WP6:
Standardization of system level radiation qualification methodology

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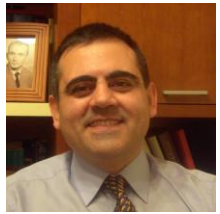
RADNEXT Kick Off Meeting – 19-21 May 2021

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

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

WP6: Participants and associates

Luigi Dilillo



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Université de Montpellier

Katholieke Universiteit Leuven (KUL)

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Work package overview

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- The main goal will be the exploration of valid qualification procedures to be effective at system level. Its main added value is a reduced qualification cost and time, without significantly affecting the radiation hardness assurance level.

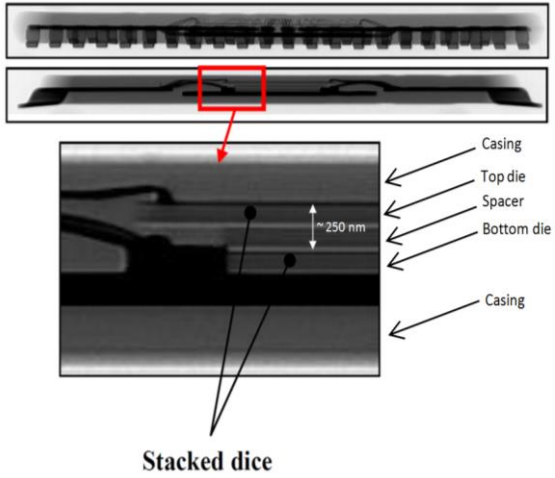
- Four tasks are planned and will focus on:
  - Task 1. Coordination
  - Task 2. Setup preparation and stimuli definition
  - Task 3. Pass/fail test
  - Task 4. Test with enhanced observability

- Most of the activities will be done in parallel, all along the duration of the project together with the experimental work. Particular attention will be placed on milestones and deliverables release.

Task 1: Setup preparation and stimuli definition

Areas of work to be studied:

- Identification of **general actions** before the actual irradiation, including setup **requirements** to enhance the success of the campaign
  - X-ray inspection of the chip
  - Use of current monitoring equipment
  - Generation of meaningful test logs (with timestamp and other parameters)
- Identification and standardization of **test conditions** and stimuli for each type of system
  - Example: dynamic and static test for memories

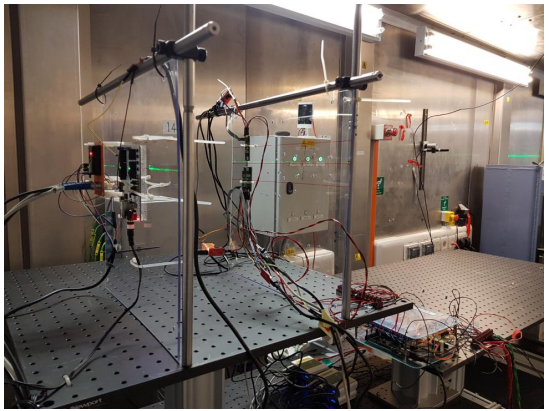


X-ray image of the 90 nm SRAM (img. LIRMM)

Task 1: Setup preparation and stimuli definition

Areas of work to be studied:

- For processors (at least the general-purpose ones) and FPGAs it would be suitable to identify a certain number of **benchmark stimuli** to use during irradiation
- Definition of a flexible and general test hardware platform that supports the identified setup requirements and allows **software qualification.** This standard platform will help the establishment of **test from remote**.

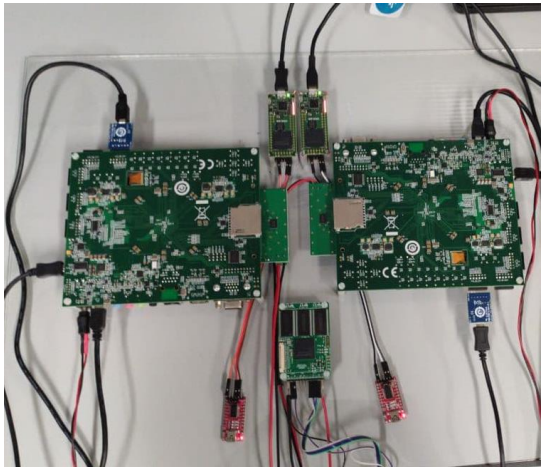


Experiment from remote in ChipIR (img. LIRMM)

Task 2: Pass/fail test

Areas of work to be studied:

- Test of the whole system structure, which is treated as a **black box**
  - Not taking in account the features and irradiation response of each composing element
  - Knowledge of the level of resilience of the whole system to a given quantity of radiation
  - Poor information to identify the weakest elements and the hardware configurations that may reduce or enhance the radiation effects.

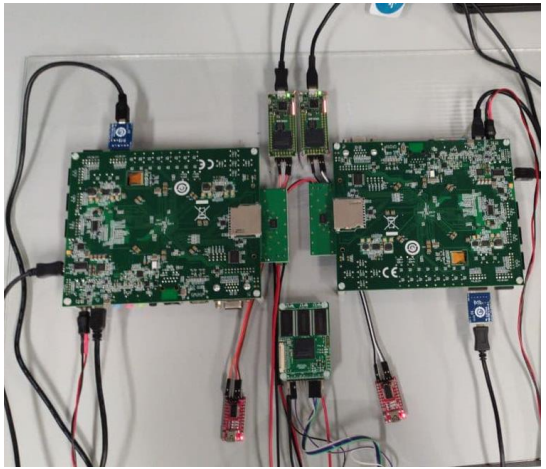


Multi-system setup for P/F test.
(img. LIRMM)

Task 2: Pass/fail test

Areas of work to be studied:

- Standardization of the pass/fail procedure to enhance the consistency and usability of the results
  - Introduction of guideline about monitoring of physical and electrical parameters during the tests
  - Limitations of pass/fail testing with regards to e.g. mitigation procedures in case of fail, or hardness assurance for non-tested units of the same type in case of pass, will be identified and when possible overcome.

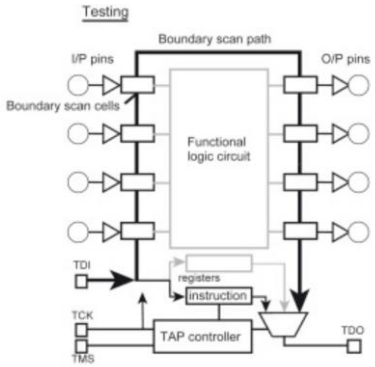


Multi-system setup for P/F test. (img. LIRMM)

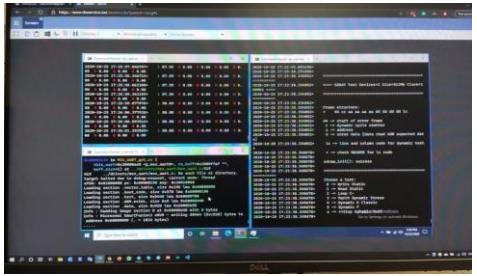
Task 3: Test with enhanced observability

Areas of work to be studied:

- Use of **fault injection** techniques in digital systems, based on fault simulation or emulation, with the utilization of saboteurs (at logical level) within the system
  - Understanding of the level of radiation weakness of the different elements
  - Analysis of error propagation mechanisms
  - Preparation of irradiation campaigns and easier the interpretation of results



Example of boundary scan scheme

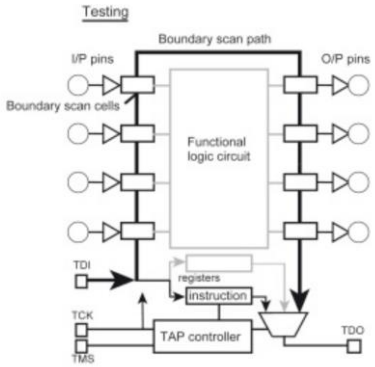


On-line data logs (img. LIRMM)

Task 3: Test with enhanced observability

Areas of work to be studied:

- Identification of techniques to increase the observability in system on Printed Circuit Board
  - Boundary Scan structure generally used for production functional test
  - Trace interface of microprocessor
- Methods to perform effective in-depth statistical analysis of the detected errors



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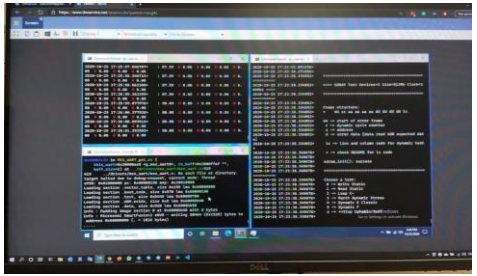


On-line data logs (img. LIRMM)

Recruitment and Results

- **Recruitment**:
  - 36-months PhD 11/2021 – 10/2024; direction UM(LIRMM) and UC3M
  - 7-months Postdoc from 01/01/2022; KUL

- **Results** derived from WP6 will be integrated in recommendations and guidelines related to the complementarity and representativeness of different experimental conditions with respect to those encountered in applications.

Deliverables

D6.1 (Book of Knowledge, **M36**, UM, UC3M) Definition and Standardization of the basic requirements for Pass/fail test of systems.

D6.2 (Book of Knowledge, **M42**, UM, KUL, UC3M, CERN) Setup preparation and stimuli definition for test of systems, final version (“good practices”)

D6.3 (Book of Knowledge, **M48**, UM, KUL, UC3M) Definition and Standardization of requirements for test of systems with enhanced observability.

D6.4 (Report, **M48**, KUL, UM, UC3M, CERN) Description of hardware platform for software qualification.

WP6: Early on-going activity

- **Meetings**:
  - Meeting 1: 25/02/2021
  - Meeting 2: 26/04/2021
  - Meeting 3: 12/05/2021

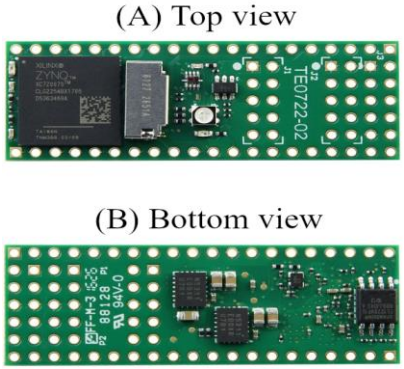
- **Targets:**
  - Mutual knowledge of all WP6 partners, with the introduction of each partner background and expectations for the WP6
  - Identification of the overlap and complementary topics and activity
  - Preparation of the first actions within the project (irradiation test campaign in autumn 2021)

- **Outcomes:**
  - Better mutual knowledge achieved
  - Identification of the some hardware system platforms that can commonly used within WP6 (e.g. ZYNQ 7000 SoCs, RISC-V processor)
  - Identification of the targets of first radiation test campaigns based on consideration of readiness and logistics:
    - Test of already known system setups (operational readiness at project start) – Propositions T1 from LIRMM, UC3M, DLR, Propositions T2 from KUL, CERN
    - Test from remote (reduced mobility because of pandemic)

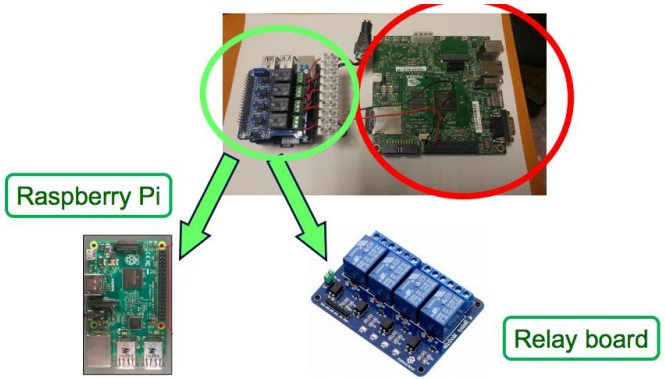
WP6: Early on-going activity

- **Propositions T1**
  - Attempt to perform test from remote
  - Selection of test facilities with beams that do not need DUT conditioning (e.g. Neutrons, High energy Protons, HEH)

Memory test to explore technology node impact (LIRMM)



RISC-V implementation in FPGA (LIRMM)



Zinq SoC testing (UC3M)

WP6: Early on-going activity

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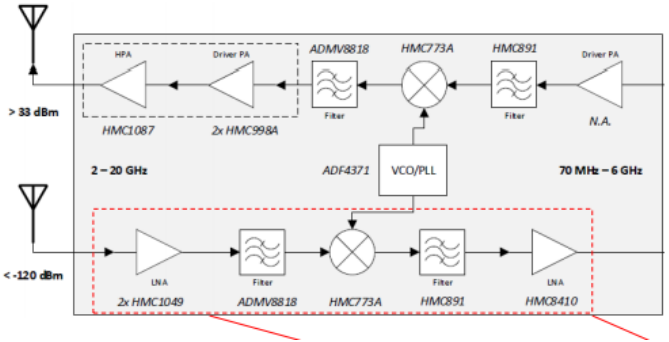
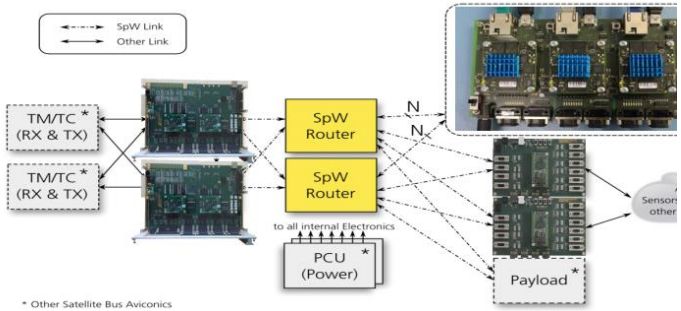


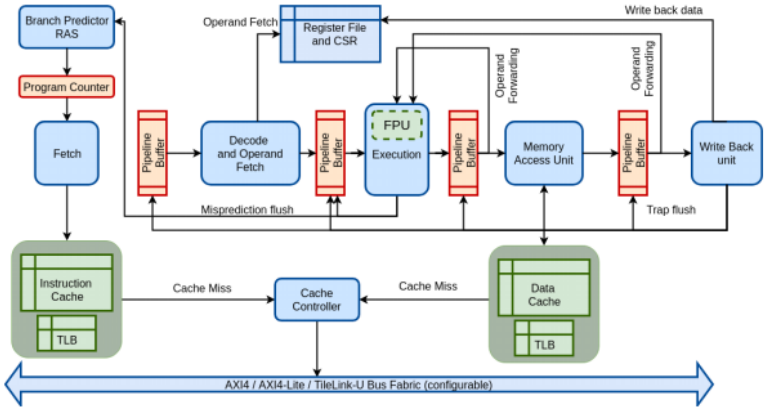
Flexible Radio System (*SDR*) for Space (DLR)



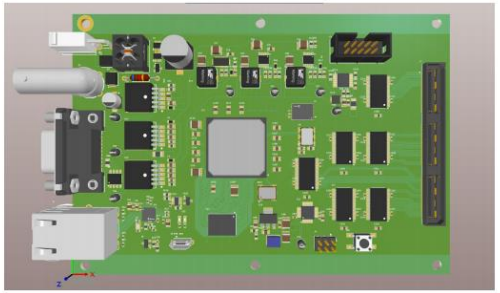
Reconfigurable Distributed Onboard Systems (DLR)

WP6: Early on-going activity

- **Propositions T2**



Radhard RISC-V processor
(KUL)



Memory tester for SRAM,
FLASH, DDR, FPGA radiation
testing (CERN)

Silicon-diode based
Instrument
(CERN)

Thanks for your attention!

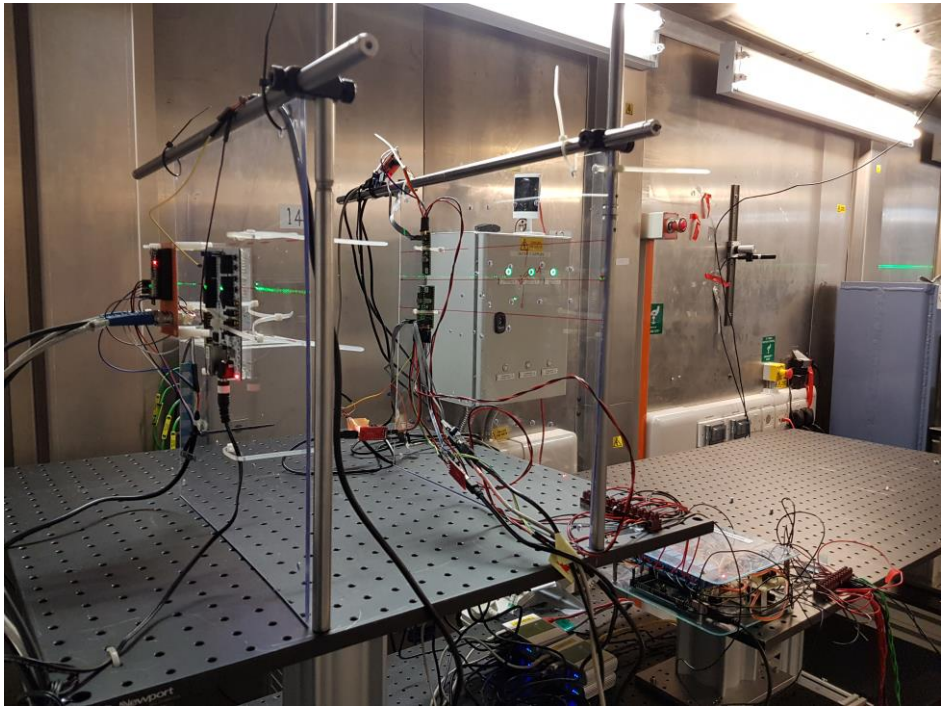


Image Source: LIRMM