Status and Outlook of WP04 “Roadmap and Pre-design of Future Irradiation Facilities”

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RADNEXT 2nd Annual Meeting – 9th - 10th of May

https://indico.cern.ch/event/1213492/

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WP04-NA3 RADNEXT

Agenda

1. WP04 structure and members
2. Task 4.1
3. Task 4.2
4. Task 4.3
5. Task 4.4
6. WP04-NA3 Conclusion

1. WP04 structure and members

- **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

- **Key tasks' description:**
  - Task 4.1: WP Coordination and Communication
  - Task 4.2: Identify limiting factors of current irradiation facilities and propose solutions for the upgrade of existing infrastructures and the development of future ones **(D4.1 and D4.2, M20)**
  - Task 4.3: Investigate innovative solutions for current irradiation facilities **(D4.3, M30)**
  - Task 4.4: Design study of new irradiation facilities **(D4.4, M40)**

2. WP04-NA3 Task 4.1 : WP Coordination and Communication

Indico category available "WP4-NA3"

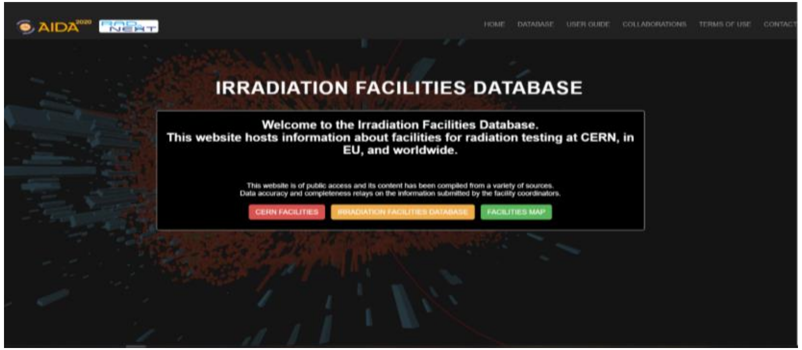
WP4 RADNEXT Team Meeting on a weekly basis

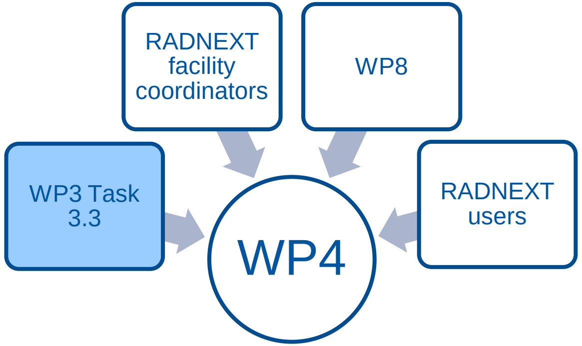
E-group created (radnext-na3) with the following email address: radnext-na3@cern.ch

3. WP04-NA3 Task 4.2 : Key performance parameters for current and new facilities

➔ **Report D4.2: Updated international irradiation facility compendium**

- Strong synergies with WP3 in order to retrieve facilities information and feedback:
  - Consolidation of the radiation test facilities database
  - Updates of important parameters and features





A unified entry point for **CERN and worldwide irradiation facilities** with an essential collection of information https://www.cern.ch/irradiation-facilities/

3. WP04-NA3 Task 4.2 : Key performance parameters for current and new facilities

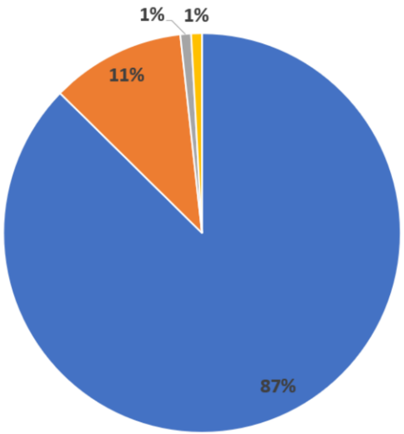
➔ A database platform dedicated to list essential features of irradiation facilities:

- **Open source** developed at CERN (EP dept.)
- List of infrastructures **across application domains**
- Information displayed under the **responsibility of the facility coordinators**

➔ **Today:**

- Maintained through RADNEXT WP4
- **234 valid facility entries** (updated from November 2022 onwards)
- ~ **9500 visits** since launch

World distribution of irradiation facilities in the CERN database



Visitor countries

COUNTRY	VISITS
Switzerland	2,830
United States	1,680
France	1,032
Italy	557
United Kingdom	450
China	387
Germany	380
Spain	252
Russia	128
Netherlands	125

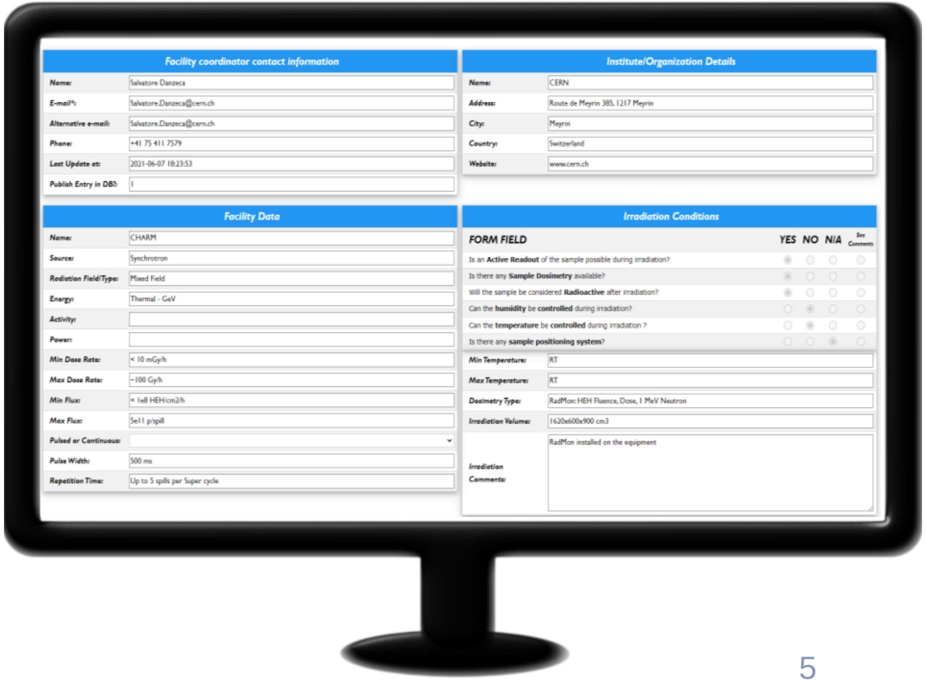
3. WP04-NA3 Task 4.2 : Key performance parameters for current and new facilities

- **A dedicated window for each facility entry:**
  - Contact information
  - Facility data, irradiation conditions, safety and accessibility

- **Search functionalities:**
  - Country, source type and radiation field/type

- **Editing functionalities:**
  - Protected by CERN authentication system
  - External "lightweight" accounts are supported

- **USER MANUAL:**
  - AIDA-2020-NOTE-2017-002



3. WP04-NA3 Task 4.2 : Key performance parameters for current and new facilities

- **Report D4.1: Determine Key Performance Indicators (KPI) and limiting factors for current facilities in view of future technological bottlenecks**

  ➔ STEP 1: a questionnaire dedicated to RADNEXT users and beyond
  - Identify the **current** and **future** needs of users performing tests in worldwide irradiation facilities

  ➔ STEP 2: a questionnaire dedicated to RADNEXT facility coordinators
  - **Assess the performance** of RADNEXT irradiation facilities by means of 9 KPI

  ➔ STEP 3: **Identify new facilities** currently not adapted for radiation testing but that can be used for components qualification and system-level testing

- **Summary for RADECS 2023:** "Bridge the gap between future users' needs and radiation-test facilities performances", P. Pelissou, I. Zymak, R. Versaci, F. Ravotti, S. Danzeca

3. WP04-NA3 Task 4.2 : Key performance parameters for current and new facilities

- **STEP 1: Identify technological limiting factors for available irradiation test facilities based on current industrial and scientific requests**

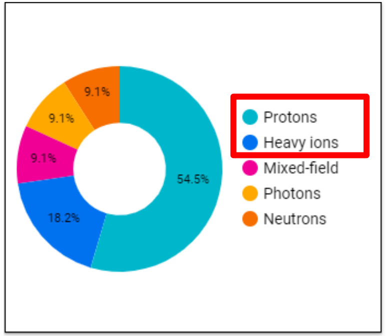
→ RADNEXT user's questionnaire focused on 4 use cases :
- Sensors and Detectors
- Electronic components
- Electronic System and Tests
- Materials

→ As well as 5 radiation fields:
- Heavy ions, protons, neutrons, mixed-field and photons

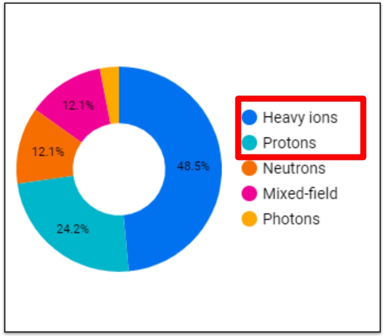
3. WP04-NA3 Task 4.2 : Key performance parameters for current and new facilities

➢ Needs for radiation fields according to the use cases

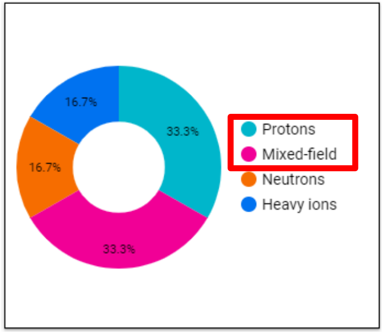
- Sensors and Detectors (**11 replies**)



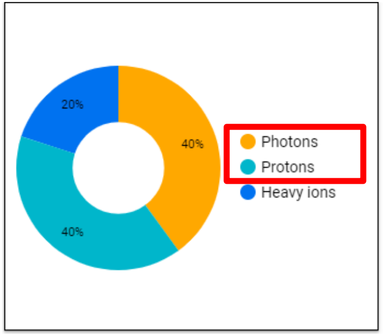
- Electronics Components (**33 replies**)



- Electronics System Tests (**12 replies**)



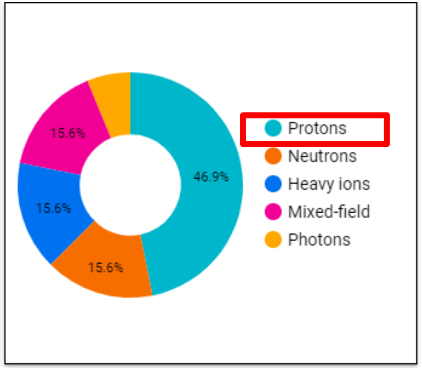
- Materials (**5 replies**)



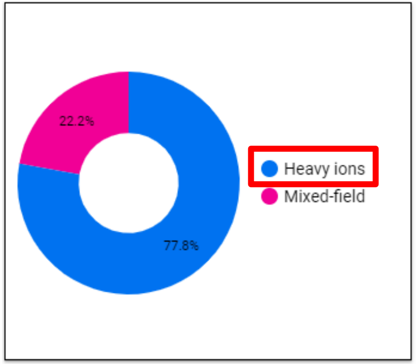
3. WP04-NA3 Task 4.2 : Key performance parameters for current and new facilities

➢ Needs for radiation fields according to the work place of users

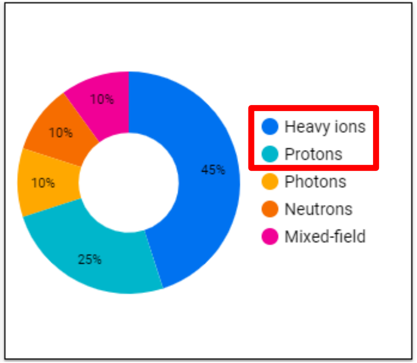
- University/Research Institute (**32 replies**)



- Space Agency/Aerospace (**9 replies)**



- Industry (**20 replies**)



WP04-NA3 Task 4.2 : Key performance parameters for current and new facilities

➢ Average number of days required to perform radiation tests per year

- Electronic Components (**33 replies**)

Particles_modified / Today / Future

Applications	Mixed-field		Protons		Heavy ions		Neutrons		Photons	
	Today	Future	Today	Future	Today	Future	Today	Future	Today	Future
Electronics Components	81	118	31	47	14	21	14	16	5	5

- Demand's increase:
- Heavy ions: +**32**%
- Mixed-field: +**31**%
- Protons: +**24**%

- Electronic System Tests (**12 replies**)

Particles_modified / Today / Future

Applications	Protons		Mixed-field		Neutrons		Heavy ions	
	Today	Future	Today	Future	Today	Future	Today	Future
Electronics System tests	81	97	81	118	18	18	15	23

- Demand's increase:
- Mixed-field: +**68**%
- Heavy ions: +**35**%
- Protons: +**16**%

3. WP04-NA3 Task 4.2 : Key performance parameters for current and new facilities

➢ Average number of days required to perform radiation tests per year

- Sensors and Detectors (**11 replies**)

Particles_modified / Today / Future

	Protons		Neutrons		Mixed-field		Heavy ions		Photons	
Applications	Today	Future	Today	Future	Today	Future	Today	Future	Today	Future
Sensors & Detectors Irradiations	38	54	10	10	10	10	8	10	5	5

- Demand's increase:
  - Protons: +**30**%
  - Heavy ions: +**20**%

- Materials (**5 replies**)

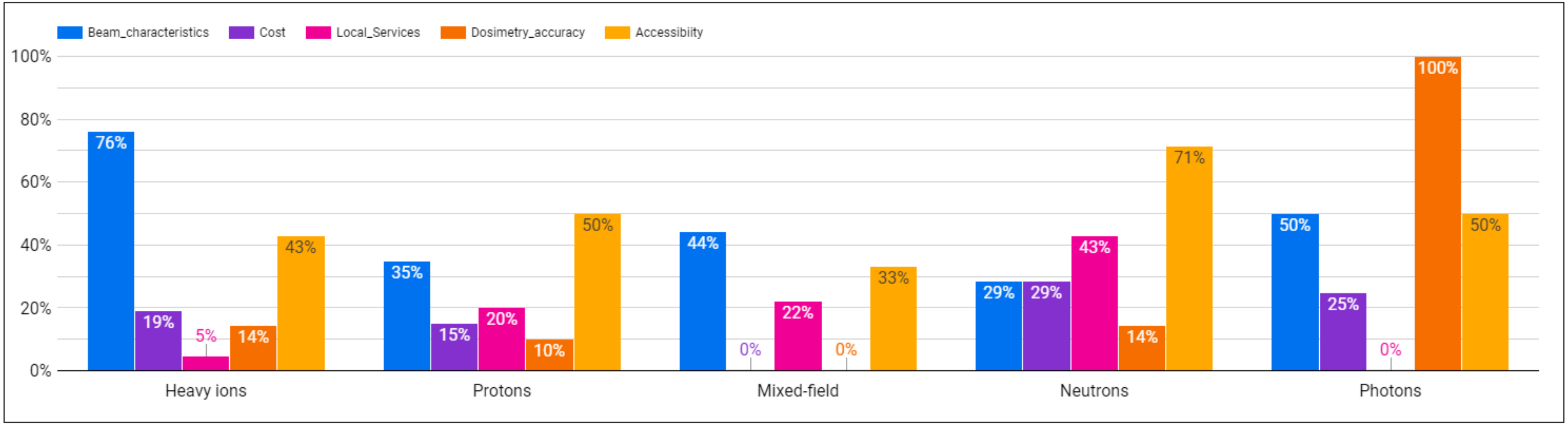
Particles_modified / Today / Future

	Protons		Photons		Heavy ions	
Applications	Today	Future	Today	Future	Today	Future
Materials	103	103	65	115	1	10

- Demand's increase:
  - Heavy ions: +**90**%
  - Photons: +**43**%

3. WP04-NA3 Task 4.2 : Key performance parameters for current and new facilities

➢ Most important criteria to select a facility for users

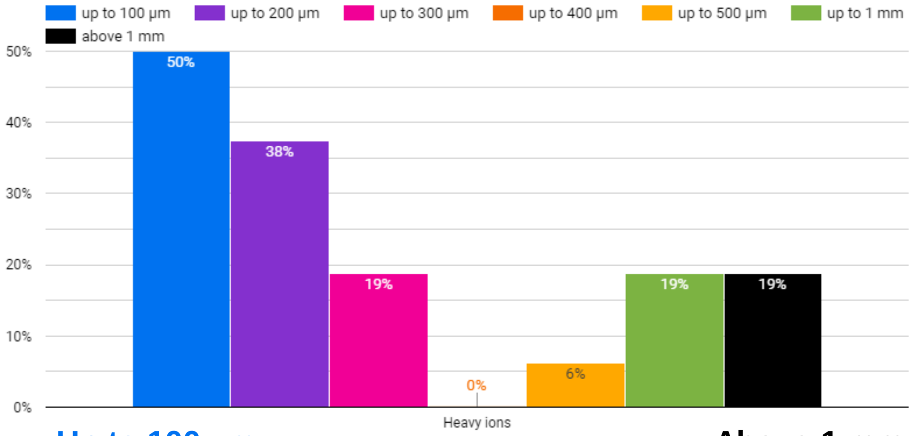


- **Beam characteristics** and **availability** prevailed in users' selection of a given facility

3. WP04-NA3 Task 4.2 : Key performance parameters for current and new facilities

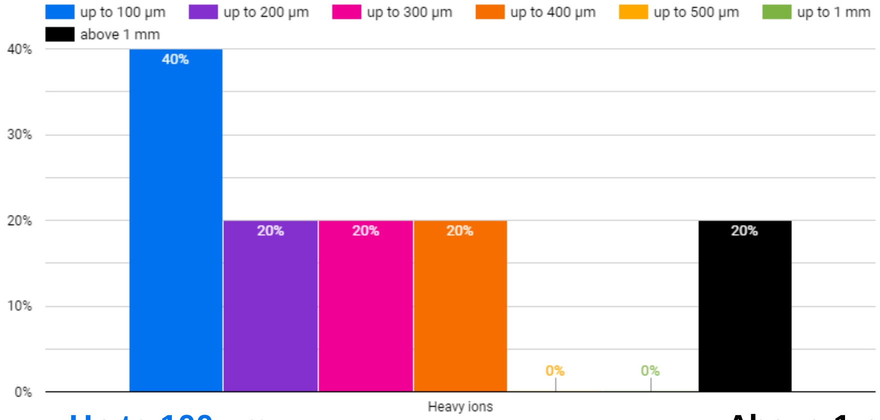
➢ Penetration depth required by users of heavy ions facility

- Electronics Components **(16 replies)**



Up to 100 µm **Above 1 mm**

- Electronics System and tests /Sensors and Detectors/Materials **(5 replies)**

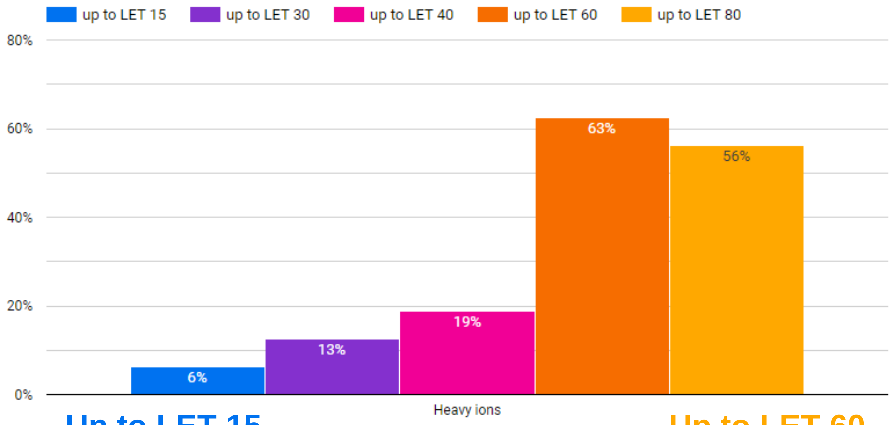


Up to 100 µm **Above 1 mm**

3. WP04-NA3 Task 4.2 : Key performance parameters for current and new facilities

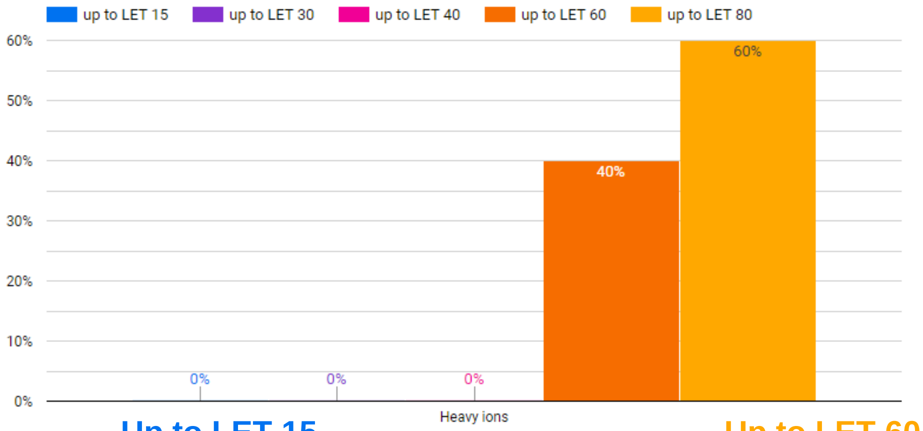
➢ LET range ($MeVcm^2/mg$) required by users of heavy ions facility

- Electronics Components **(16 replies)**



Up to LET 15 Up to LET 60

- Electronics System and tests /Sensors and Detectors/Materials **(5 replies)**



Up to LET 15 Up to LET 60

3. WP04-NA3 Task 4.2 : Key performance parameters for current and new facilities

- **Takeaways:**

- Access to **heavy ions** and **protons facilities** should rise within the five coming years according to the needs expressed by the research and industrial sectors.

- The demand for **mixed-field facilities** follows a similar tendency among users.

- Among the use cases of interests for RADNEXT (electronics system tests and electronics components), the essential criteria are **the beam characteristics**, **the accessibility** of irradiation facilities and **the local services** provided by the personnel.

- **Focus on heavy ions' beam:**

- Penetration depth's outlooks tend to point towards lower values (**up to 200 µm**).

- LET range usually varies **from up to 60 or to 80 MeVcm^2/mg**.

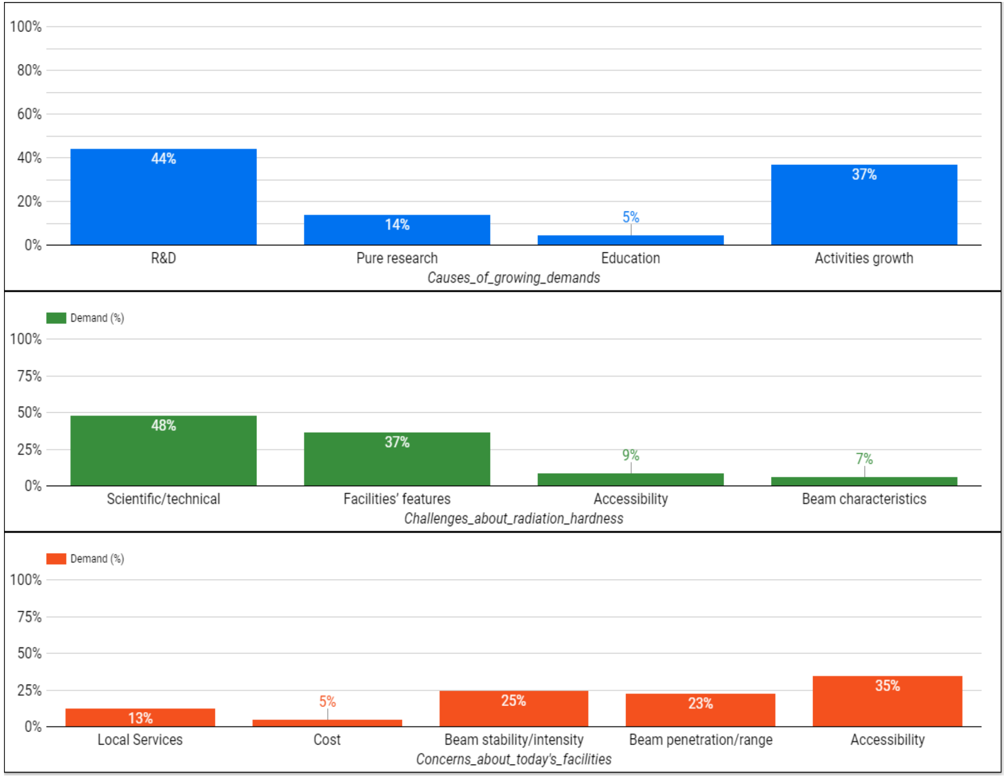
3. WP04-NA3 Task 4.2 : Key performance parameters for current and new facilities

➢ Future needs of users

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

- Mismatch between **beam time availability** and **market's needs**

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



3. WP04-NA3 Task 4.2 : Key performance parameters for current and new facilities

➢ **STEP 2: Identify operational issues and challenges for radiation testing coping with different applications and environments**

➔ RADNEXT facility coordinators questionnaire focused 9 KPI :
- High dose rate and flux
- Large volumes and surfaces
- High Energy/mixed-field energy
- Intermediate energy field
- High availability
- Services & environmental control
- Penetration in matter
- Low cost per irradiation unit
- Post irradiation services

➔ The facility coordinators have to assess each KPI according to the following scale :
- Routinely = 3, with little effort = 2, with great effort = 1, impossible = 0

3. WP04-NA3 Task 4.2 : Key performance parameters for current and new facilities

- **Clear takeaway from our evaluation protocol:** lack of high-energy beam or mixed-field energy that can be provided by a single facility (CHARM)

1. Deliver high dose rate/flux

2. Provide intermediate energy field

3. Propose lower cost offers per irradiation units

- Apply for facility/external grants
- Choose a fix cost per exposure unit/time

3. WP04-NA3 Task 4.2 : Key performance parameters for current and new facilities

➢ **<u>STEP 3:</u> Identify new facilities currently not adapted for radiation testing but that can be used for components qualification and system-level testing**

➔ LPA facilities can offer unique beam characteristics, but some trade-offs mitigation is required:

- Provides a radiation beam with ultra-short particle duration
- Radiation is delivered with ultra-high particle flux (e.g. kA range electron currents) and ultra-high dose rates
- The energy spread, beam pointing, divergence and pulse-to-pulse variation are relatively high compared to conventional sources

➔ LPA facility coordinators questionnaire focused to determine the current facilities suitability:

- Requests are sent to more that 20 facilities/beamlines
- Limited feedback so far, still collecting replies

3. WP04-NA3 Task 4.2 : Key performance parameters for current and new facilities

➢ **STEP 3: Identify new facilities currently not adapted for radiation testing but that can be used for components qualification and system-level testing**

➔ Laser Plasma-based Accelerators (LPA) have reached a reasonable **technology** readiness level

➔ Several LPA facilities declare their readiness to radiation experiments and tests:
- HZDR, Dresden – DARCO laser driven electron, proton/ions accelerators
- ELI Beamlines ALFA (electron) and ELIMAIA (proton)

4. WP04-NA3 Task 4.3 : Future solutions for current irradiation facilities

- **Task Leader: Federico Ravotti (CERN) and Roberto Versaci (ELI)**

➔ Study solutions for increasing the usability of the existing facilities:
- Standardized mechanical supports,
- Cabled and wireless solutions to have multi-users patch panel connectivity
- Virtual access/3D views of the installations

➔ Propose techniques and methods to overcome technological bottlenecks in the short term:
- Ion energies modulation and particle flux tuning in a wide dynamic range
- Beam steering techniques

➔ Guide research groups and facilities coordinators in their efforts to fulfill the long-term requirements

5. WP04-NA3 Task 4.4 : Design study of new irradiation facilities

- **Task Leader: Federico Ravotti (CERN) and Roberto Versaci (ELI)**

CERN **ELI BEAMLINES**

➔ Propose new primary beam and mixed-field facilities

➔ Laser-based facility in their infancy for radiation production

➔ Study the beam parameters of such facilities due to a growing interest in operational parameters and beam availability:
- Study the tools and dosimetry methods to assess the performances of LPA facilities
- Select a pool of infrastructures to lead test campaigns
- Evaluate the suitability to radiation tests according to the users’ needs

6. WP04-NA3 Conclusion

Task 4.2

➔ A complete update of the international irradiation facility compendium:
- **234 valid facility entries** entry all around the world – ensure the durability of the available information
- **Objective:** Make this database a worldwide reference - **your support matters**

➔ 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 their future demand in the scope of radiation tests

➔ Assessment of a pool of RADNEXT facilities:
- Identify the technological and logistics bottlenecks that must be tackled

Tasks 4.3 and 4.4: Ongoing

➔ Implement a process based on set-ups and dosimetry tools to perform beam diagnosis and characterization of LPA facilities

Thank you for your attention!

Image Source: CERN – CHARM facility