WP8: Complementary modelling tools

Frédéric Wrobel / Francesco Cerutti

RADNEXT Kick Off Meeting – 19-21 May 2021

https://indico.cern.ch/event/983095/

https://indico.cern.ch/event/1029314/

WP8: Complementary modelling tools

Objectives

Develop and apply tools and approaches for modelling radiation effects on electronics + comparison against experimental results.

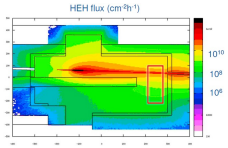
These require a multi-physics approach, at radiation-matter interaction, semiconductor physics, circuit level and even facility level.

Participants and associates

- Université de Montpellier
- CERN
- GSI
- ELI

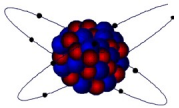
Multi physics / multi scale simulations

Radiative environment



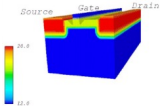
Natural environment, beam facilities (FLUKA)

Particle-matter interaction



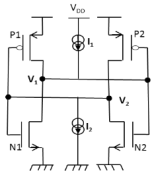
FLUKA, DHORIN

Electrons and holes transport trapping and detrapping



Ecorce, PredicSEE

Effect on the cell (SET, SEU …)



Spice

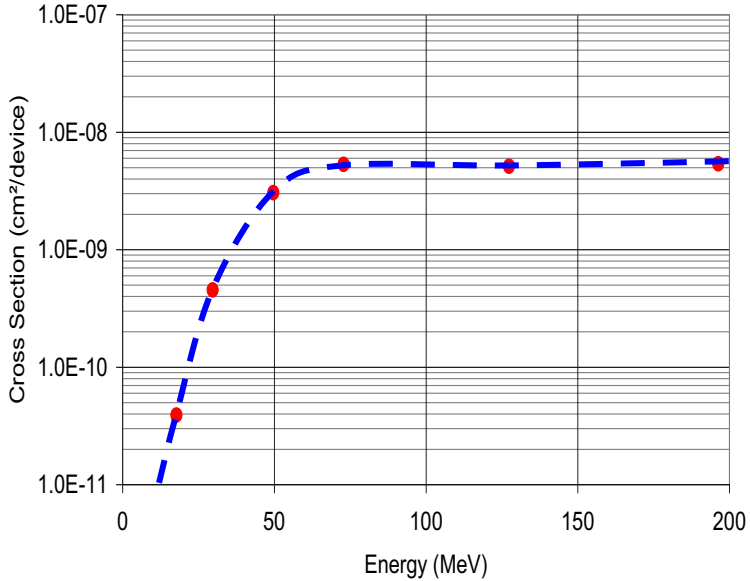
Effect on the system

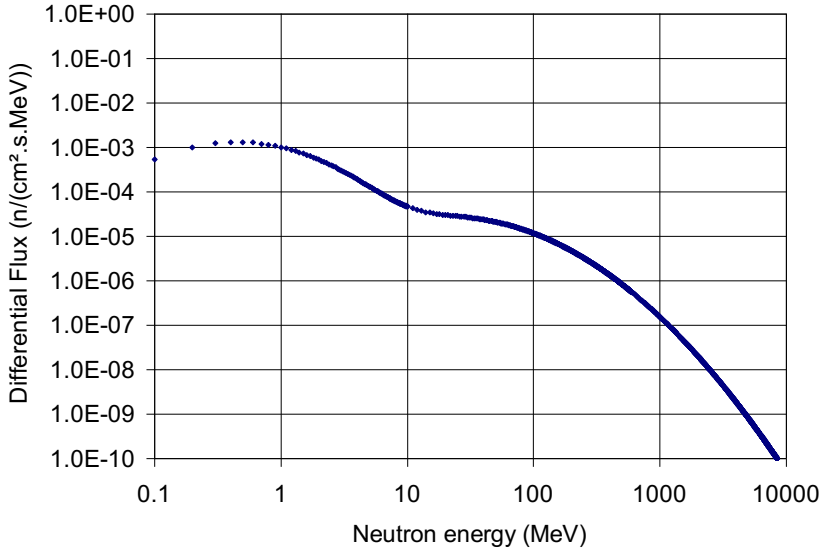
WP8: Work Package Overview

- Task 8.1: Coordination (UM, CERN, GSI, ELI)
- Task 8.2: Impact of low energy particles on SEU rate prediction (UM)
- Task 8.3: Circuit level modelling (UM)
- Task 8.4: Facility modelling (CERN, GSI, ELI)
- Task 8.5: Dose Effect with ECORCE (UM)
- Task 8.6: Integration of SEE event-by-event scoring in FLUKA (CERN)

Task 8.2: Impact of low energy particles on SEU rate prediction (UM)

NEUTRON CASE





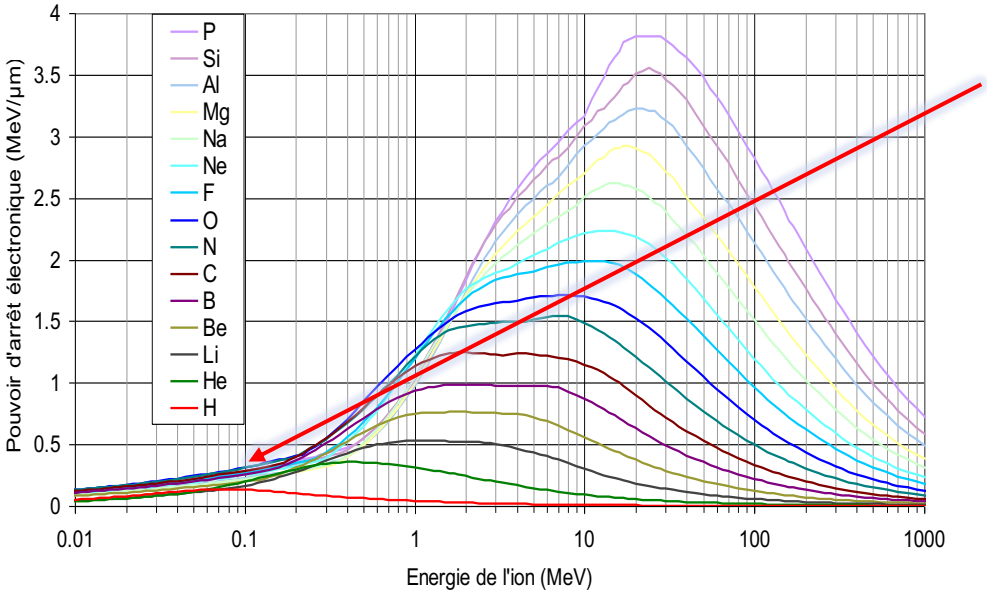
When neutron energy decreases :

- Device sensitivity decreases
- Neutron flux increases

Need to investigate low energy range because device sensitivity increases with shrinking

Task 8.2: Impact of low energy particles on SEU rate prediction (UM)

PROTON CASE



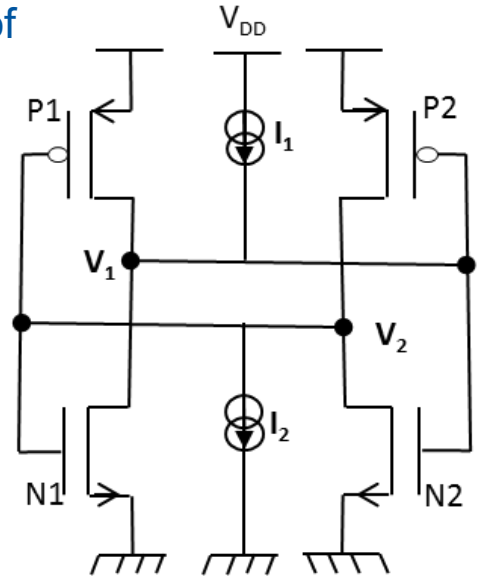
Device sensitivity is currently so low that protons and silicon recoils are able to trigger SEE even at very low energy (<100keV)

Need to investigate proton induced low energy recoil cross section.

Task 8.3: Circuit level modelling (UM) 1/2

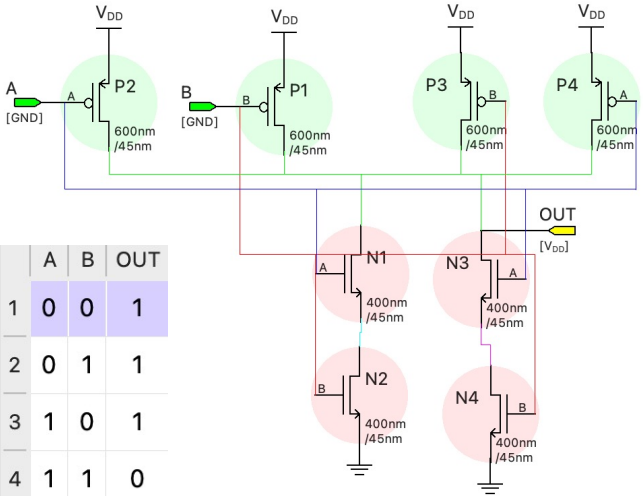
- Tools that predict SEE sensitivity need the electrical models of each component used in the circuits (SPICE).
- These models are generally difficult to obtain.

What is the impact of the model
on the SEE sensitivity prediction?

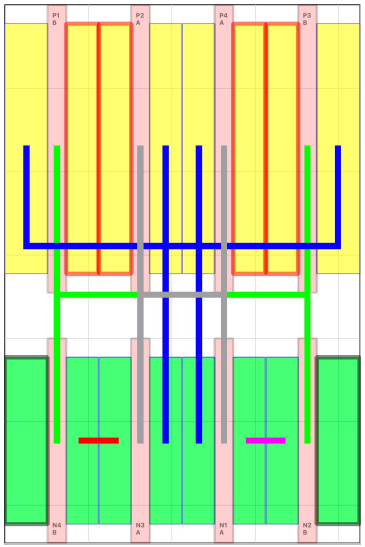


Task 8.3: Circuit level modelling (UM) 2/2

- Impact on the sensitivity of digital circuits considering:
  - different transistor layout design approaches (i.e., sizing, placement, folding…);
  - the implications of the input stimuli (i.e., sensitive area, driving capability,…).



	A	B	OUT
1	0	0	1
2	0	1	1
3	1	0	1
4	1	1	0

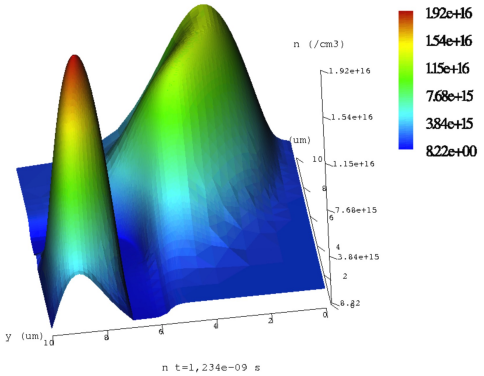


Task 8.4: Experimental beam and facility modelling (CERN, GSI, ELI)

- Knowledge of the radiation environment must be as high as possible in order to:
  - Optimize the preparation of the experiments
  - Enhance the interpretation of the results
- Need to perform simulations at beam and facility level (including various elements)
- Simulations will be performed with the FLUKA Monte Carlo tool developed in CERN.
- Results will be an input of WP7 (RX generator and Co60 source)

Task 8.5: Dose Effect with Ecorce

- Traps play a key role in electronic reliability when irradiated
- We aim to simulate the **creation** of oxide and interface traps (not only the trapping of charges on existing defects)
- We'll study dose effect and dose rate effect
- Use of ECORCE, a TCAD simulation tool developed at UM
- Simulations will be performed for 2 technologies (150nm and 28nm)
- Results will be an input of WP7.



Task 8.6: Integration of SEE capabilities in FLUKA Monte Carlo code (CERN)

- FLUKA is a general-purpose Monte Carlo code able to describe the transport and interaction of any radiation type in complex geometries
- The aim of this task is to render FLUKA usable and accessible to the radiation effects community:
  - Simple engineer tool
  - Scoring
  - Adapted interface
- A FLUKA course wil be organized during the 3rd year of the project

Timeline

T0	WP8 kickoff
+5m	PhD recruitment (tasks 8.2, 8.3, 8.4)
	PostDoc/Fellow recruitment (2x6months) for facility modelling
+18m	Simulation results of the importance of 1-10MeV energy range on the SER for neutrons
+18m	Modelling of the X-Ray generator and Co60 source
+24m	Recommendation for simulating low energy protons
+30m	Simulation results and report on circuit modelling
+42m	Determination of the fitting parameters for the target device and comparison with the experimental results

Thanks for your attention!

Image Source: CERN