Testing of electronic components

Rudy Ferraro (BE-CEM-EPR)

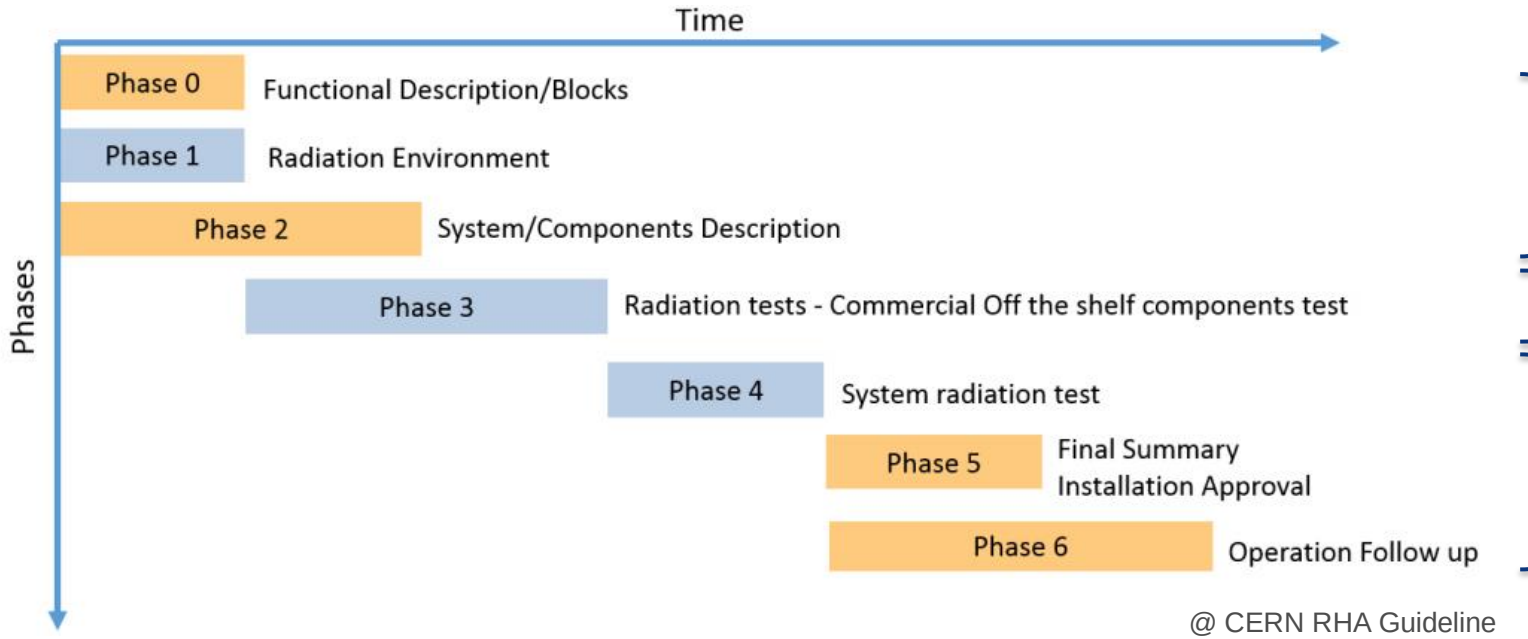
R2E Annual Meeting – 2-3 Feb, 202

Radiation Test Service

- BE-CEM-EPR provides, through R2E resources, the service of radiation testing of electronic components supporting the Radiation Working Group (RadWG)
- The RadWG **supports** the accelerator sector equipment groups for the assessment of radiation tolerance of electronic equipment to be installed in radiation exposed areas.
- It is as a **forum** for electronic engineers to discuss
  - design practices
  - radiation tests
  - radiation induced failures in the accelerators.
- The RadWG is one of the pillars of the R2E project

CERN RHA Guideline for COTS-based system

Within the R2E project we have defined the process for system qualification:



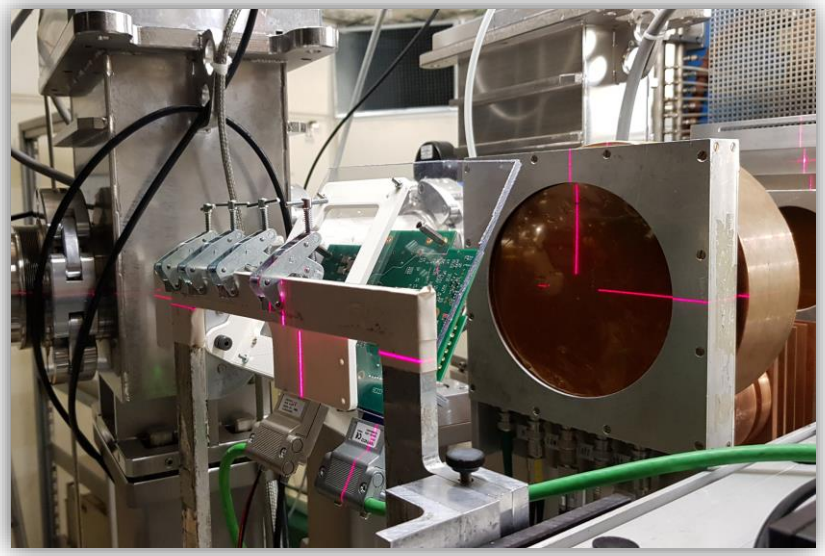
@ CERN RHA Guideline

- Provide advices and support for component type & technology choice
- Collect Test request
- Test & Reporting
- Provide support on system failure analysis and mitigation

- Provide advices in early development stages for component choice
- Help analyzing system failure observed in operation or during system-level test and propose mitigation techniques or part replacement candidates

Radiation test as a sector-wide service

- Radiation testing requires:
  - Knowledge of radiation effects on electronic
  - Tests setup
  - Instrumentation
  - Facilities
  - Result comprehension and reporting



CERN - WorldFip repeater system on beamline

- Objective:
  - Reduce and help the equipment groups to lower the burden of the radiation test by giving the support as a service
  - Still keep high the knowledge sharing and the collaborations

Radiation test service – BE-CEM-EPR

Request collection

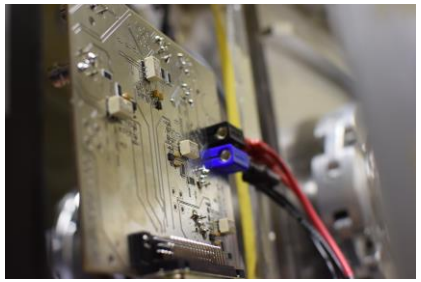
The requests for radiation testing are collected and processed selecting the most suitable methodology and facilities

Test planning and structure

Each component/system is analyzed, and all the possible radiation effects are taken into account for planning the test and structure it

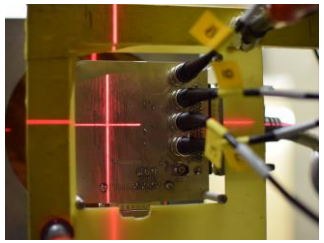
Board and instrumentation preparation

For each component a dedicated set of test board is prepared and the associated instrumentation is chosen to face the complexity of the radiation test



Testing

The test are carried out at CERN facilities such as CHARM or Co60 and in external facilities. The transport, personnel and instrumentation are selected considering the peculiar aspect of each facility



Result analysis

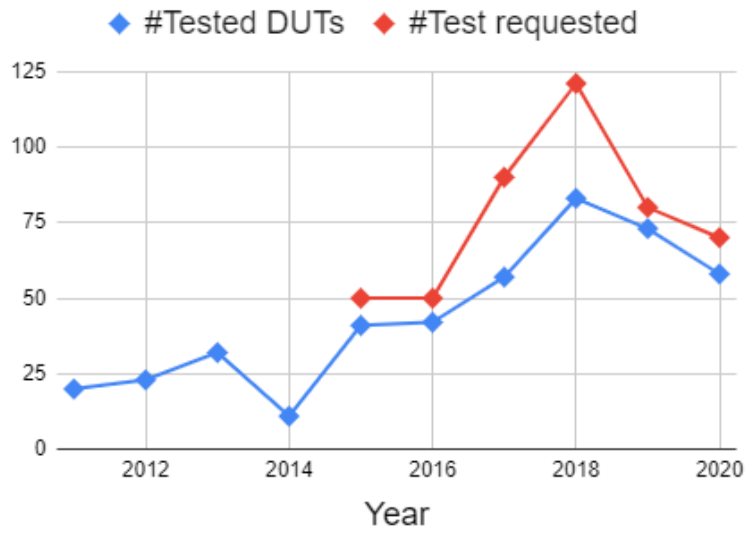
The results are analyzed during and after the tests for each component considering the end application and the possible operational issues

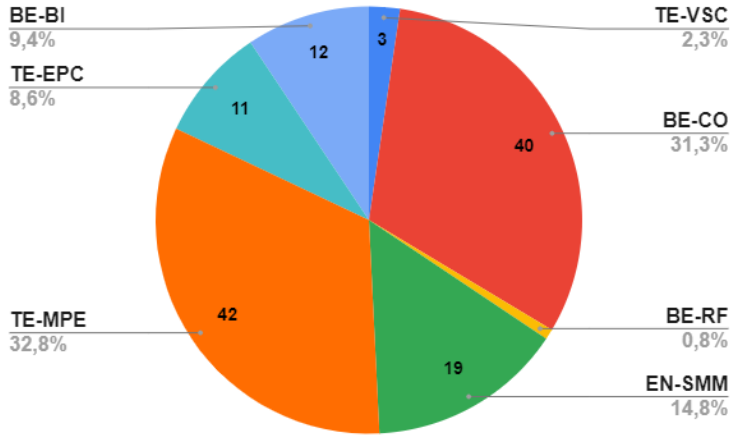
Database and Publication

The results are collected, stored and in EDMS and published in the RADWG database to allow an easy research of the best candidates for the new radiation tolerant des

Request Collection

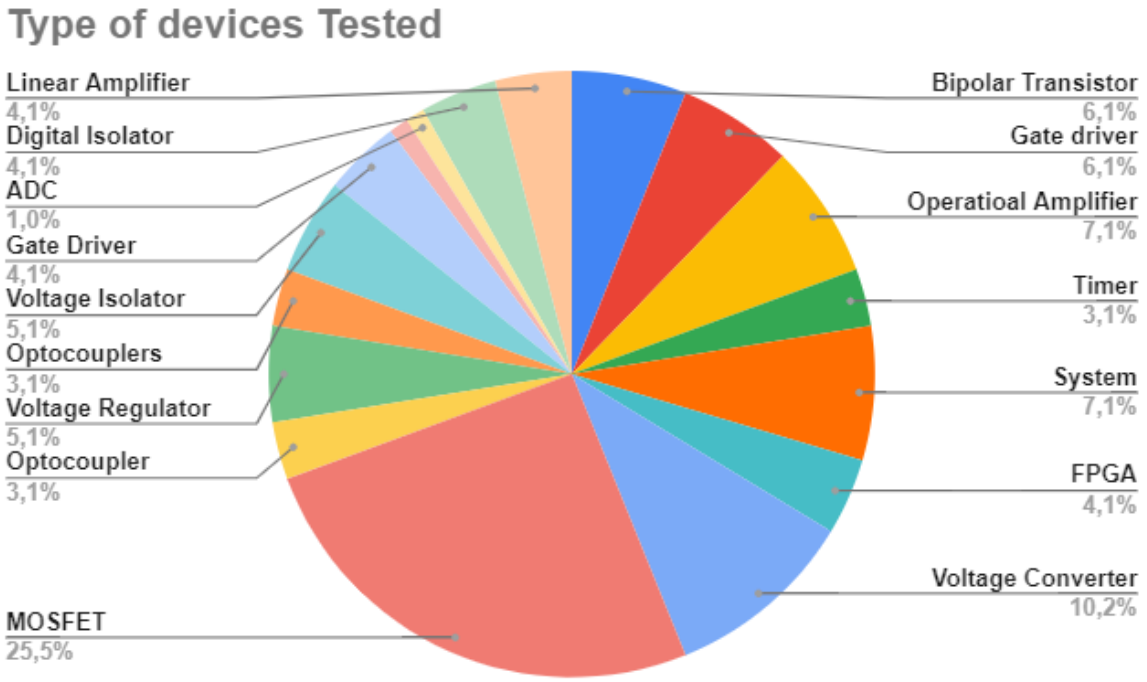
- During the last two years 150 component requests were collected
- The trend is expected to remain at 80-100 components per year
  - **Systems consolidation requires components testing too**
- Less campaigns were performed in 2020 compared to usual due to the COVID situation
- All the equipment groups in charge of new developments requested the radiation test service to qualify the selected components

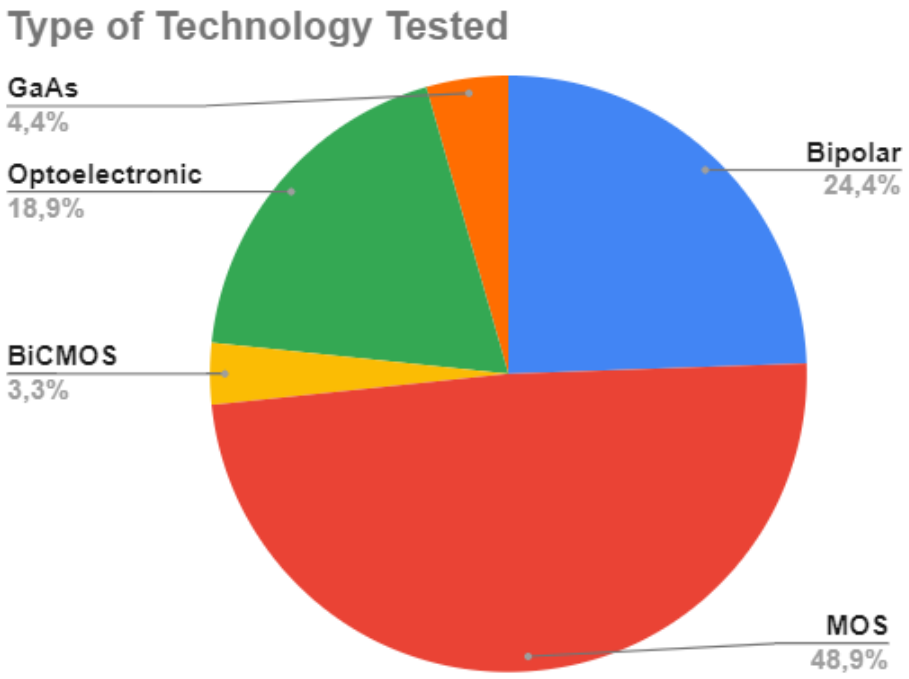




Statistics about the type of components

- Various types of device tested, from single transistors up to entire systems
- Different types of technology tested



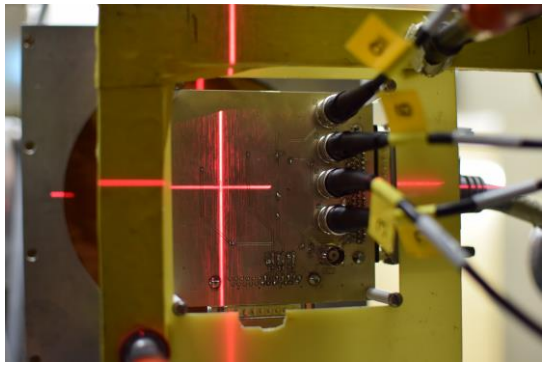


How do we prepare the tests?

- Acquired know-how and development of standard test structures and instrumentation to be used allows a test every month on new devices
- Tests are not limited to the requested parameters monitoring but general parameters are measured to be as general as possible and allow other users to verify the suitability of the devices for their purposes.
- Key points:
  - Ability to produce test cards and setup within few days
  - Ability to quickly develop firmware and software suited for the tests
  - Availability of high-end instrumentation to face the most difficult task (i.e fA measurements under irradiation, Single Event Transient)

19/1-019 Rapid Prototyping lab

107/1-A10 Main PCB Assembly Atelier



PSI Beam Line

CC60 Instrumentation

Where do we test: Key point is the facilities

PSI-PIF – Switzerland, Viligen
- 30-220 MeV Proton beam
- Combined **SEE**, **TID**, **DD** Tests
- **5 Years collaboration agreement with CERN**

JSI – Slovenia, Ljubljana
- Triga Mark II Nuclear Reactor
- **DD**, TID
- **Punctual use, possibility to make a contract**

ILL – Genoble, France
- Thermal Neutron Beam
- Thermal neutron sensitivity Tests
- **Punctual use, possibility to make a contract**

CC60 – Switzerland, CERN
- 10 Tb Cobalt 60 Source
- **TID** Tests
- **Available all the year**

CHARM – Switzerland, CERN
- Representative LHC Radiation mixed-fields
- SEE, TID, DD
- **Not available during technical stops**

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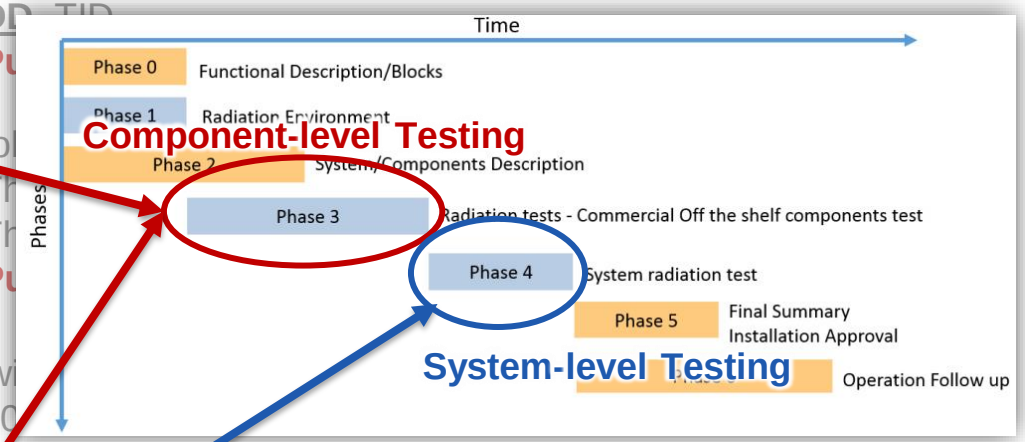

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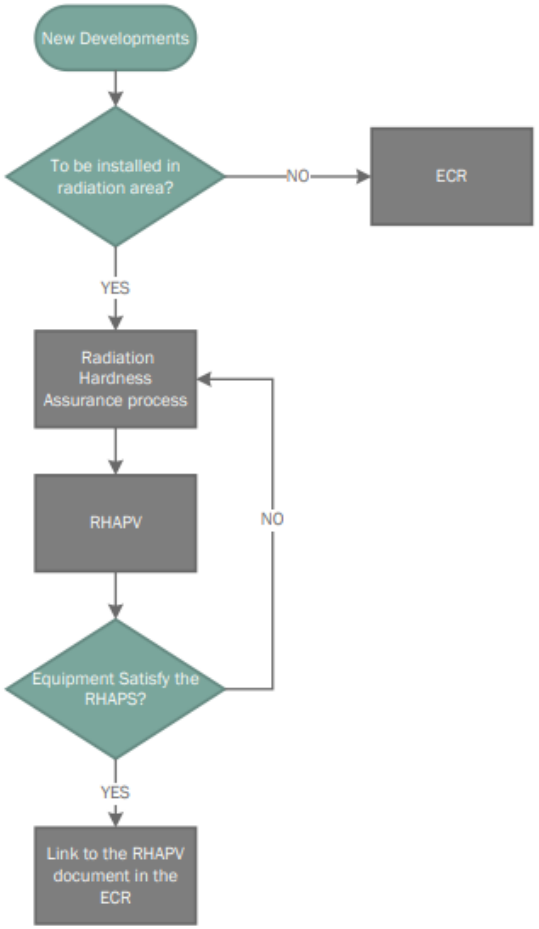
See "Upgrade of the CERN Cobalt-60 (CC60) facility" presentation from M. Brucoli, *today at 11:40*

CHARM – Switzerland, CERN
- **SEE, TID, DD**
- **Not available during technical stops**

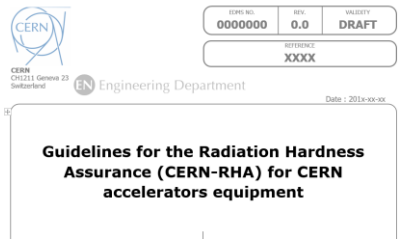
See "CHARM facility operation and user support" presentation from S. Danzeca, *today at 11:20*

RHA validation procedure

- A system radiation hardness assurance (HRA) procedure was developed within the R2E project:

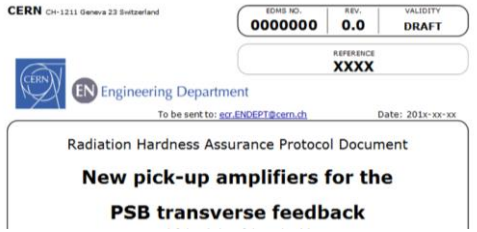


- Linked to the Engineering Change Request (ECR) as final validation
  - **Check-box in ECR** template for electronics installed in possible radiation area
- Contains the RHA Project Validation (RHAPV) document as cornerstone
  - The RHA for the various developments is reviewed and approved by R2E project management, ensuring an independent check with respect to system developers and testing activity

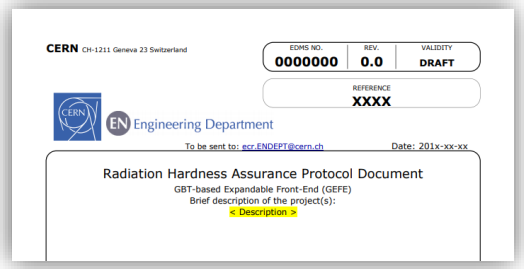


Radiation Hardness Assurance Procedure (RHAP) document

Radiation Hardness Assurance Project Validation (RHAPV) document



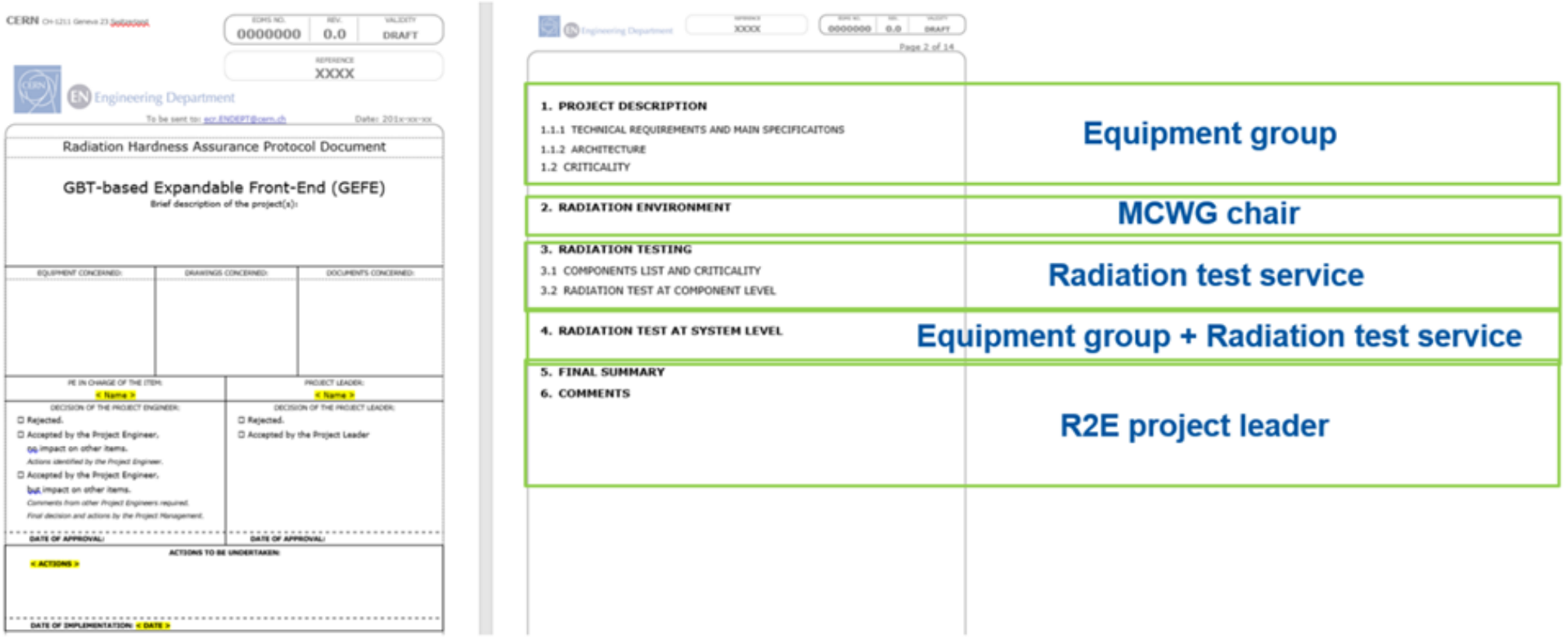
Example of a filled document can be found here



GEFE RHAPV

RHA validation procedure

- A system Radiation Hardness Assurance (RHA) based procedure was developed within the R2E project:



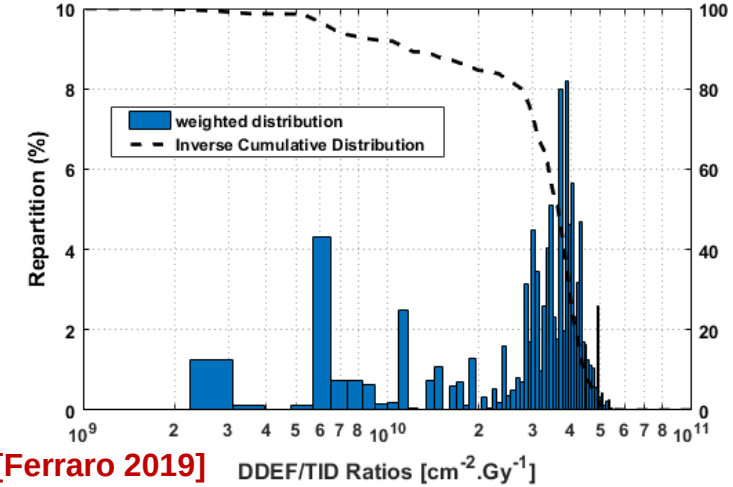
Testing R&D

- Different researches were conducted to face new radiation tolerance challenges imposed by the High-Luminosity LHC update:

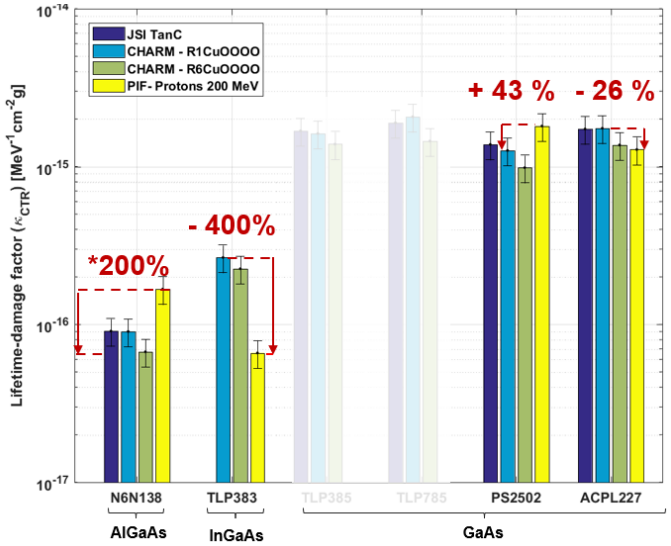
- **Test Methodology:**
  1) Study of the Impact of the LHC Radiation Environments on the Synergistic DD and TID Effect on Electronic Components
     (*R.Ferraro, IEEE Trans. Nucl. Sci. 66 (2019) 1548 - 1556*)
     → **Proved the importance of selecting the correct TID/DD rate ratio to obtain reliable degradation profiles**

  2) COTS Optocoupler Radiation Qualification Process for LHC Applications Based on Mixed-Field Irradiations
     (*R.Ferraro, EEE Trans. Nucl. Sci. 67 (2020) 1395-1403*)
     → **Proved the importance of carefully selecting the test environments to obtain reliable degradation rates**

- **FPGA Candidate:**
  3) Se[illegible] **see dedicated presentation: "Update on FPGA Testing" from myself,** *today at 16:45 today*



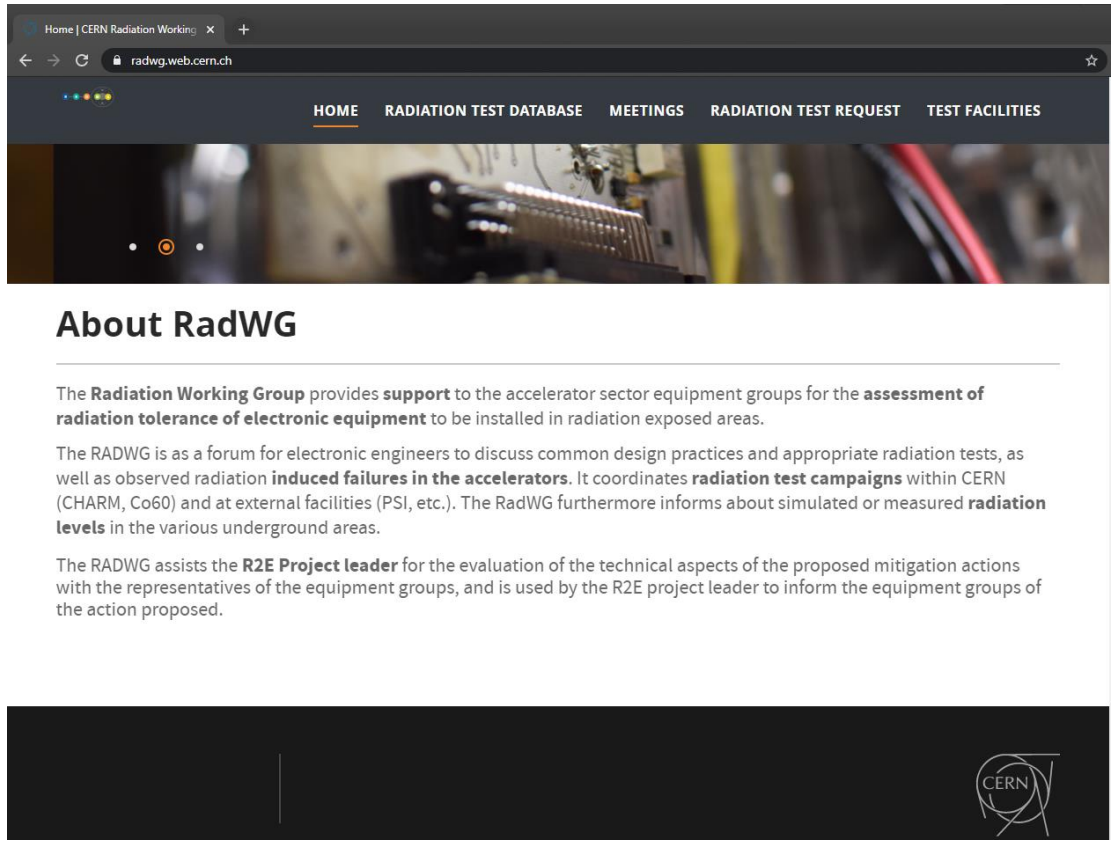
[Ferraro 2019]



[Ferraro 2020]

Test results analysis and reporting

- 180 users subscribed to the mailing list ***lhc-proj-radwg-members***
- The website https://radwg.web.cern.ch/ embeds an User-Friendly database
  - More than **434 reports** from the 2011 up to 2020
- It **embeds** also the **TE-EPC component list and tests**
- The service produces reports in a common template for all the components tested
  - Test reports template ensure a coherent reporting
- The service maintains two databases accessible by all the equipment groups



https://radwg.web.cern.ch

Conclusions

- BE-CEM-EPR supports the RADWG and the R2E project by providing a radiation test service to all the ATS equipment groups
- The service mandate is to provide radiation test data to the equipment groups developing rad-tolerant design profiting of the well established know-how in radiation testing
- The radiation test service covers all the steps for a radiation campaign, from the test specification up to the reporting.
- Tests are carried out to be more general as possible in order to create the common building blocks that can be re-usable by many other equipment
- The service maintains the website and the database with more than 434 test reports accessible to all the CERN equipment groups

Thank you for
your attention!

CERN

R2E

Controls
Electronics &
Mechatronics