WP8: Complementary modelling tools

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WP leader

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(CERN)

Deputy WP leader

- **CERN**
  - Giuseppe Lerner
  - Ygor Aguiar
  - Matteo Cecchetto
  - David Lucsanyi
- **ELI**
  - Roberto Versaci
  - Illia Zymak
- **GSI**
  - Marco Durante
  - Tim Wagner
- **UM**
  - Jérôme Boch
  - Alain Michez
  - Frédéric Wrobel
  - Cleiton Marques
  - Luigi Dilillo
- **Univ. Saint Etienne**
  - Sylvain Girard (WP5)

GSI Helmholtzzentrum für Schwerionenforschung GmbH

Overview of the Activities

This WP will develop and apply ***tools and approaches for modelling radiation effects on electronics***. The modelling efforts focus on:

- Benchmarking simulation tools to be used for SEE applications as complement to experimental data
- Establishing SEE equivalences between different radiation fields
- Providing transversal support to the RADNEXT TA and JRA activities in terms of Monte Carlo simulation studies aimed at improving the description and understanding of the radiation fields in experimental beam and facilities.

Multi-physics and multi-scale approach

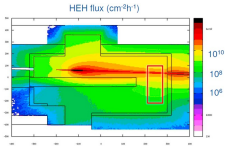
Radiative environment

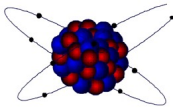
Particle-matter interaction

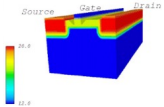
Electrons and holes transport
trapping and detrapping

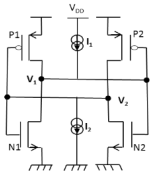
Effect on the cell (SET, SEU …)

Effect on the system









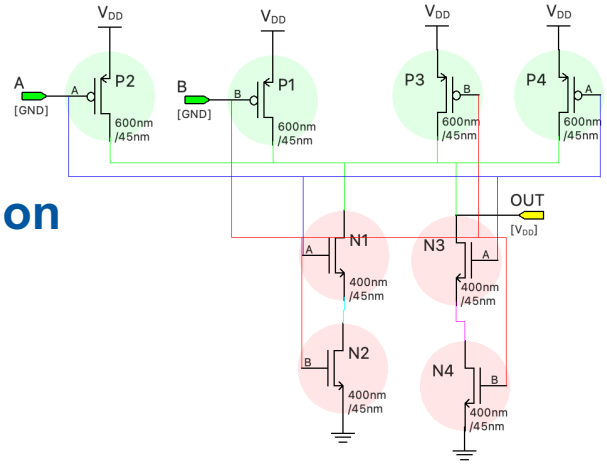
Natural environment, beam facilities (FLUKA)

FLUKA, GEANT4, DHORIN

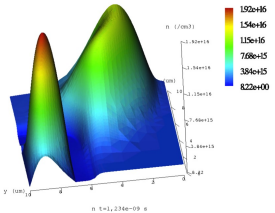
Ecorce, PredicSEE

Spice, or simplified approach

Main topic



- Impact of low energy particles on SEU rate prediction
- Circuit level modelling with PredicSEE
- Facility/beam modelling with FLUKA/GEANT4
- Dose Effect/Dose rate effect with ECORCE
- Integration of SEE event-by-event scoring in FLUKA



FLUKA

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)

Achieved Deliverables and milestones

T0+18	déc-22	D8.1	Frederic Wrobel	+ Ygor Aguiar	+ Cleiton Marques
		M8.1	Roberto Versaci	+ All	+ Postdocs
		D8.2	Roberto Versaci	+ Jérôme Boch	+ Postdocs
T0+24	juin-23	D8.3	Frederic Wrobel	+ Ygor Aguiar	+ Cleiton Marques
T0+30	déc-23	D8.4	Frederic Wrobel	+ Ygor Aguiar	+ Cleiton Marques
		M8.2	Alain Michez	+ Jérôme Boch	
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T0+42	déc-24	D8.5	Alain Michez	+ Jérôme Boch	

D8.1	**Simulation results of the importance of 1-10MeV energy range on the SER for neutrons (T0+18months)**
D8.2	**Modelling of the X-Ray generator and Co60 source (T0+18months)**
D8.3	Recommendation for simulating low energy protons (T0+24months)
D8.4	Simulation results and report on circuit modelling (T0+30months)
D8.5	Determination of the fitting parameters for the target device and comparison with the experimental results (T0+42months)
M8.1	**Facility modelling for RADNEXT experimental conditions (modelling released and simulations are running at T0+18months)**
M8.2	ECORCE evaluation (Modelling released and simulations are running at T0+30months)
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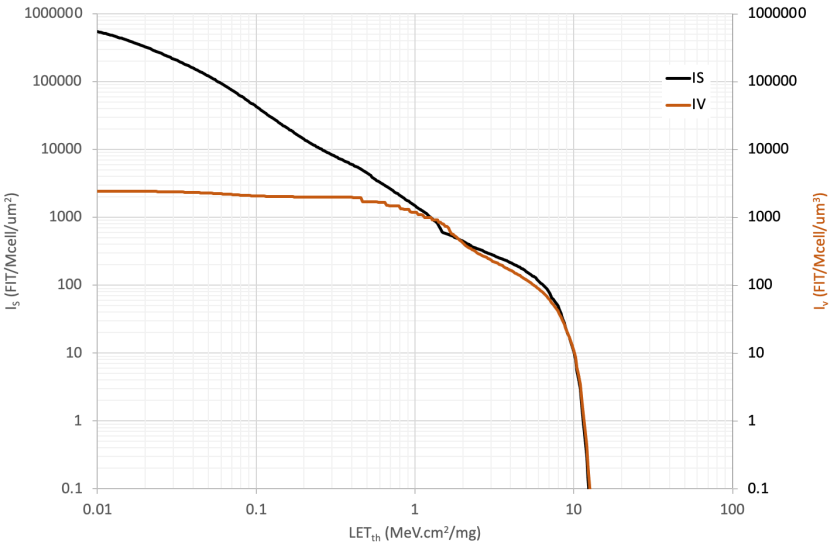
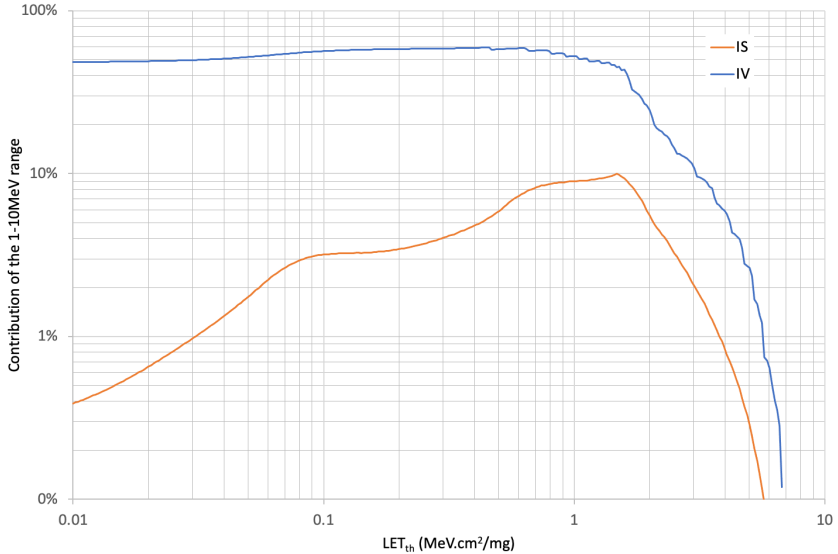
D8.1: Simulation results of the importance of 1-10MeV energy range on the SER for neutrons

$$SER(R_S, LET_{th}) = I_V(LET_{th}) \times \frac{4}{3}\pi {R_S}^3 + I_S(LET_{th}) \times \pi {R_S}^2$$



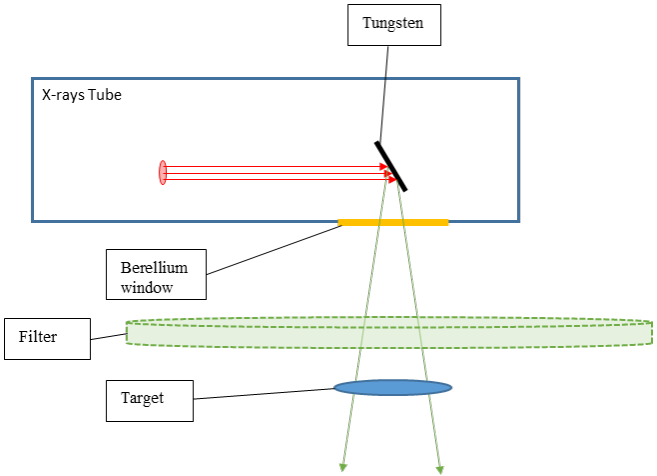
I_S and I_V functions as a function of LET for atmospheric neutron in the 1-200 MeV energy range



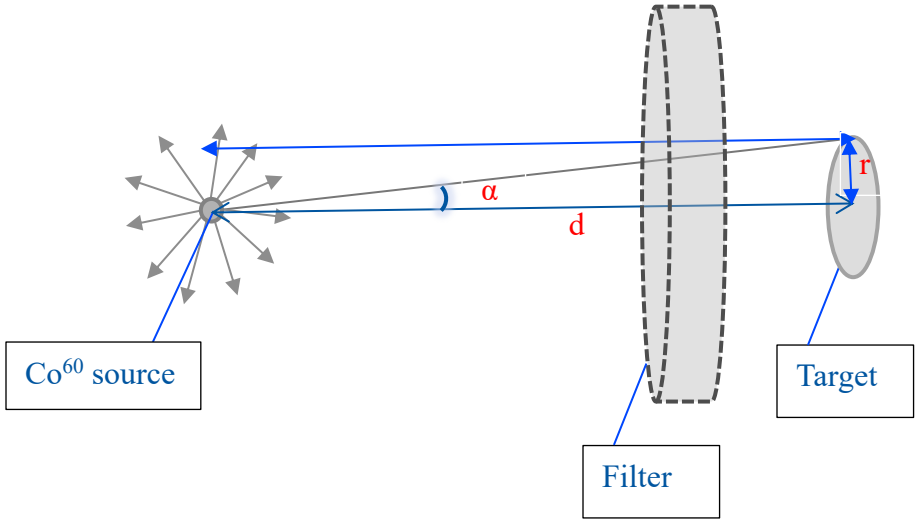
Contribution of the 1-10 MeV energy range to the functions I_S and I_V as a function of threshold

M8.1: Facility modelling for RADNEXT experimental conditions

- Modeling of RX generators and Cobalt Source (for WP7)



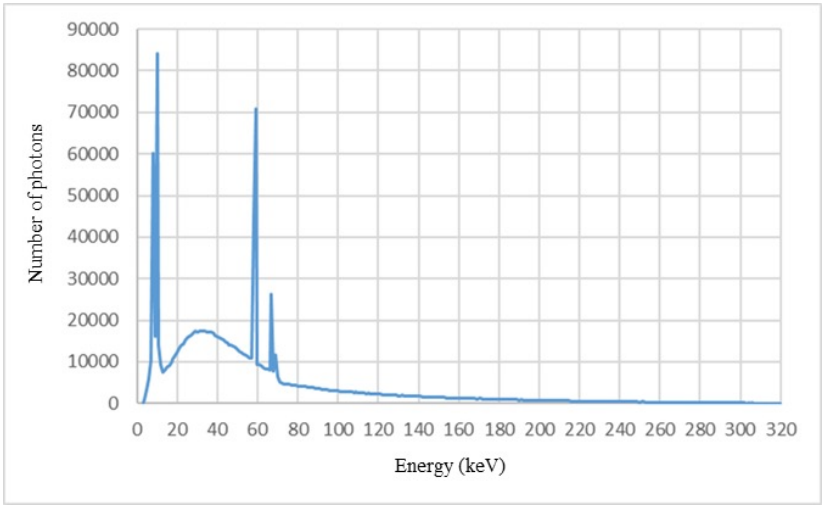
Schematic representation of the X-rays generator



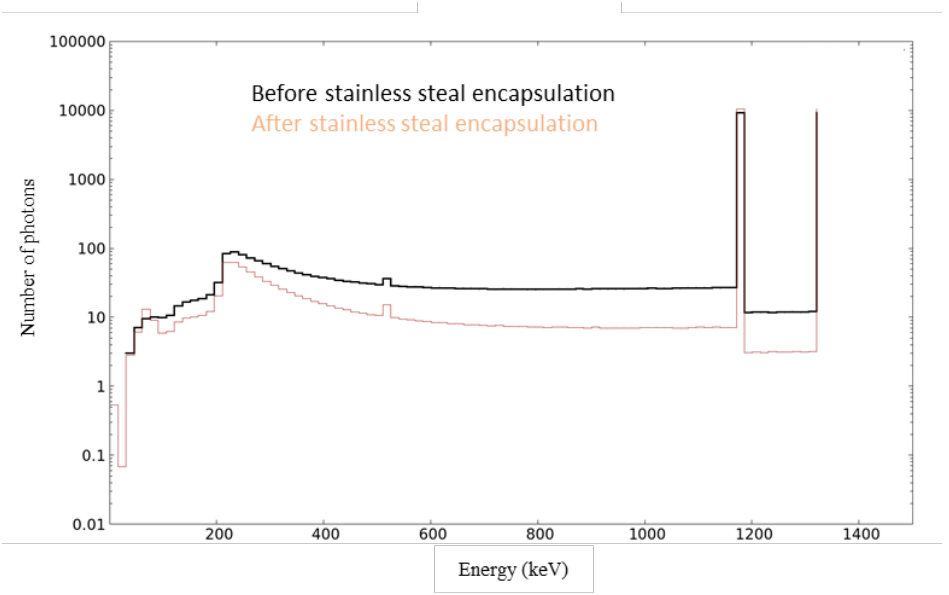
Schematic representation of the cobalt 60 source.

D8.2: Modelling of the X-Ray generator and Co60 source

Some results:



Energy sprectrum of the X-rays generator (GEANT 4)



Energy spectrum of cobalt 60 irradiator with Fluka before and after the stainless steel encapsulation.

Next Deliverables and milestones

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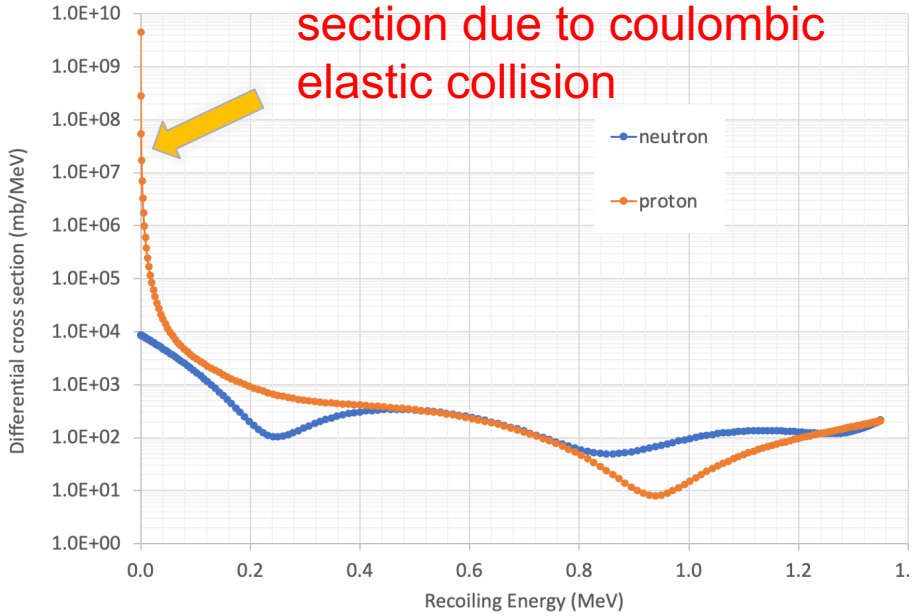
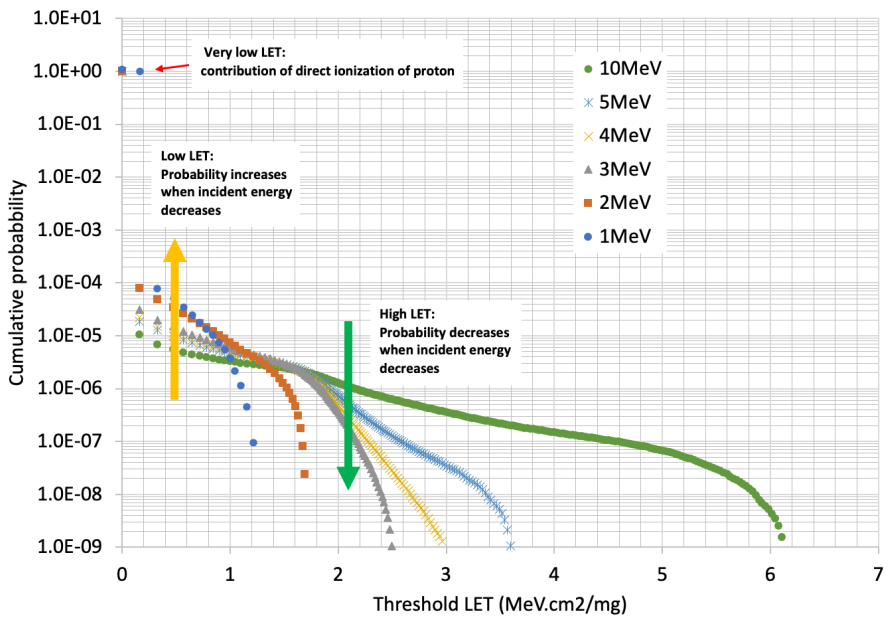
D8.3: Low energy protons (T0+24months)

Rapid increase of the cross section due to coulombic elastic collision



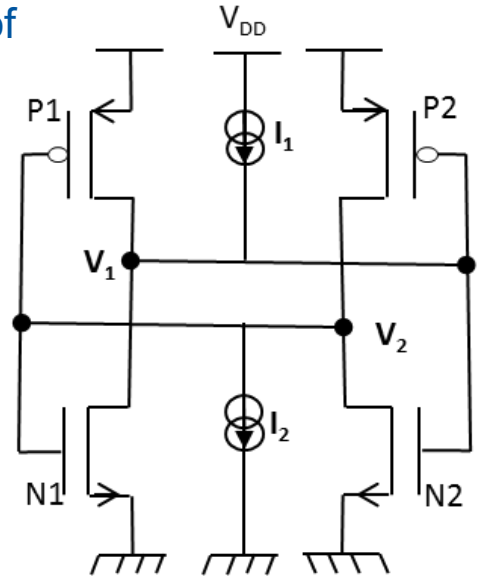
Differential cross section for incident neutrons and protons at 10 MeV as a function of recoiling energy.



Cumulative probability to obtain a silicon recoil with an LET > LET_{th} at the entry of the sensitive region. The silicon layer thickness is d = 10 μm.

D8.4: Simulation results and report on circuit modelling (T0+30months)

- 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?

➡ **Part of Cleiton's PhD work.**

Publications/Dissemination

- Lucas Matana Luza, Frédéric Wrobel, Luis Entrena, and Luigi Dilillo.
  « Impact of Atmospheric and Space Radiation on Sensitive Electronic Devices. »
  In ETS 2022 - 27th IEEE European Test Symposium, pages 1–10, Barcelona, Spain, May 2022. IEEE. doi: 10.1109/ets54262.2022.9810454. URL https://hal-lirmm.ccsd.cnrs.fr/lirmm-03833958

- Frédéric Wrobel, Ygor Aguiar, Cleiton Marques, Giuseppe Lerner, Rubén García Alía, *et al.*.
  “An Analytical Approach to Calculate Soft Error Rate Induced by Atmospheric Neutrons”
  Electronics, 2023, 12 (1), pp.104. https://doi.org/10.3390/electronics12010104

- Cleiton Marques *et al.*
  "SEU prediction using a simplified electrical model for different technology nodes"
  Submitted to RADECS23

- In preparation: elastic process for proton at low energy (<10MeV). Late news NSREC

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Thanks for your attention!