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RADNEXT Transnational Access Summary Report

Project title	SEE evaluation on RFID tags under fast neutrons (TagSEEn)
Project TA identifier	TA03-12
General application	high-energy accelerators and others
Type of test	TNID-NIEL
Group leader, Institute	Federico Ravotti (CERN)
Dates of the experiment	21-25/3/2022
Facility	FNG
Amount of access granted	72 hours

Objectives of the experiments

Over the past years, the CERN IRRAD proton irradiation facility has developed a custom data management system capable of keeping track of several aspects of the irradiation tests performed. This system is called Irrad Data Management (IDM). In the framework of the AIDAInnova H2020 project, the integration of the existing Irrad Data Management system with an RFID tagging system is being carried out. This would allow following the samples before and after the irradiation, tracking their position wirelessly inside the facility. IDM is also foreseen to be extended to different irradiation facilities, including fast neutron ones.

For this reason, testing the radiation hardness of RFID tags under fast neutrons, with fluences of the order of the ones foreseen in Radiation Hardness testing, is mandatory. RFID tags could in fact integrate neutron fluences close to the ones targeted for the Devices Under Test (DUT), being the tags ideally attached to the DUT boards.

As a representative of such facilities, the Frascati Neutron Generator FNG was exploited as a fast neutron source. This facility delivers 14 MeV neutrons from D-T fusion reactions, with a maximum, steady state yield of $5 \cdot 10^{10}$ n/cm²/s.

At FNG, the NIEL effect on several RFID tag samples was measured, by exposing them in different steps to a total neutron fluence comparable with the typical expected values for a SEE or a TNID test on electronics.

Experiment test report

We used two different setups, for the first step the tags were irradiated at a larger and uniform distance as seen in Figure 1, from the second step we moved the tags closer to the sources (Figure 3) using a new configuration (Figure 2) in which the tags were not equally irradiated.

<https://radnext.web.cern.ch/>

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Figure 1: Step 1 configuration

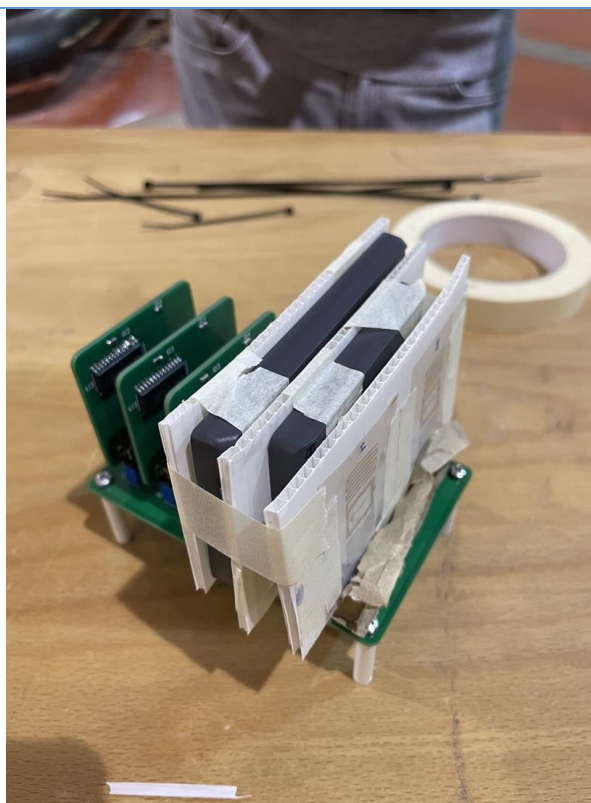


Figure 2: Configuration from Step 2 onwards.

The test and measurement procedure was similar to the one performed during a previous test at CERN IRRAD with 24 GeV protons (<https://edms.cern.ch/document/2680300/1>).

The tags were read/written at the end of each step at 5 cm from the RFID antenna and at contact. For each tag, the functionality was checked by both reading the EPC code, that is the unique identifier of the tag that cannot be changed by the user, and by writing and reading a word in the volatile memory of the tag. After each step, the volatile memory was first read out to check for bit flips or loss of readout capability, and then a new word was written and readout to check for the full functionality of the memory plus r/w controller.

Another parameter that was measured was the RSSI, the strength of the signal emitted by the tag in response to the active interrogation by the antenna.



Figure 3: Detail of the neutron source and the distance from the tags.

Results

A total of nine tags were tested, one was located on the stairs far away from the neutron source and used as a reference (also to be constantly read by the antenna).

The other eight tags were placed in front of the source, for the first step the location was uniform as the tags were at 16 cm from the source, but the integrated number of neutrons, as shown in Table 1, was about an order of magnitude less than the following steps. This allowed for a slow ramp up of the instantaneous flux and to check the tag behavior with operational fluxes.

During *Step 2* and *Step 3* the tags were irradiated to higher fluences thanks to a different location of the tags, now placed between 4 cm and 6 cm. Different distances meant different fluences as shown in the last columns of Table 1.

Table 1: irradiation steps for the different tag samples

EPC	Characteristics	Chip	Location	Step 1 (10^{11} n/cm ²)	Step 2 (10^{12} n/cm ²)	Step 3 (10^{12} n/cm ²)	Total (10^{12} n/cm ²)
E2801105200072DAD51E0913	TAG SyS	Monza 4E	Stairs	5.7E-3	6.0E-4	1.3E-3	2.4E-3
E2009B8030038AF00000067	Small plastic	ALIEN Higgs-3	Target	1.36	1.47	3.09	4.70
E2009B8030038AF00000032	Small plastic	ALIEN Higgs-3	Target	1.36	1.47	3.09	4.70
E2009A8010045AF000022062	Large plastic	ALIEN Higgs-3	Target	1.36	1.01	2.12	3.27
E2009A8010045AF000020070	Large plastic	ALIEN Higgs-3	Target	1.36	1.01	2.12	3.27
E280110520007A5AD5250913	TAG SyS	Monza 4E	Target	1.36	1.47	3.09	4.70
E28011052000731AD51E0913	TAG SyS	Monza 4E	Target	1.36	2.30	4.83	7.26
E2806F12000000021F918042	Thin/Transparent	U7-XM2	Target	1.36	2.30	4.83	7.26
E2806F12000000021F918040	Thin/Transparent	U7-XM2	Target	1.36	2.30	4.83	7.26

Conclusions

After several irradiation steps, all the RFID tags were still fully functional, the EPC and the volatile memory being readable and writable, with no bit flip detected, and with only a slight reduction of the RSSI response signal strength from the interrogated tag.

The final fluences were above 10^{12} n/cm², a typical target fluence for high flux radiation hardness test with 14 MeV neutrons, and more generally with fast neutrons in the MeV range.

Such tags demonstrated to be a valid opportunity to be integrated in the IDM system for fast neutron facilities, where the target fluence will be below 10^{13} n/cm².

Outcome of the experiments

Please indicate what the experiment is likely to lead to by putting an 'X' next to one or more of the possible outcomes below.

Journal publication	X
Data for Thesis	
Follow-up experiment at same facility	
Follow-up experiment at another facility	X
Other	

As a RADNEXT user, we encourage you to submit the scientific results of your experiments to journals as well as to the NSREC and RADECS data workshops. Please remember to include the RADNEXT acknowledgment into your publications!

RADNEXT acknowledgment:



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