# Short and long-term user needs and possible upgrades for current and future irradiation facilities

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G-RADNEXT workshop – June 12th – 13th 2024

https://indico.cern.ch/event/1353707

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This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No **101008126**

# G-RADNEXT workshop

## Agenda

A. Introduction to the task 4.2 of the WP4 RADNEXT
B. Methods and motivations of the users' survey
C. Requirements for radiation tests in the future
D. Focus on radiation tests with heavy ions
E. One tangible example to leverage radiation tests with heavy ions at CERN
F. Focus on the cost to perform radiation tests
G. Services under irradiation tests: what do users typically find in today's facilities
H. Services post-irradiation tests: what do users typically find in today's facilities
I. Focus on future needs – the next step to engage both users and facility coordinators
J. Conclusion

# A. Introduction to the task 4.2 of the WP4 RADNEXT

- **Main objective:** Define long term scientific and industrial **needs for irradiation facilities** based on key parameters, considering inputs from relevant research groups and industrial community

- **Task 4.2:** Key performance parameters for current and new facilities

  - Identify technological limiting factors for available irradiation test facilities based on current industrial/scientific requests

  - Identify operational issues/challenges for radiation testing coping with different applications and environments

  - Summarize the status of the radiation test facilities as a function of those limiting factors

  - Identify new facilities currently not adapted for radiation testing but that can be used for components' qualification and system-level testing (*cf. Presentation: "Laser-driven beams for radiation-to-electronics study – R. Versaci"*)

# B. Methods and motivations of the users' survey

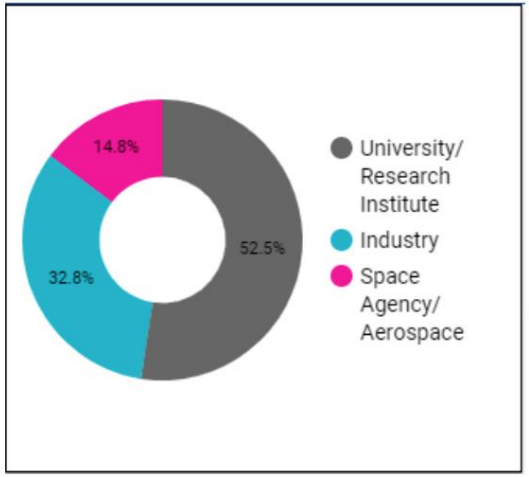
- **Main objective:** Determine the short-term and long-term users' needs of the academic and industrial sectors regarding radiation tests. 61 replies were analysed.

  https://docs.google.com/forms/d/e/1FAIpQLScdO8dwXy8ps2OlwIL-haCMKRgEAGCzdKUVaFo9lUwBDUccQA/viewform?usp=sf_link

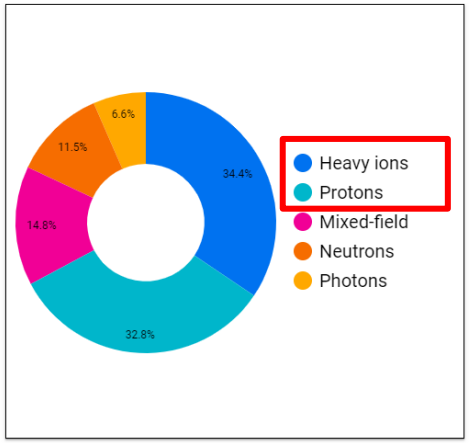
- **Analysis tool:** Looker Studio.

- **Motivations:**

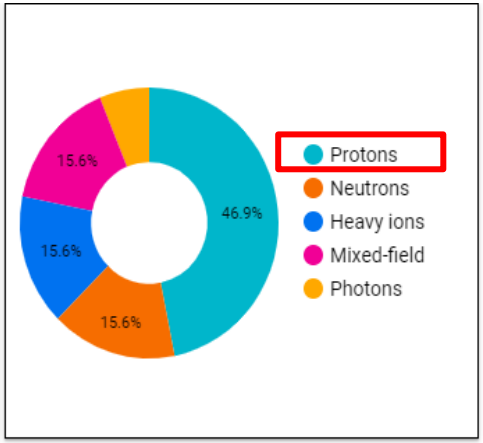
  - Target the largest possible users' community beyond RADNEXT
  - Review the users' requirements according to a wide range of facilities (heavy ions, protons, neutrons, electrons, photons, and mixed fields)
  - Address the main specifications according to 4 relevant use cases (Sensors and Detectors Irradiations, Materials, Electronic Components and System tests)
  - Pinpoint limiting factors of current irradiation facilities, propose solutions for the upgrade of existing infrastructures and the development of future ones




Industry & Space Agency / Aerospace (**29 replies**)




University/Research Institute (**32 replies**)

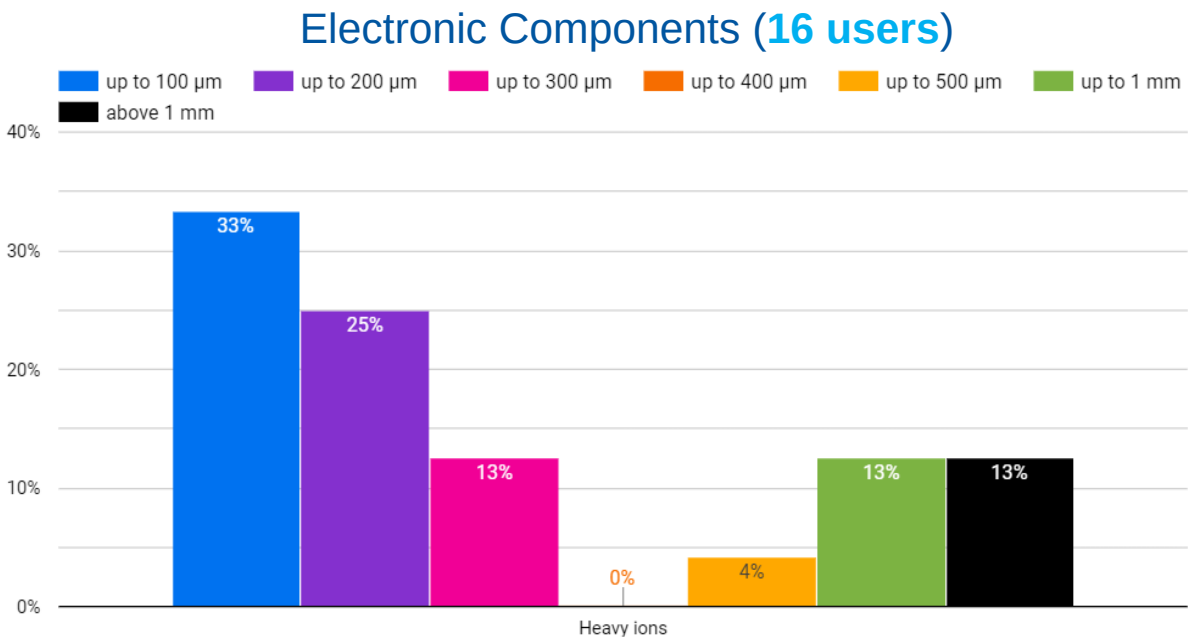


# C. Requirements for radiation tests in the future

| Use Cases | Facilities needed | Beam energy/Flux/Dose | Size of samples | Number of days/year for radiation tests | Selection criteria for a facility |
|---|---|---|---|---|---|
| **Sensors and Detectors Irradiations** | • Protons | • Beam energy: [20; 230] MeV<br>• Flux: [1E2; 1E8] part/cm$^2$/s<br>• Dose: [~10's; 1E5] Gy/h | • 2*2 cm$^2$ | ~ 50  | • Accessibility<br>• Beam features<br>• Local services |
| **Electronic Components** | • Protons<br>• Heavy ions | • Beam energy: [10; 230] MeV / [10; 1E3] MeV/n<br>• Flux: [1E4; 1E9] / [1E2; 1E8] part/cm$^2$/s | • 2*2 cm$^2$<br>• 20*20 cm$^2$ | • ~20<br>• ~50  | • Accessibility<br>• Beam features<br>• Local services |
| **System tests** | • Protons<br>• Mixed field | • Beam energy: [10; 200] MeV / [10; 1E3] MeV<br>• Flux: [1E2; 1E9] / [1E3; 1E8] part/cm$^2$/s<br>• Dose: [~10's; 1E2] Gy/h for both | • 20*20 cm$^2$<br>• 5*5 cm$^2$ | • ~100 for both  | • Accessibility<br>• Beam features |
| **Materials** | • Photons<br>• Protons | • Beam energy: [10; 1E5] MeV / [10; 50] MeV<br>• Flux: [1E2; 1E14] part/cm$^2$/s<br>• Dose: [~1E3; 1E5] Gy/h | • 20*20 cm$^2$<br>• 5*5 cm$^2$ | • ~100 for both  | • Accessibility<br>• Beam features<br>• Dosimetry accuracy |

# D. Focus on radiation tests with heavy ions

➢ Penetration depth required by users of heavy ions facility

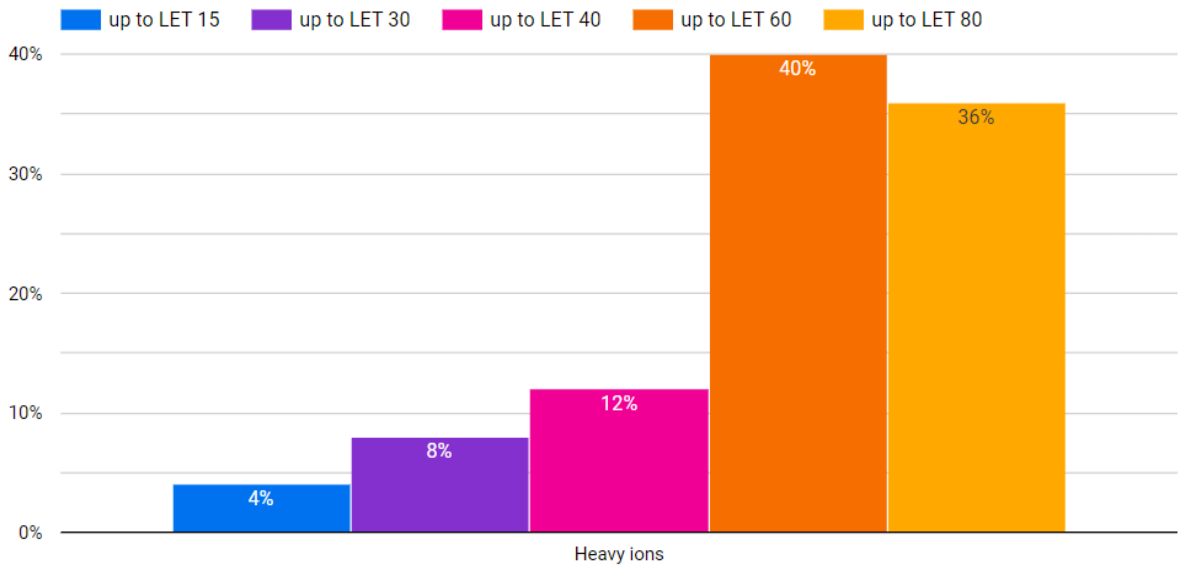



**Up to 100 µm** **Above 1 mm**

# D. Focus on radiation tests with heavy ions

➢ LET range (MeVcm$^2$/mg) required by users of heavy ions facility

Electronic Components (**16 replies**)

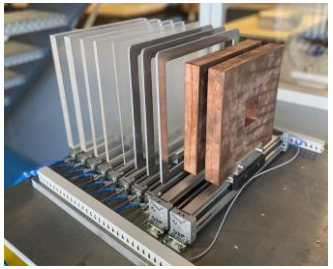



**Up to LET 15**

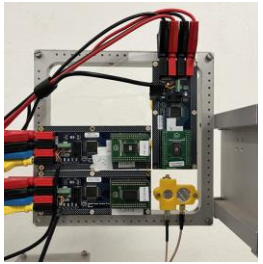
**Up to LET 80**

# E. One tangible example to leverage radiation tests with heavy ions at CERN

- **Heavy ions** are interesting for **radiation hardness assurance of electronics** by **combining high LET and deep penetration depth** in matter
- **Pb ions** are transferred through from PS to **CHARM/IRRAD** CERN experimental facilities for single event effect testing
- Electronics testing requirements and goals:
  - Broad linear energy transfer (LET) range by variable energy extraction (**650 MeV/n - 3 GeV/n**) + passive energy degradation using LET booster: **10 - 100 MeVcm$^2$/mg**
  - Penetration depth: **Si material > 1 mm**
  - Low beam flux (to ensure single events): **$10^2$ -$10^5$ ions/cm$^2$/s**
- Ongoing challenges:
  - Move from current test location in **CHARM** to **IRRAD**, improving beam quality and accessibility
  - **Access to the external users possible over 2 weeks in November 2024**
  - Explore feasibility of a separate dedicated beam line and use of lighter ions to reach LETs lower than **10 MeVcm$^2$/mg**

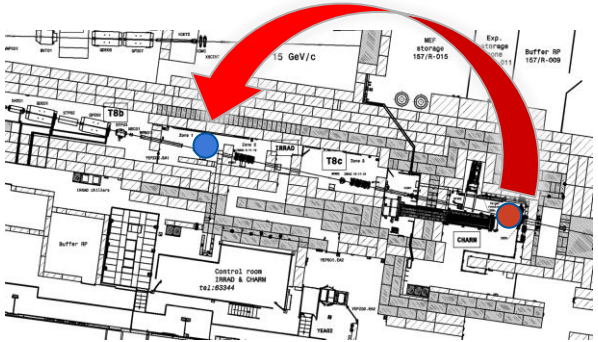


*LET booster*



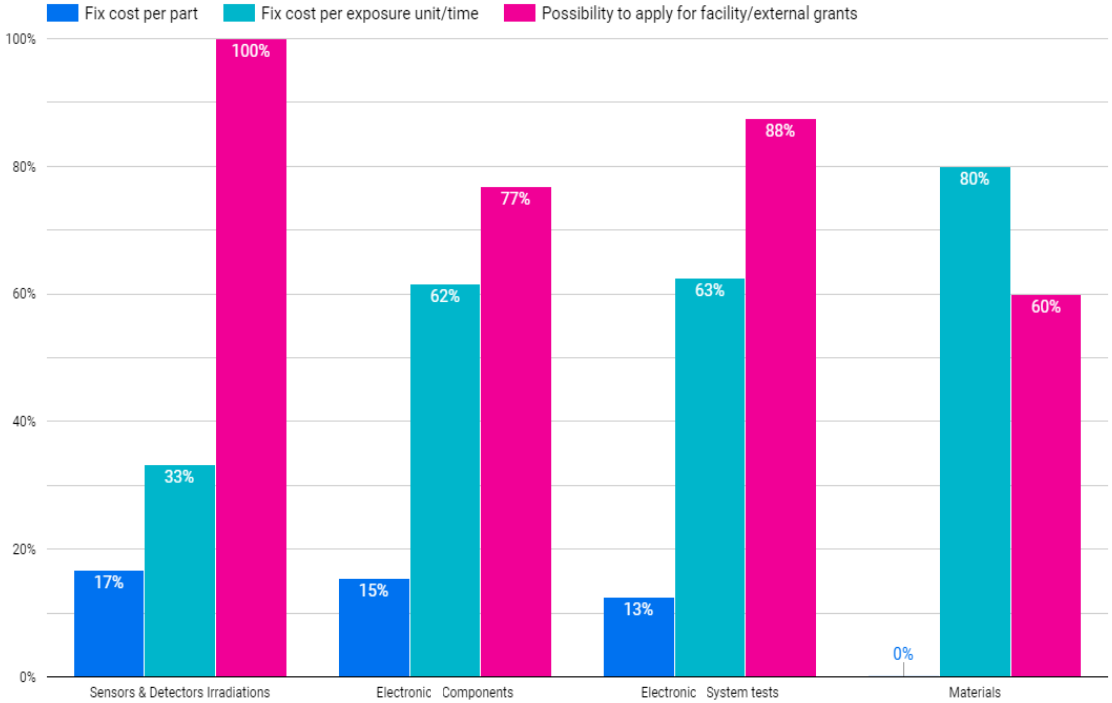
*Electronic components under test*

*Relocation of heavy ions activities*




*PS East Area/T8 beam line layout*

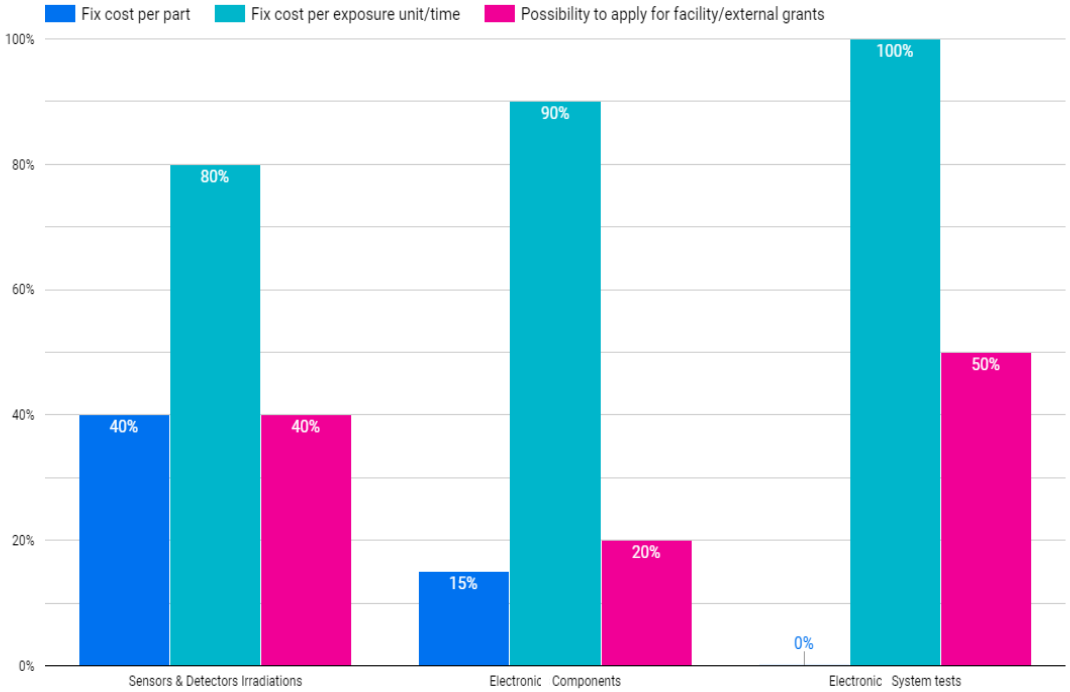
# F. Focus on the cost to perform radiation tests




University/Research Institutes

- **Close relationship** between the facility/external grants and the research sector
- **Sensors & Detectors** rely mainly on R&D projects
- **Materials study seem to remain the expertise of academia**

# F. Focus on the cost to perform radiation tests




Industries/Space Agencies

- **Close relationship** between the options of fixed cost and the industrial sector
- **Electronic Components/System tests** are the use cases where the industry has a role to play

# G. Services under irradiation tests: what do users typically find in today's facilities

| Type of facilities | Basic connectivity and monitoring | Empty cable ducts or fix patch-panels infrastructure | Full services by the on-site personnel | Fixed infrastructure | Samples preparation and data acquisition | Tools for positioning and alignment |
|---|---|---|---|---|---|---|
| Heavy ions | | | | | | |
| Mixed-field | | | | | | |
| Neutrons | | | | | | |
| Photons | | | | | | |
| Protons | | | | | | |

Frequent

Commonly found

Rarely found

# H. Services post-irradiation tests: what do users typically find in today's facilities

| Type of facilities | Logistics services | On-site testing/measuring equipment | Material storage services |
|---|---|---|---|
| Heavy ions | | | |
| Mixed-field | | | |
| Neutrons | | | |
| Photons | | | |
| Protons | | | |

Frequent

Commonly found

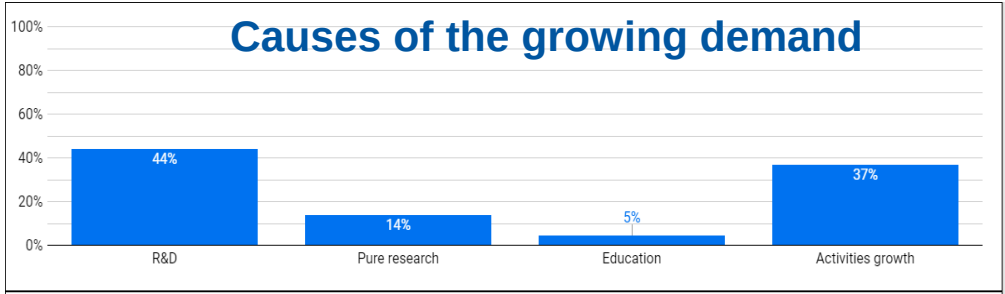
Rarely found

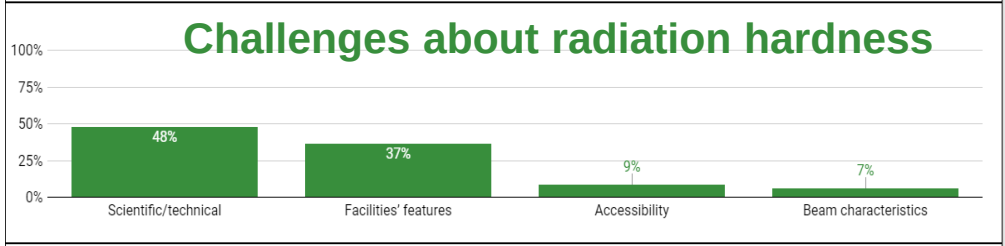
# I. Focus on future needs – the next step to engage both users and facility coordinators

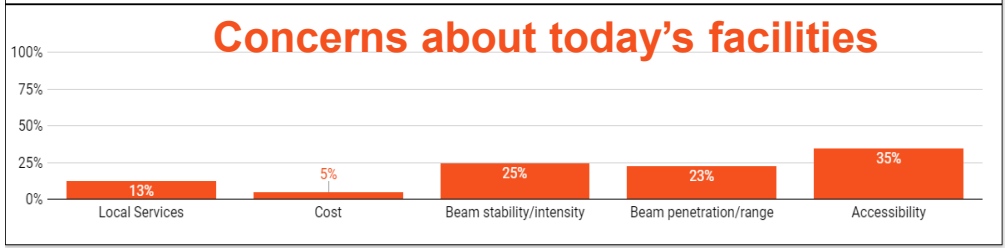
- Development of the space market (**New Space**)
- Emergence of new components with **higher sensitivity and complexity**

- Understanding radiation response of SiC power devices
- SEE tests **in small feature size / micro beam facilities** for SEE

- **Accessibility** in a reasonable geographical perimeter
- Limited range of **beams energy/penetration depth**



# J. Conclusion

## Task 4.2: Production of Key performance parameters for current and new facilities

➔ In-depth investigation of the current and future needs of irradiation facilities' users:
- Collect relevant experiences on **4 use cases** and **5 radiation fields**
- Determine some technical specifications for the research and industrial sectors
- Identify some technological and logistics bottlenecks that must be tackled

➔ General trend regarding the 4 use cases:
- Protons, heavy ions, neutrons, and mixed-field facilities will be more requested
- Identification of a series of beam parameters of interest with tangible figures: beam energy, flux, dose
- **Synergy between research and industry:** address the fast evolution of components' design coupled with the rising demand for radiation tests ⇒ improve the accessibility/remote testing (*cf. Presentation: "Remote radiation hardness campaigns at facilities: Challenges and Perspectives – A. Scialdone")*

➔ Services under (fixed infrastructure) and post-irradiation (on-site/testing equipment) should be improved

# Appendix

# Beam parameters figures wrap-up

| Type of facilities | Energy range | Flux | Dose |
|---|---|---|---|
| **Heavy ions** | [10; 1E3] MeV/n | [1E2; 1E8] part/cm$^2$/s | x |
| **Protons** | [10; 230] MeV<br><br>[10; 1E5] MeV (for "Materials" only) | [1E2; 1E9] part/cm$^2$/s<br><br>[1E2; 1E14] part/cm$^2$/s (for "Materials" only) | [10's; 1E5] Gy/h |
| **Mixed-field** | [10; 1E3] MeV | [1E3; 1E8] part/cm$^2$/s | [10's; 1E2] Gy/h |
| **Neutrons** | [10; 1E3] MeV | [1E3; 1E8] part/cm$^2$/s | x |
| **Photons** | [10; 50] MeV | x | [1E3; 1E5] Gy/h |