG (PORTOUT)



Conclusions

- New approach based in HDL-A to introduce transient current caused by high energy particles => useful to digital or analog.
- Same results in simulations and experiments (qualitatively) for the VCO.
- Simulation of overall PLL system to obtain the transient propagation.
- In the future :
 - Study for the rest of the blocks in order to find the more sensible parts.
 - Behavioral model for the PLL system under irradiation.

