



WP5 : Radiation effects testing with VHE ions

CERN, 20.01.2023

HEARTS Kick-off Meeting

<https://indico.cern.ch/event/1216205/>



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Padova



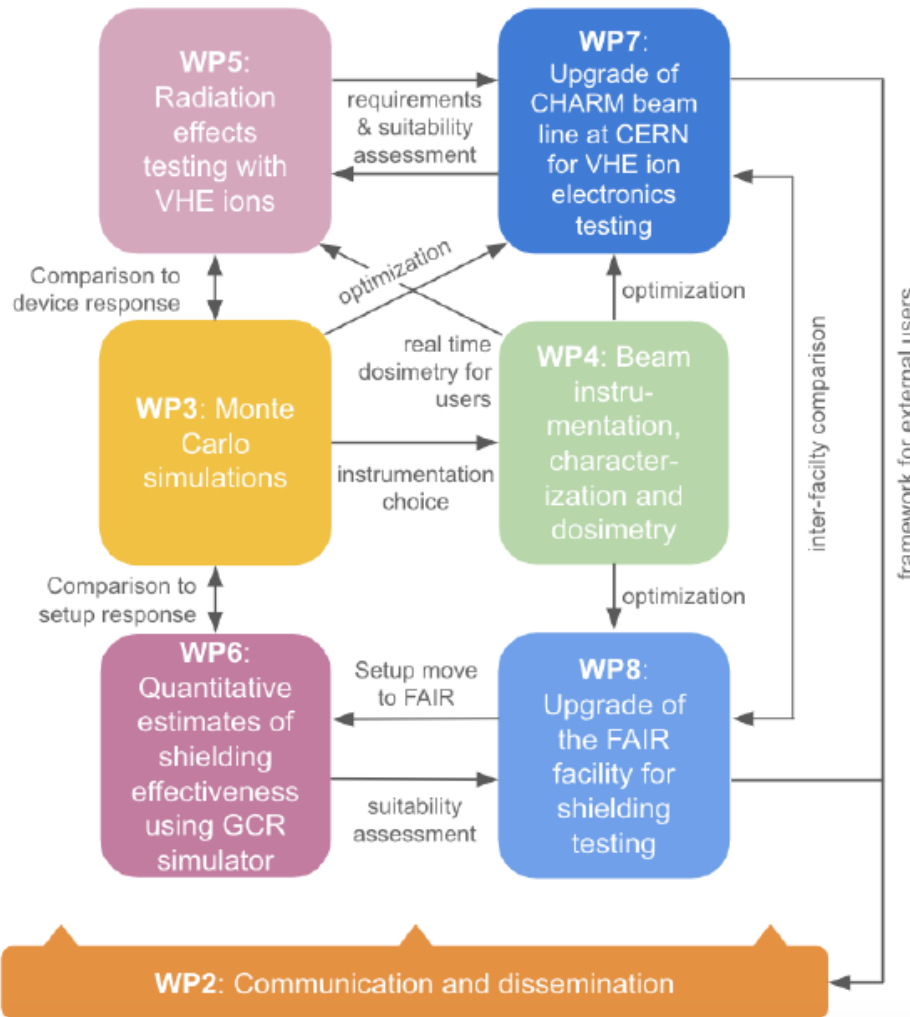
This project has received funding from the European Union's Horizon Europe Research and Innovation programme under GA No 101082402.

Objectives

- Project: provide **>100 MeV/n heavy ion beams to space users**, to mimic the effects of Galactic Cosmic Rays (GCR) at ground level
 - penetration levels large enough to enable electronics testing in air, without the need of special preparation and at board and box level
 - Essential for the exploitation of high-end microelectronics technology in space, for e.g. onboard artificial intelligence or Big Data processing applications
- The suitability of the **infrastructures** for the testing and qualification of EEE devices (\uparrow TRL to 6-7) and **electronic boards** is a key aspect
- WP5: study of **radiation effects induced by VHE heavy ions** on a set of **technologies representative of current state-of-the-art COTS electronics**
 - Comparison with standard-energy heavy ions.
 - Hierarchical approach, based on three levels of complexity, will highlight different levels of details

In the Project

WP1: Project management



- WP5 is strongly interconnected with the other work packages
 - WP3: comparison with simulation results
 - WP4: beam dosimetry
 - WP7: facility development

Description of work: Tasks

1. Final review of VHE ion beam requirements for SEE testing
2. Analysis of ionization response in a PIN diode for beam quality assessments

From
1st year

3. Suitability of the proposed VHE ion beams for 3D integrated device structures
4. Validation of the VHE ion beams for industrial use with TRL 6-7 achievement

From
2nd year

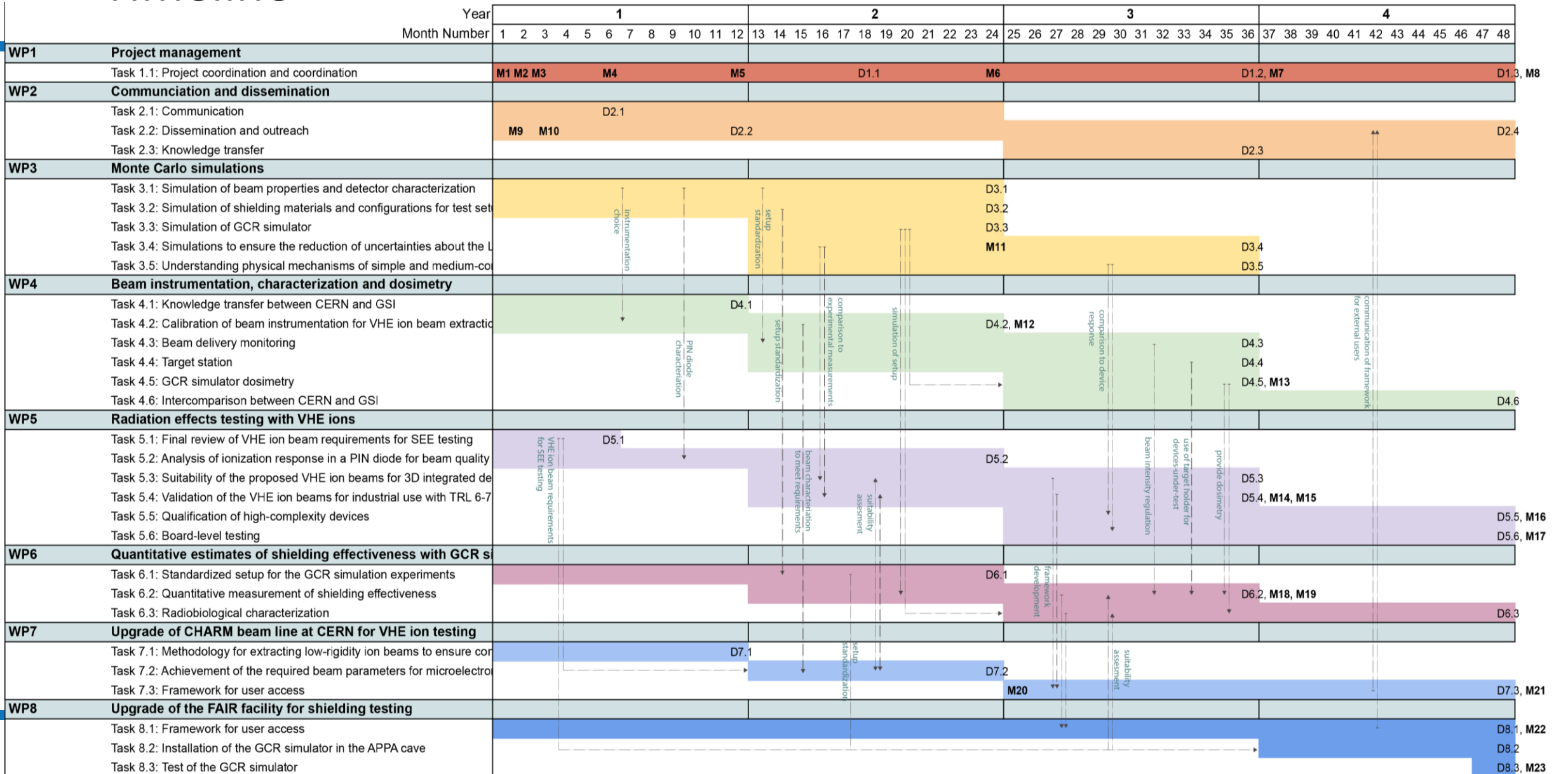
5. Qualification of high-complexity devices
6. Board-level testing

From
3rd year

Milestones

- Month 36: Achievement of TRL6-7 for electronics testing at the CHARM facility (MS14)
- Month 36: Achievement of TRL6-7 for electronics testing at GSI (MS15)
- Month 48: First-time heavy ion SEE qualification of highly-integrated electronic devices in Europe (MS16)
- Month 48: Release of guideline for SEE testing with VHE ion beams (MS17)

Timeline



Timeline (WP5)

	Year	1												2												3												4													
	Month	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48		
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Task 5.5: Qualification of high-complexity devices																																																			
Task 5.6: Board-level testing																																																			



Description of work: Task 5.1

Final review of VHE ion beam requirements for SEE testing

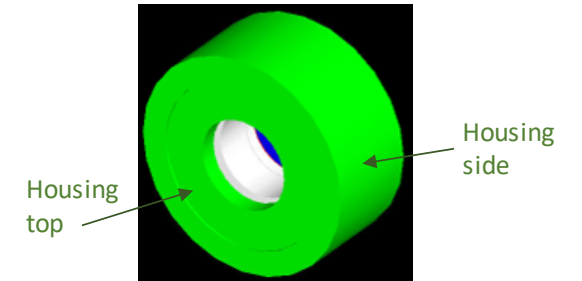
- ADS, TAS M1-6
- Industrial partners will review the goals in terms of **VHE ion beam parameters** to be reached with the CHARM and GSI-FAIR upgrade (WP7-8)
- Other than parameters such as ion type, energy, LET and range (and related accuracy), **beam time availability** (facility usable/bookable with reasonable delays) and **commercial conditions of access** (competitive with respect to European standard-energy ion facilities) will be included. Optimal trade-offs will be identified and submitted to the facilities

D5.1 (M6) Beam
Requirements

Description of work: Task 5.2

Analysis of ionization response in a PIN diode for beam quality assessments

- UNIPD, M1-24
- **PiN diode**: simple and effective structure to study heavy ion beams. It provides precise measurements of energy deposition in semiconductor materials. Diagnostic tool to assess the quality of the provided beam in terms of purity and energy straggling (e.g. with degraders).
- **Large experimental data set available** with standard energy heavy ion beams.
- **Monte Carlo model** of the diode **available** (see also WP3)



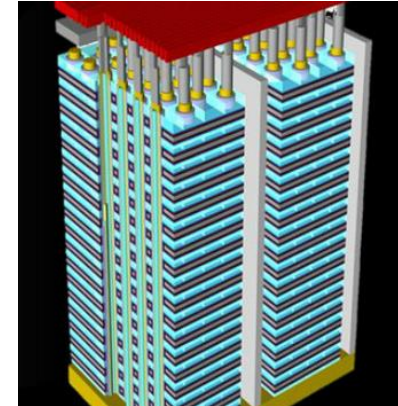
D5.2 (M24) Beam Quality

D5.5 (M48) Impact of beam energy in SEE testing

Description of work: Task 5.3

Suitability of the proposed VHE ion beams for 3D integrated device structures

- UNIPD, M12-36
- **3D NAND Flash memories** the first and most successful example of 3D integration in the semiconductor industry
- Devices with **hundreds of layers** are now available and increasing, reaching tens of microns of thickness.
- VHE heavy ions are extremely useful for these technologies



D5.3 (M36) Beam suitability for 3D structures

D5.5 (M48) Impact of beam energy in SEE testing

D5.6 (M48) SEE qualification guidelines for high complexity devices and board level testing

Description of work: Task 5.4

Validation of the VHE ion beams for industrial use with TRL 6-7 achievement

- ADS, CERN, M-12-36
- **VHE SEE testing on devices which have already been characterized** by the ADS at **standard-energy heavy ion test facilities** (e.g., UCL, RADEF)
- Previous tests carried out according to ESCC 25100 (package lid removal)
- Broad range of technologies will be tested:
 - High power diodes (Silicon or SiC)
 - High power MOSFETs (Silicon or SiC)
 - A stacked memory
 - all the dies will be tested as opposed to only the top die as customary with standard energy ions
- Benchmark SRAMs from CERN
- High complexity device

D5.4 (M36)
Verification of
beam parameter
requirements

D5.5 (M48) Impact
of beam energy in
SEE testing

D5.6 (M48) SEE
qualification
guidelines for high
complexity devices
and board level
testing

Description of work: Task 5.5

- **Qualification of high-complexity devices**
 - UNIPD, TAS, M24-48
- **Graphical Processing Units (GPUs) and Field Programmable Gate Arrays (FPGAs)** are two key enablers for on-board **artificial intelligence**
- Heavy-ion SEE qualification is very complex because of the very high power-consumption (standard energy ions require in-vacuum irradiations) -> in air irradiation is key
- UNIPD will perform a test campaign on a GPU
- TAS will perform a test campaign on a FPGA
- The results will be used together to compile recommendations and guidelines about SEE testing with very high energy ion beams



D5.5 (M48) Impact of beam energy in SEE testing

D5.6 (M48) SEE qualification guidelines for high complexity devices and board level testing

Description of work: Task 5.6

- **Board-level testing**

- TAS, M24-48
- Board-level testing can enable the qualification of several devices by irradiating them simultaneously under the same beam.
- In some cases, and thanks to the properties of VHE ion beams, it can even be envisaged to test more complex systems that are made of a few electronic boards stacked on top of one another.
- The task will consist of testing electronic boards enabling power conditioning functionalities, which may be particularly sensitive to radiation.
- The objective of the task will be that of defining a methodology for testing these kinds of boards with a VHE ion beam that will be integrated in the guideline.

D5.6 (M48) SEE qualification guidelines for high complexity devices and board level testing

Deliverables

- D5.1 (M6) Finalised list of beam parameter requirements concurring to establish a TRL 6-7 for the CHARM facility
- D5.2 (M24) Validation of beam parameter quality of CERN and GSI infrastructures for testing of electronics
- D5.3 (M36) Verification of the beam parameter suitability for testing 3D structures
- D5.4 (M36) Verification of the compliance with beam parameter requirements and awarding of TRL 6-7
- D5.5 (M48) Implications of beam energy in single event testing for various levels of device integration
- D5.6 (M48) Guideline on SEE qualification procedures for high complexity devices and boardlevel testing with VHE ion beams

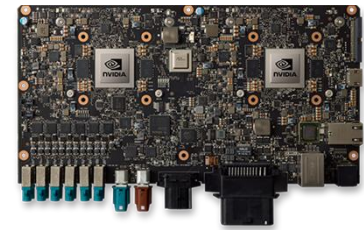
Key Personnel

- ADS:
 - R. Mangeret, M. Rostewitz
- TAS:
 - R. Mancini, S. Francola
- UniPD:
 - M. Bagatin, UniPD project leader
 - S. Gerardin, WP5 leader
 - A. Paccagnella, staff

Work package number	5.	Lead beneficiary	UNIPD	
Work package title	Radiation effects testing with VHE ions			
Participant number	1	3	4	5
Short name participant	CERN	ADS	TAS	UNIPD
Person-months per participant	2	19	4	16
Start month	M1	End month	M48	

Material Procurement

- ADS:
 - Purchase of the components and test set-up development/upgrade (test sockets and PCBs, cables, test software etc.)
- TAS:
 - Test board for radiation testing (FPGA and DC/DC)
- UniPD:
 - Electronic components for SEE testing (GPUs, FPGAs, PCB, cables, etc.)



Meetings, Collaboration within the WP

- Shared tool for documentation and deliverables
 - CERNBox
 - EDMS
- Main areas of collaboration among partners
 - Test plans
 - Data analysis
 - Deliverables
- Monthly 1-hour meeting
 - Discuss hardware/software choices/testing methods/results
 - Additional specific meetings for test campaigns, deliverables, ...
 - Zoom/Indico



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