WP07-JRA3 Cumulative radiation effects on electronics

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RADNEXT 1st Annual Meeting – 8-9 June 2022
https://indico.cern.ch/event/1143084/

WP7 members

- Université de Montpellier
- ISAE-SUPAERO
- Université de Liège
- Université Jean Monnet Saint-Etienne
- ATRON
- Airbus Defence & Space


Jérôme Boch


Vincent Goiffon

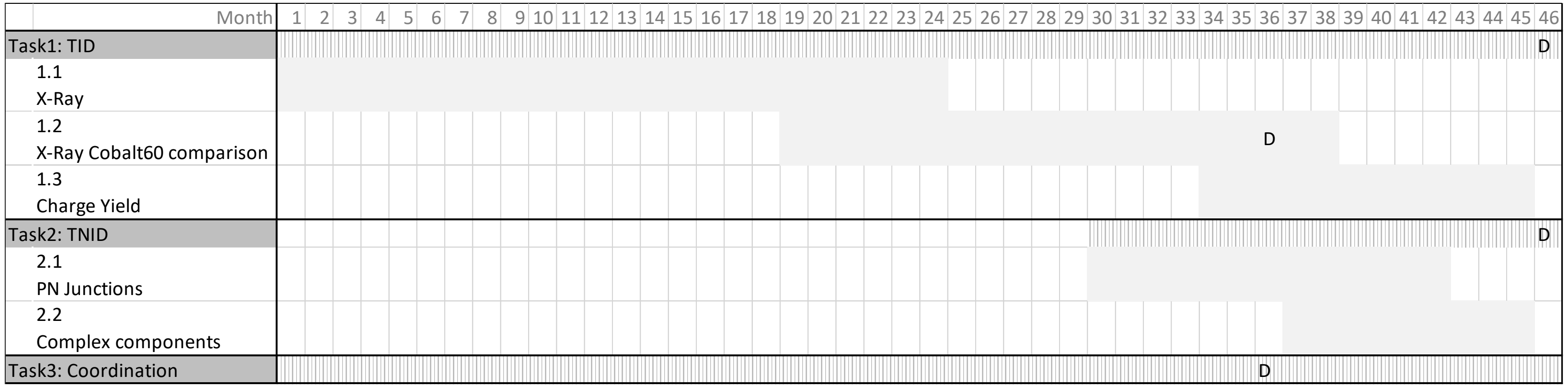
WP7 structure

The main objective is to understand the physical mechanisms behind the damage caused by TID and TNID and to propose test methodologies adapted to the use of electronic components and systems in radiative environment.

Two main technical tasks are studied:

- **Task 7.1: The effects of ionizing dose (TID = Total Ionizing Dose)**
  This task will start at month 1
  PhD recruitment from October 2021 (36 months)

- **Task 7.2: The effects of non-ionizing dose (TNID = Total Non-Ionizing Dose)**
  This task will start later in the project
  Postdoc recruitment in 2023 (12 months)



WP7 Task 7.1: Study of TID effects (1)

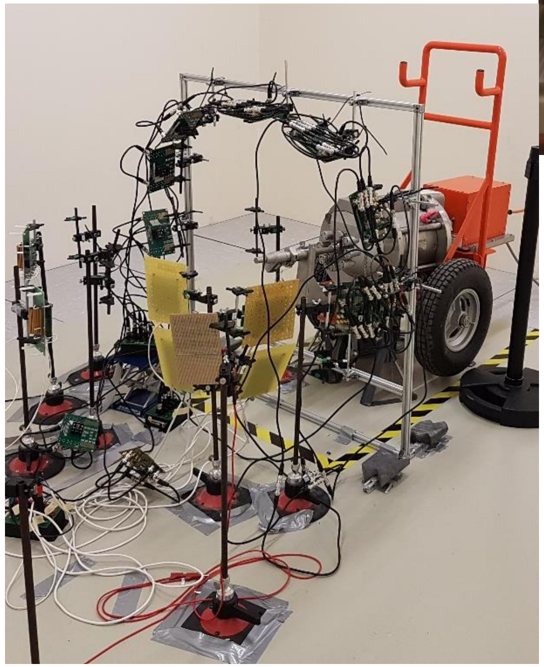
<u>Areas of work to be studied:</u>

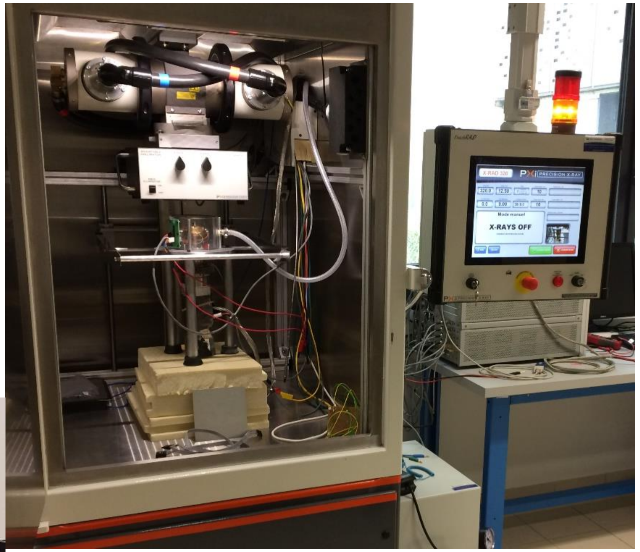
- Experimental investigation of X-ray facilities and simulation
- Comparison of component and system degradation between X-ray and cobalt60
- Specific study on the charge yield

⇒ Experimental data at component and system levels

⇒ The development of a testing methodology using X-ray facilities

⇒ Inputs for system level qualification (WP6) and links with WP5 and WP8





Source: UM

WP7 Task 7.1: Study of TID effects (2)

- **SubTask1.1: How to perform a TID test with a X-ray facilities**
  - How to modify the energy spectrum: choices of energy, filters; dosimetry, … .
  - Simulation of the X-ray facilities with Geant4 (in link with WP8: Complementary modelling tools) to provide additional elements to make these choices.
  - Several X-ray facilities will be used (X-ray facilities in Montpellier and Saint-Etienne Universities and ISAE-SUPAERO, the ATRON 3.5MeV electrons accelerator with X-ray target).

- **SubTask1.2: Comparison of component and system degradation between X-ray and cobalt60**
  - This comparison will be made on several kind of dosimeters (RADFET, FGDOS, and in link with WP5: Radiation monitors, dosimeters and beam characterization) and on generic electronic components or systems (in link with WP6: Standardization of system level radiation qualification methodology).

- **SubTask1.3: A specific study on the charge yield**
  - This study will be executed in order to increase our knowledge on the initial recombination.
  - Several kind of facilities (Cobalt60, X-ray, electrons, protons) will be investigated, under a wide temperature range (50K to 400K) and for several bias configuration.

=> Main outcome: Guidelines and recommendation for TID testing.

WP7 Task 7.1: Study of TID effects (3)

Vincent GIRONES

A PhD student has been recruited at UM in October 2021 : Vincent GIRONES.

He is working on task 1 with the objective to show how we can use an X-ray generators for total dose testing.
The first obtained results have been accepted for a poster presentation at RADECS2022.

RADECS 2022
Venice, 3-7 October

The Use of High Energy X-Ray Generators for TID Testing of Electronic Devices

Vincent Girones, Jérôme Boch, Frédéric Saigné, Rubén García Alía

***Abstract* — The use of a high energy X-ray generator for electronic device testing is studied and compared to cobalt-60. X-ray spectrum is filtered to reduce photoelectric effect. Experimental results are presented and discuted.**

***Index Terms*—Total Ionizing Dose, X-ray, Cobalt-60, Dose testing.**

I. Introduction

Electronic devices used in many space, military, accelerator and nuclear power plants systems may be exposed to Total Ionizing Dose (TID). For the use of these devices, it is essential to have test methods to determine the hardness in a radiative environment. A number of different standards and guidelines exist for testing TID effects: MIL-STD-883 test method (TM)

the photons which can be easily stopped by a protective enclosure, and the fact that the X-ray generator can easily be turned off. Another advantage of the X-ray generator is that the photon energies are low enough that it can be easily collimated. As a result, it is possible to irradiate with ARACOR-like 10keV generator a single device on a wafer. X-ray generator also offers a relatively high dose rate, in comparison to 60-Co or Cesium-137 sources, thus offering reduced testing time. During the design of a system, this allows a fast (within a day) TID sensitivity characterizations of several components of the same type (screening), in order to obtain a first estimate of the TID hardness. Finally, X-ray generators are less expensive to purchase and maintain than radioactive sources or particle beams. The main disadvantage of low energy X-ray generators is that photons penetration depth is low and irradiation must be performed at wafer level or with delidded devices, while higher

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WP7 Task 7.2: Study of TNID effects

<u>Areas of work to be studied:</u>

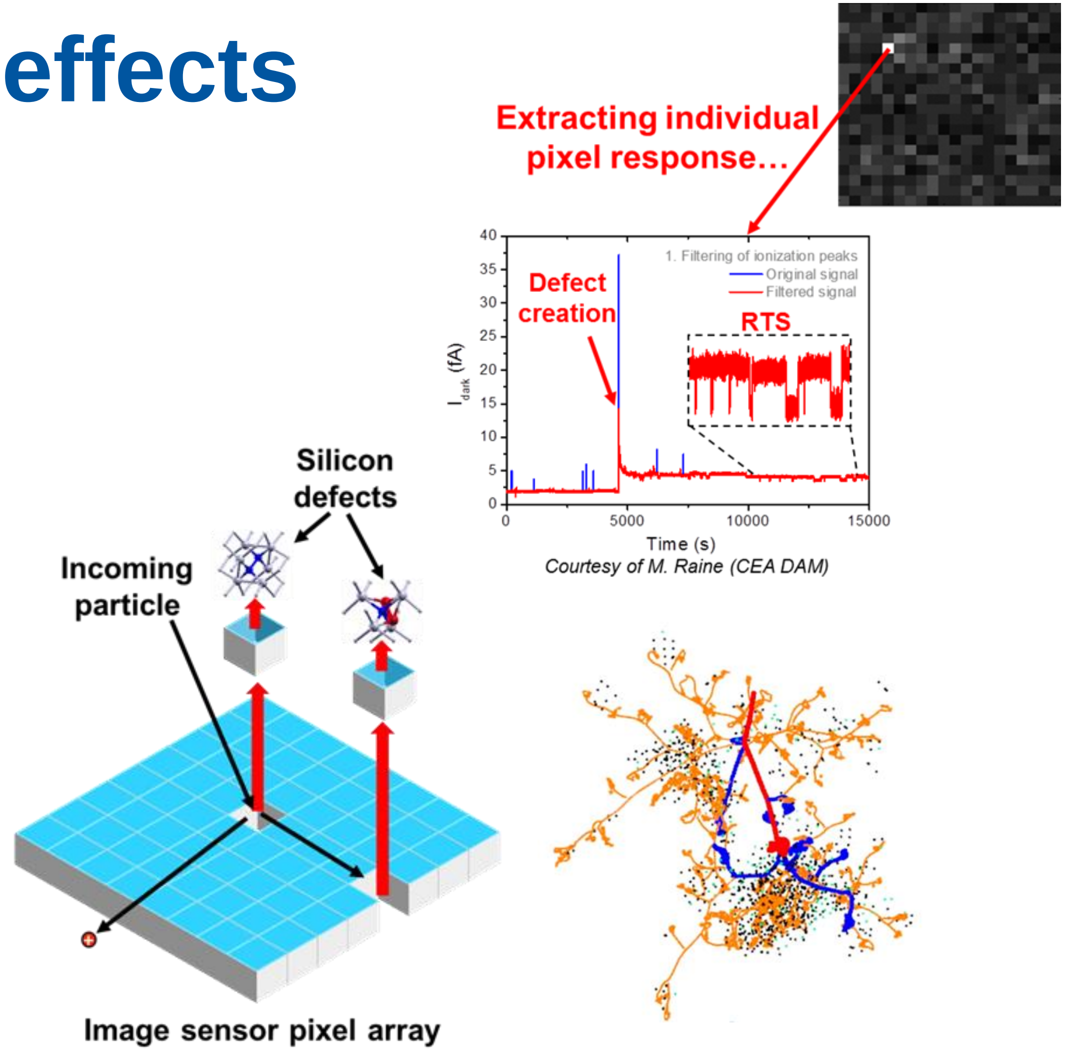
- Influence of irradiation conditions (biasing, particle type and flux) on the average leakage current degradation of silicon diodes

- More detailed study on the statistics of displacement damage by the use of image sensors and pixel arrays

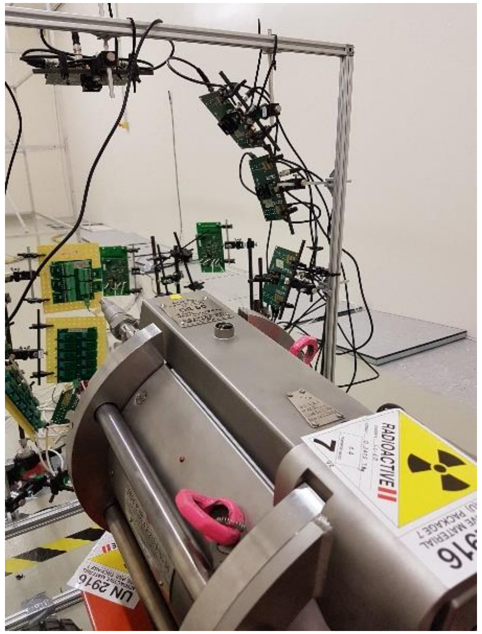
- Comparison to existing models to clarify their validity range

⇒ Guidelines for TNID tests for the different fields of application encountered in RADNEXT

⇒ Inputs for system level qualification (WP6)



Thanks for your attention!



Cobalt 60 Irradiator
Source: UM

3.5 MeV e-beam Accelerator
Source: ATRON