WP7:
Cumulative radiation effects on electronics

Jerome BOCH, Vincent GOIFFON

RADNEXT Kick Off Meeting – 19-21 May 2021

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

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

WP7: Participants and associates

Jérôme Boch

Vincent Goiffon

- Université de Montpellier
- ISAE-SUPAERO
- Université de Liège
- Université Jean Monnet Saint-Etienne
- ATRON

WP7: Work package overview

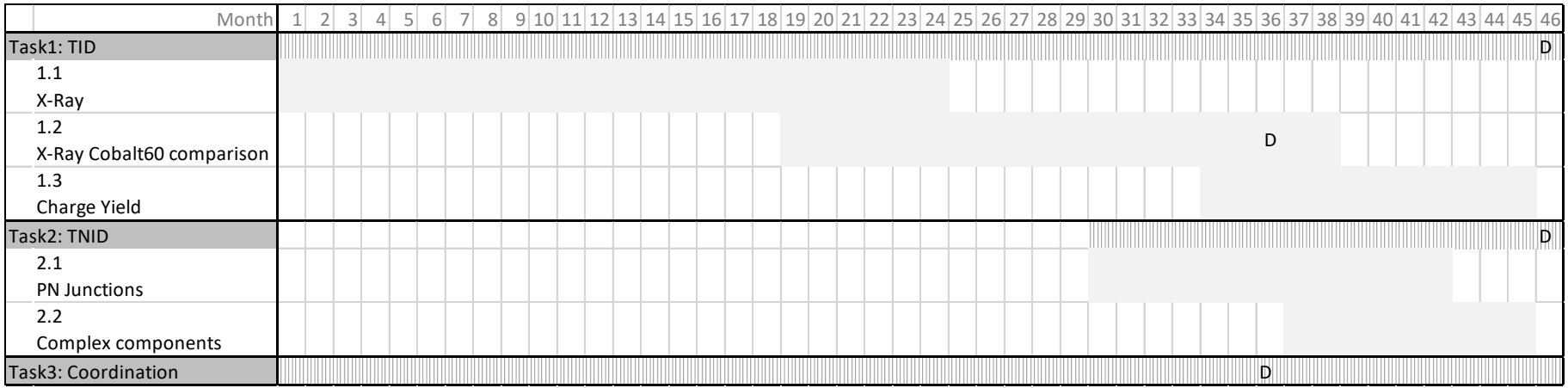
In this Work Package (WP7-JRA3) a study of the cumulative radiations effects on electronics will be accomplished. Cumulative effects in electronics are highly relevant both for actual applications (e.g. space, high-energy accelerators, nuclear dismantling, etc.) as well as related to by-product effects of Single Event Effects (SEE) testing.

- Two main tasks will be studied:
  - The effects of ionizing dose (TID = Total Ionizing Dose),
  - The effects of non-ionizing dose (TNID = Total Non-Ionizing Dose).

- The main objective is to understand the physical mechanisms behind the damage and to propose test methodologies adapted to the use of electronic component and system.

WP7: Project structure

- Task 1: Study of TID effect
- Task 2: Study of TNID effect
- Task 3: Coordination



WP7: Task 1: Study of TID effect

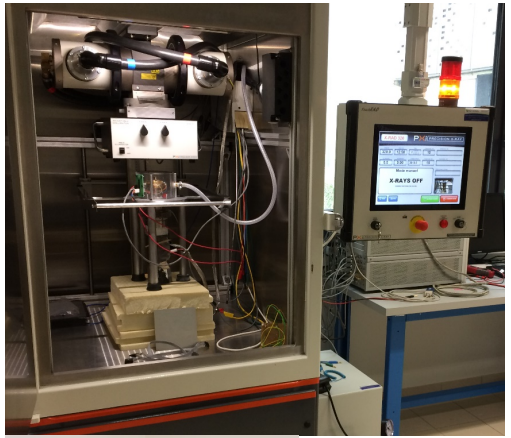
Areas of work to be studied:

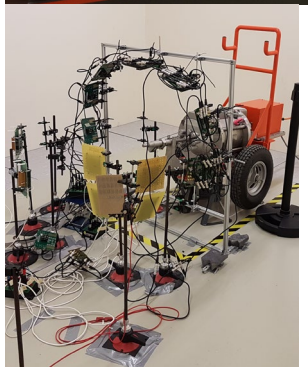
- Experimental investigation of X-ray facilities and simulation
- Comparison of component and system degradation between X-ray and cobalt60
- Specific study on the charge yield

⇒ 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





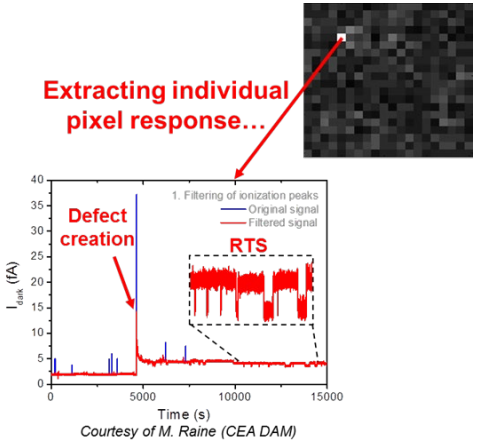
Source: UM

WP7: Task 1: Study of TID effect

- 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 2: Study of TNID effects

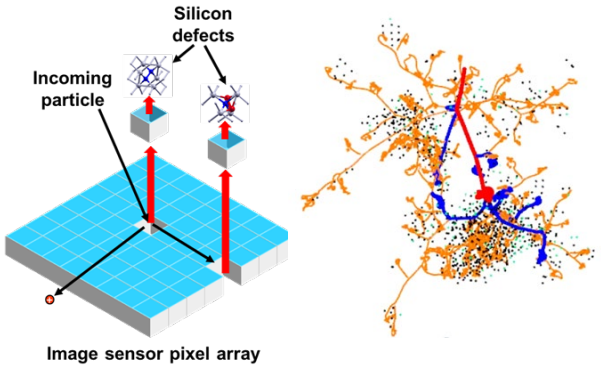


Areas of work to be studied:

- 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)



WP7: Task 2: Study of TNID effects

- SubTask2.1: Comparison of TNID effects on “ideal” silicon diodes
  - Selection of an “ideal” silicon PN junction (mm²-cm² scale)
  - Comparison of irradiation conditions on TNID induced **mean dark current** increase
  - Envisaged experimental parameters to explore:
    - Facility, particle type/energy, flux, biasing
    - Envisaged particles (TBC): protons vs neutrons vs electrons (and possibly gamma-rays)
    - The parameters selection (including the particles) will be the first step of this subtask
  - Comparison with existing prediction models and clarification of their validity domain
  - Point defect VS clustered defect discussion
- SubTask2.2: Study of the TNID effects statistics in microvolumes (µm² scale)
  - Selection of a pixel array to push the previous comparison to the µm scale
  - Comparison of TNID induced **dark current distributions and statistics** at the µm scale
  - Depending on SubTask2.1 conclusion ➔ selection of a few irradiation parameters to explore
  - Improvement of existing statistical models of TNID effects in silicon microvolumes

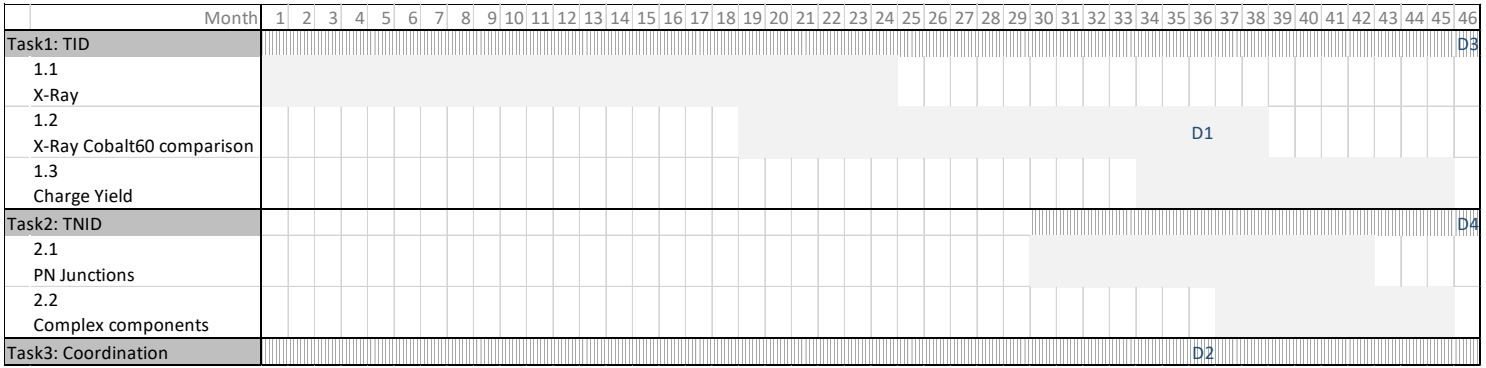
=> Main Outcome: Guidelines for TNID testing.

WP7: Task 3: Coordination and Results

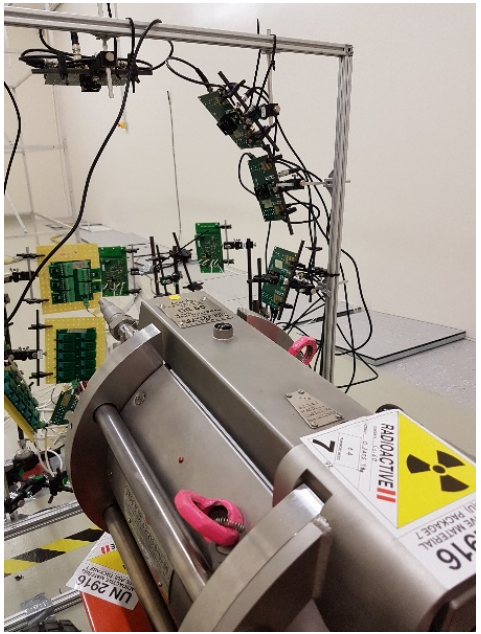
- Recruitment:
  - Task1: 36-months PhD 09/2021 – 08/2024
  - Task2: 12-months Postdoc starting in 2023

- Results derived from this WP will be integrated in recommendations and guidelines related to the complementarity and representativeness of different experimental conditions with respect to those encountered in applications.

D1	Comparison of X-ray / cobalt experimental data
D2	Published list of tested components against cumulative effects
D3	Final TID results and guidelines for dose testing with X-ray facilities
D4	Final TID results and guidelines for dose testing with X-ray facilities



Thanks for your attention!



Cobalt 60 Irradiator
Source: UM

3.5 MeV e-beam Accelerator
Source: ATRON