Minutes of meeting – HEARTS P1 Review Meeting

25 September 2024

Indico link: https://indico.cern.ch/event/1411185/

Participants: Simon Conticello (Project Officer – European Commission), Arto Javanainen (External Reviewer – JYU), Isabel López (External Reviewer – University of Cadiz), Rubén García Alía (Project Leader, WP1 and WP7 Leader – CERN), Pablo López (CERN), Cloé Levointurier-Vajda (CERN), Andreas Waets (CERN), Svetlomir Stavrev (CERN), Luigi Esposito (WP3 Leader – CERN), Odile de la Ruë (CERN), Thomas Brent (WP2 Leader – CERN), Christoph Schuy (WP6 Leader – GSI), Simone Gerardin (WP5 Leader – UNIPD), Miha Vitorovic (WP9 Leader – COSYLAB), Renaud Mangeret (ADS), Claudio Cipriani (TAS-I), Luca Bocchini (TAS-I), Alessandra Costantino (ESA).

Minutes prepared by: Andreas Waets and Pablo López

Meeting notes, focusing on key information points and open actions.

Work Package 1 – Project Management

More information in the slides.

WP1 objectives:

- Ensuring the efficient steering and management of the project throughout its duration with the aim of supervising and coordinating the scientific and technical progress of the different Work Packages.
- Taking care of the contractual and administrative implementation and keeping track of the use of resources.
- Supervising the preparation of periodic and final project reports to the European Commission as well as the arrangement of the project annual meetings.
- Taking over the coordination of beam access for users throughout the project and until the frameworks established in WP7-8 are defined.

Overall during RP1, good progress has been made towards the achievement of these objectives, with no delay nor issue to report. We can note the expansion of the Consortium with the inclusion of an additional beneficiary, COSYLAB, during P1, demonstrating interest to HEARTS project beyond our initial consortium.

All deliverables (D1.1) and milestones (MS1, MS2, MS3, MS4 and MS5) were reached and submitted in time.

The 2nd HEARTS Annual Meeting will likely be scheduled in late January 2025 at GSI (current tentative dates are 20th-21st January, action on Pablo to set the dates). The user test reports of the heavy ion run (November 2024) won't be fully completed by then but, in terms of beam characteristics and dosimetry reports, as well as in qualitative feedback from the users related to the facility readiness levels and points for improvement, we can realistically expect to be at a more advanced stage.

Work Package 2 – Communication and dissemination

More information in the slides.

WP2 objectives:

- Establish effective communication and data exchange between the partners within the project.
- Communicate the results of the project to external interested parties.
- Disseminate the results of the R&D achieved within the project and the knowledge transfer activities to open up the possibility of collaborations with external parties.

All deliverables (D2.1 and D2.2) and milestones (MS9 and MS10) have been reached and submitted according to plan.

In P1, 6 HEARTS papers have been presented by CERN, whereas GSI had 3 talks in conferences. A section dedicated to conference contributions and publications will be created and kept up to date on the website (action on Thomas/David).

The CERN heavy ion run in November will be a good opportunity to boost the project's social media and website.

Comment from Isabel López: Having a page describing the HEARTS facilities on the website could be useful for the users (action on Thomas/David).

Goals moving forwards:

- Increase Linkedin visibility
- Attract more media attention
- Foster future knowledge transfer activities through dissemination of project results

Work Package 3 - Monte Carlo simulations

More information in the slides.

WP3 objectives:

- Characterization of beams and secondary radiation fields in irradiation facilities or for beams going through shielding materials.
- Revealing the physical processes behind the triggering of radiation effects in electronics and damage delivered to organic tissues using FLUKA and Geant4.

Significant progress has been made in all tasks in developing and validating simulation models and tools for beam characterization, shielding material assessment, and understanding the effects of VHE ions on electronic devices. Deliverables 3.1, 3.2 and 3.3, and Milestone 11 are on track to be completed in due time (31.12.2024).

FLUKA is not used for the optics studies of the T8 beam line at CERN but studies were done to reconcile the FLUKA data with MADX data which is the tool used for developing the optics. Experimental validations of the simulation model did not reveal a showstopper in terms of unknown beam line materials. All resources are available to continue. University of Padova will test a standard PIN diode.

Mitigating differences between simulation codes and their uncertainties is not in the scope of HEARTS: comparing FLUKA and SRIM for VHE heavy ion beams would include a full measurement campaign in itself. When it comes to the dedicated HEARTS user tool the goal is not to reinvent the wheel, the collaboration with NSRL allowed them to update their StackUp tool with Pb ions.

The goal at GSI is to make the simulations of the GCR simulator faster for the users. The optimizer uses Python based on MC data but will not use MC simulations itself. The simulation model will be frozen. Efforts are made at CERN which intend to make the comparison between Geant4 and FLUKA simulations easier within this work package.

Work Package 4 - Beam instrumentation, characterization and dosimetry

More information in the slides.

WP4 objectives:

- Standardisation of the beam instrumentation in terms of beam delivery, online monitoring, target station remote controlling and dosimetry at CERN and GSI.
- Define and calibrate the beam delivery sensors at GSI and CERN for both material shielding and microelectronics, characterising monoenergetic beams and the full GCR spectrum.

At GSI U beams are used for HEARTS electronics testing purposes. Users can however request other ion beams which can be set up in the same run, the ion schedule at GSI for the following year is known at this point in the year.

The use of different detectors requires a good common calibration. However, for these high energy heavy ion beams no metrology exists since there are no dedicated institutes that can provide it. The facilities should agree among themselves, for quality assurance a microdosimeter can be a good and reliable instrument.

The WP is progressing as planned with activities either on or ahead of schedule. The knowledge transfer between CERN and GSI Deliverable 4.1 was completed.

Work Package 5 - Radiation effects testing with VHE ions

More information in the slides.

WP5 objectives:

- Studying the radiation effects induced by VHE heavy ions on a set of technologies that is representative of current state-of-the-art COTS electronics.
- Bridge this novel qualification methodology to the existing one based on standard-energy heavy ions through a hierarchical approach using three levels of study complexity.

The presented data should indicate the error bars (both on fluence and LET) in a clearer way. Test results on non-decapsulated devices are shown, indicating the LET on the lid. For the beams used

in HEARTS the LET should remain constant due to the high range. Some artefacts in the data cannot be explained due to angular effects since no effective LET tests were done. The comparison with standard energy facilities can be made by testing multiple dies in a stack (an "untestable" device) with a VHE beam. The preliminary testing of the €100 Jetson Nano board (smallest technology node, less stringent power requirements) with neutrons was done with HEARTS money in the scope of the project. The board level test plan of Thales for the DC/DC converter is not yet finalized, this is because deliverable 5.6 comes later in the project. Efforts will be made on the Airbus side to finalize the list of devices to be tested and to present those in the annual meeting in January. The PIN diode setup of UniPD is ready to be tested.

Action on Airbus to finalize list and present in the January annual meeting.

The final review of VHE ion beam requirements for SEE testing deliverable 5.1 was completed. The rest of the WP is progressing as planned.

Work Package 6 - Quantitative estimates of shielding effectiveness with GCR/SPE simulator

More information in the slides.

WP6 objectives:

- Simulation of the full GCR spectrum and SPE events in terms of LET and, partially, in charge composition for testing shielding materials and a variety of space applications.
- Standardization of dosimetry and test setup for GCR/SPE simulator experiments.
- Perform a quantitative estimate of shielding effectiveness and carry out a radiobiological characterization.

The delicacy of the setup in terms of modulator angles and detector distance to modulator is made. Compensating for the surplus in the spectra for H and He particles might not be necessary due to their presence in the intravehicular particle spectrum as opposed to free space. Using a more bruteforce approach with a single material slab (as used at CERN) gives a worse representation in terms of particle energies. The cosmic ray spectrum data (CREME96, DLR model) used as reference are all very similar except in the low LET part of the spectrum.

A comparative assessment of detectors meant for quality assurance was made (PIN diode, SO microdosimeter, TEPC microdosimeter). The LET spectra shown are in water but the conversion to silicon can be made in a straightforward way. The SOI microdosimeter offers the advantage for electronics testing to directly measure LET in silicon. There is in principle no immediate danger to ancillary devices since secondary particles generated by the interaction of the beam with the modulators are directed in a forward fashion. Interaction of the measuring devices is minimized by the robotic arm.

No milestones or deliverables were due in P1 for WP6.

Work Package 7 - Upgrade of CHARM beam line at CERN for VHE ion testing

More information in the slides.

WP7 objectives:

- Adapting the existing CHARM beam line infrastructure at CERN to accommodate very high energy (VHE) heavy ion beams for radiation effects testing on electronics, requiring the

capacity of accurately tuning the beam energy and intensity in a large dynamic range and to ensure the parallelization of activities at CERN around the PS East Area.
- Tackle the definition of an adequate administrative and technical framework for external users to first validate and later regularly exploit the VHE beam for electronics testing and qualification.

The objective is a successful HEARTS@CERN pilot run with external users. No showstoppers were identified from an access formality point of view. The timeline for facility access is roughly two months but the facility agreement process can be further streamlined. Communication with the users is important on the functionalities available during the beam time. A beam on/off switch is made possible, an option for this is to switch of the RFKO gain as is done at GSI. Testing at angles can yield a response change in modern devices due to charge sharing effects.

Beam preparation and commissioning is currently ongoing with a few open challenges such as the lower energy beam limit and beam size. Changing of ion species is envisaged in the future but would take too long to change species within the scope of a user dun. Duplicating the current ion source is the way forward.

Action on Ruben to send list of HEARTS@CERN pilot run users to Simon. The summary of the run will also have to be distributed in due time.

Work Package 8 - Upgrade of the FAIR facility for shielding testing

More information in the slides.

WP8 objectives:

- Develop a framework for user access to the GCR simulator.
- Installation and testing of the GCR simulator in the APPA cave or CBM vault where 10 GeV/n beams from the SIS100 accelerator can be used.

The work package is progressing as planned given the FAIR construction context. No deliverables or milestones were due in P1 for WP8. A similar beam delivery interface between GSI and CERN can be created by Cosylab, there would however be some restrictions on the GSI side as to what can be displayed from a legal point of view. The goal is to be better than NSRL in terms of live beam monitoring and display.

Work Package 9 - Tools and instruments for standardized dosimetry and user experimentation

More information in the slides.

WP9 objectives:

- Develop a user interface tool for experimentation.
- Develop an interface for the user experiment lifecycle.

There were no deliverables or milestones for WP9 due in P1. The tasks are proceeding according to plan and are on track for end-of-year prototype testing. The idea would be to have a dedicated machine at CERN and GSI which runs the GUI, it could also be a good idea to have a read-only GUI and have the data logging associated with it.

Feedbacks, comments and concluding remarks

The Project Officer and reviewers congratulated HEARTS project members of the work undertaken since the start of the project. Overall, activities are advancing surely and smoothly according to the defined timeline, even in the light of FAIR construction delays.

During the review meeting, all questions were answered.

The final dates of the 2nd annual meeting will depend on the progress of the CERN heavy ion run results and the schedule of the GSI run.

Precise information will have to be sent to Simon Conticello, regarding the delays at GSI in WP8 (action on WP8 members).