



HEARTS P1 Review Meeting: WP4

25 September 2024

<https://indico.cern.ch/event/1411185/>



**Funded by
the European Union**

HEARTS is a project funded by the European Union under GA No 101082402, through the Space Work Programme of the European Commission.



Tim Wagner
Uli Weber
GSI

Outline

- Reminder about WP4 Tasks
- Status of WP4 Tasks
- WP4 Deliverables and Milestones
- Plans for the future
- Conclusion

Tasks & Objectives

- **Task 4.1:** Knowledge transfer between CERN and GSI (*CERN & GSI, M1 – M12*)
 - Exchange on beam instrumentation and characterization methods
 - Visit of CERN colleagues to GSI to see beam instrumentation in Cave A
 - Discussion with related experts
- **Task 4.2:** Calibration of beam instrumentation for VHE ion beam extraction (*CERN, M1 – M24*)
 - Calibration and exploitation of existing beam instrumentation
 - Identification and installation of new beam instruments and detectors
 - Closely linked to Task 3.1 and Task 7.2
- **Task 4.3:** Beam delivery monitoring (*GSI, M12 – M36*)
 - Define necessary beamline instrumentation for beam monitoring during space radiation testing
 - Platform should handle both high intensities ($10^8 - 10^{10}$ ions/s) for shielding measurements and low intensities ($10^2 - 10^5$ ions/s) for SEE cross-section measurements
 - Dedicated set of dosimeters, thin gas ionization chambers and plastic scintillators

Tasks & Objectives

- **Task 4.4: Target Station (*GSI, M12 – M36*)**
 - Optimization of GSI sample handling to increase TRL
 - Remotely controlled holder for microelectronics with input from industrial partners
 - Automatic placement and removal of material for shielding measurements
 - Standardization between GSI and CERN device under test (DUT) holder
- **Task 4.5: GCR/SPE simulator dosimetry (*GSI, M24 – M36*)**
 - Definition and standardization of Dosimetry-on-target
 - Explore possibility of microdosimetry behind shielding to characterize the quality factor Q of the mixed field
 - Dedicated measurements for the GCR/SPE simulator measuring the LET spectrum and charge composition of the mixed field
- **Task 4.6: Intercomparison between CERN and GSI (*CERN & GSI, M24 – M48*)**
 - Transfer of experience between CERN and GSI
 - Dedicated comparison measurement between the facilities (e.g. with the same beam instruments and reference electronics)

Status Task 4.1: Knowledge transfer between CERN and GSI (CERN & GSI) [1/2]

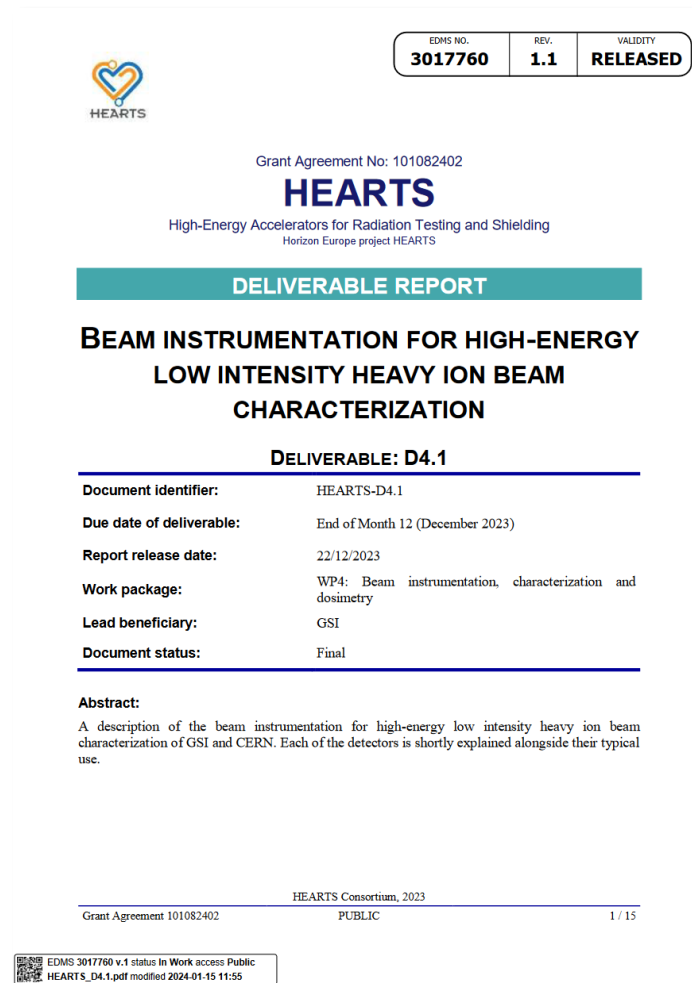
- Knowledge Transfer Meeting at GSI on 20.04.2023
 - Participants from GSI, CERN and Univ. Oldenburg
- Discussions about:
 - The challenges at each of the two facilities
 - Dosimetry detectors used for beam characterization and monitoring
 - Plans for a comparison measurement between the standard detectors available CERN and GSI
→ Beamtime October 2023 @ CERN (see Task 4.6)



Picture by: A. Waets, CERN

Status Task 4.1: Knowledge transfer between CERN and GSI (CERN & GSI) [2/2]

- Deliverable D4.1: Beam instrumentation for high-energy low intensity heavy ion beam characterization
- Reporting on the different detectors used for characterization and monitoring used at CERN and GSI
 - Examples GSI: Parallel Plate Ionization Chamber; Scintillators; various standard dosimetry detectors (Farmer Chambers, etc.); Octavius detector; and more
 - Examples CERN: Silicon diode; Secondary emission chambers (XSEC, XION); Multi Wire Proportional Chamber

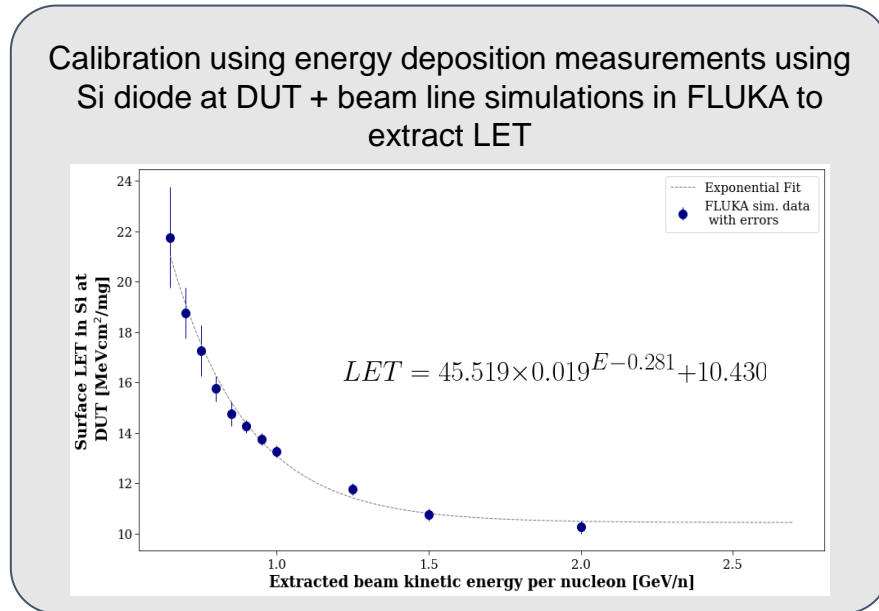


The screenshot shows the cover page of a deliverable report. At the top right, there is a table with three columns: 'EDMS NO.' (3017760), 'REV.' (1.1), and 'VALIDITY' (RELEASED). Below this is the HEARTS logo and the text 'Grant Agreement No: 101082402'. The main title is 'HEARTS High-Energy Accelerators for Radiation Testing and Shielding Horizon Europe project HEARTS'. A teal banner reads 'DELIVERABLE REPORT'. The report title is 'BEAM INSTRUMENTATION FOR HIGH-ENERGY LOW INTENSITY HEAVY ION BEAM CHARACTERIZATION'. Below this, it specifies 'DELIVERABLE: D4.1'. A table lists document details: Document identifier (HEARTS-D4.1), Due date of deliverable (End of Month 12 (December 2023)), Report release date (22/12/2023), Work package (WP4: Beam instrumentation, characterization and dosimetry), Lead beneficiary (GSI), and Document status (Final). An abstract follows, describing the beam instrumentation for high-energy low intensity heavy ion beam characterization at GSI and CERN. At the bottom, it says 'HEARTS Consortium, 2023' and 'Grant Agreement 101082402 PUBLIC 1 / 15'. A QR code and a small text box at the bottom left of the page indicate the document's status and modification date.

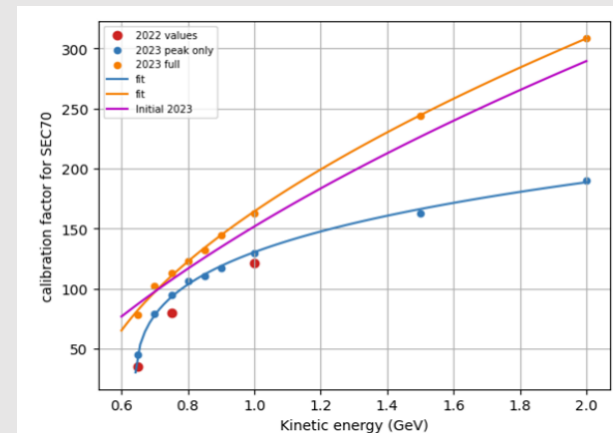
Status Task 4.2: Calibration of beam instrumentation for VHE ion beam extraction (CERN) [1/2]

- CERN approach: accurate provision of **LET** and **flux/fluence** as dosimetric quantities for users as function of extracted beam energy.
- Energy/LET and flux/fluence calibration achieved after Oct. 2023 test campaign (further detailed in WP7)

LET



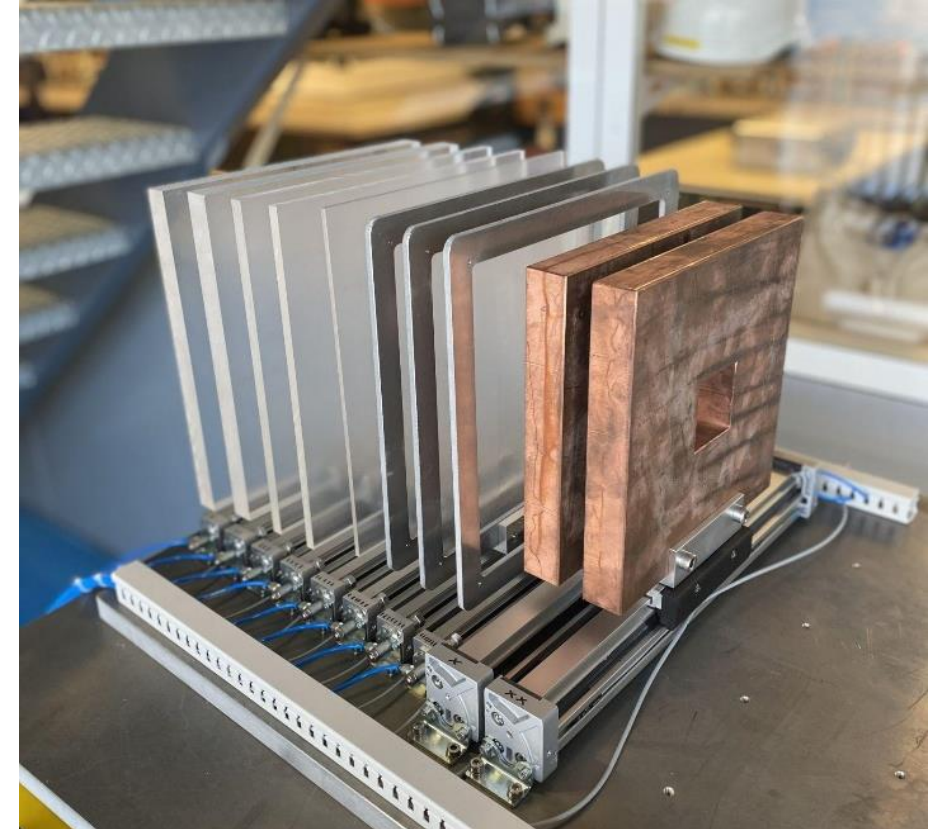
Calibration of relative beam monitor signal (emission chambers), provided by Si detector at DUT



Flux/fluence

Status Task 4.2: Calibration of beam instrumentation for VHE ion beam extraction (CERN) [2/2]

- PMMA degraders
 - 24 * 24 cm² area with thicknesses between 0.5 mm and 40 mm
 - Used to reduce the beam energy to increase the available LET range
- Two copper collimators / collimators
 - 20 * 20 cm² area and 3 cm thick
 - Square cutouts in the center to cut off the tails of a broad Gaussian beam and achieve a uniform irradiation area



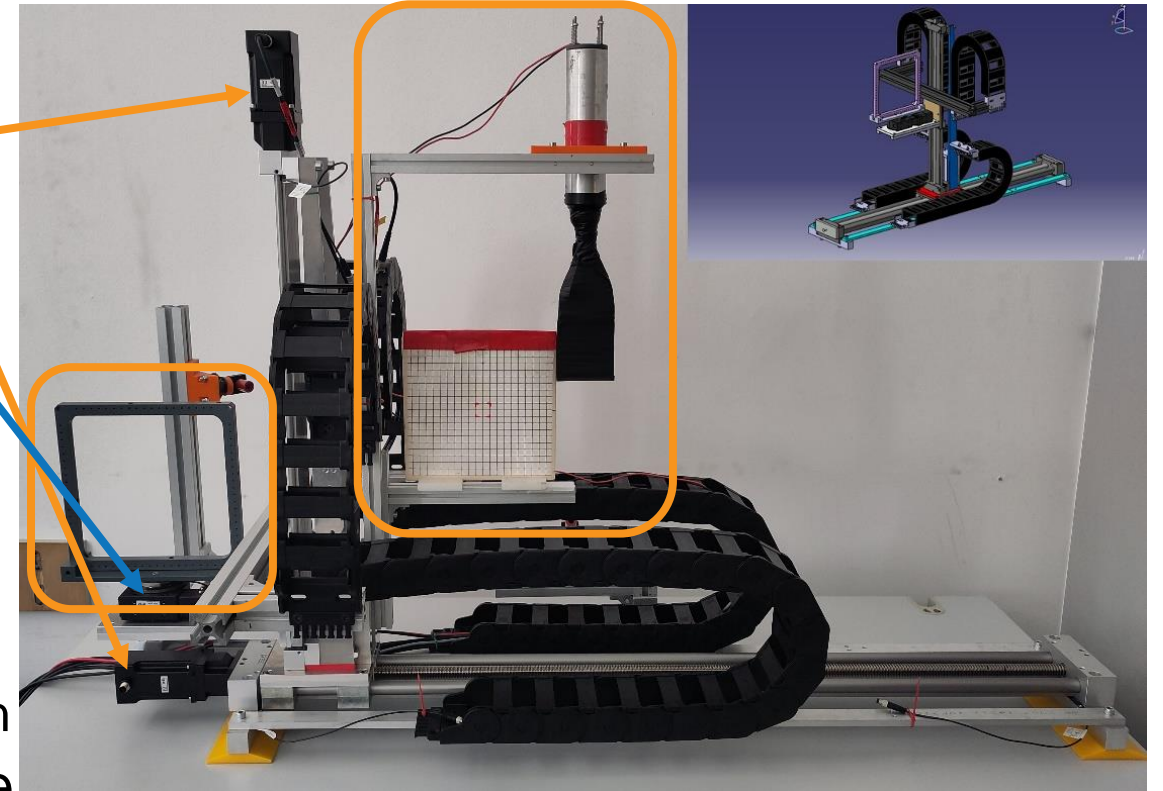
Picture by: CERN

Status Task 4.3: Beam delivery monitoring (GSI)

- Standard GSI beam monitoring detectors:
 - Parallel Plate Ionization Chambers (Used for medium to high intensities)
 - Scintillators (Used for low intensities, as single particles are counted)
 - Calibration detectors:
 - Farmer Chamber
 - Octavius detector array
 - Various other absolute dosimetry detectors, e.g., Pinpoint, Markus Chamber, etc.
- All of the above detectors are described in D4.1 in detail
- Exploration of addition of a position sensitive detector to the beamline instrumentation of Cave A
 - Possibility to always monitor the beam position during the irradiation
 - Possible options: multi-wire proportional chamber (MWPC) or silicon strip detector
 - Exploration of the addition of microdosimetric spectra as part of the standard dosimetry for Cave A

Status Task 4.4: Target station (GSI) [1/4]

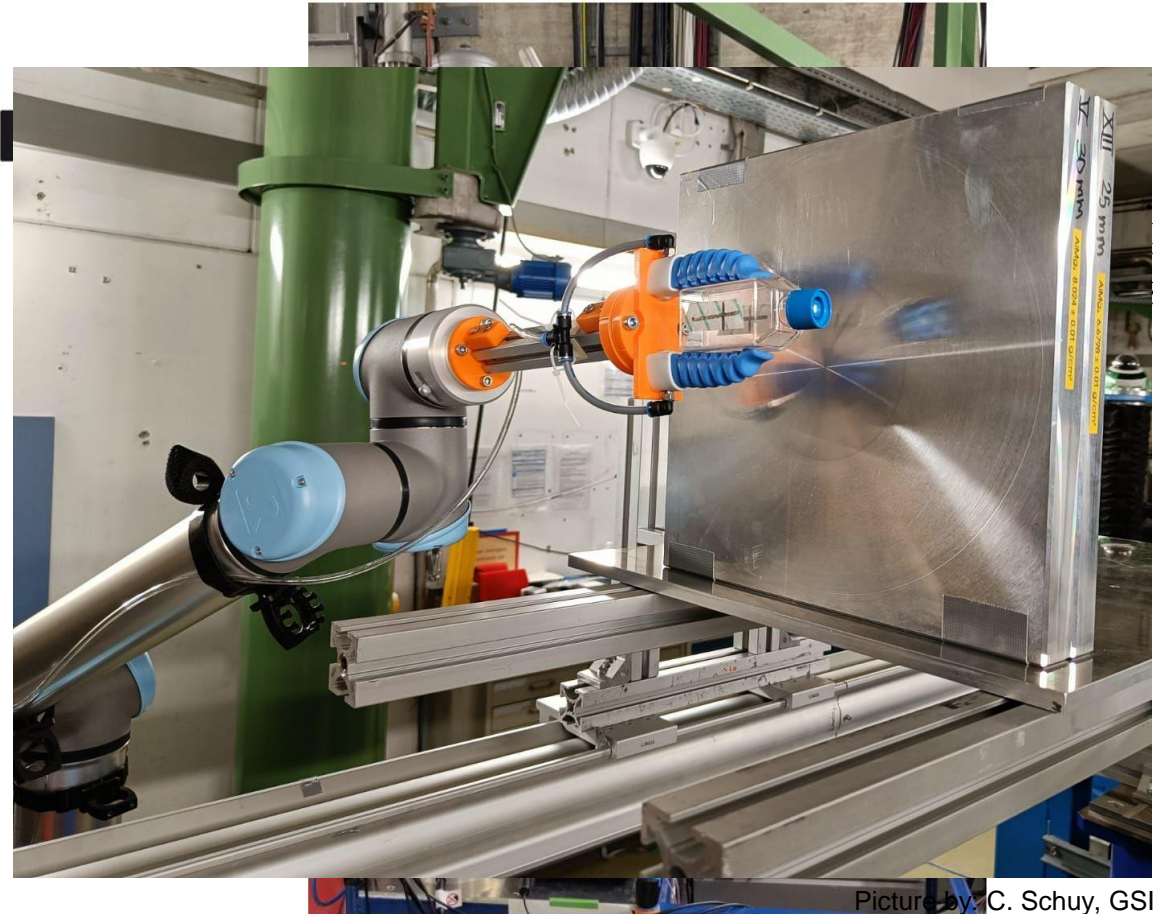
- Movement in 2 dimensions + 1d rotation possible
 - 2d movement for the positioning of the sample
 - 1d rotation for irradiation with grazing angles, if desired by the use
- Compatible with the “ESA standard frame” (according to the recommendation of D5.1)
 - “ESA standard frame” allows users familiar with other electronics irradiation facilities to mount their samples quicker and easier
- Beam diagnostics mounted to target station
 - Allows beam calibration at the DUT position
- Already used in February, April and June 2024



Picture by: C. Schuy & A. Gera, GSI

Status Task 4.4: Target station (GSI) [2/4]

- Robotic arm UR10e with a reach of 1300 mm and a payload of 12,5 kg
- Confirmed operation in an environment with ionizing radiation (December 2023)
- Has been used in April 2024 to position detectors and biological samples into the beam (more details in WP6)



Picture by: C. Schuy, GSI
Picture by: C. Schuy, GSI

IVERSITY
WOLLONGONG
STRALIA

Status Task 4.4: Target station (GSI) [3/4]

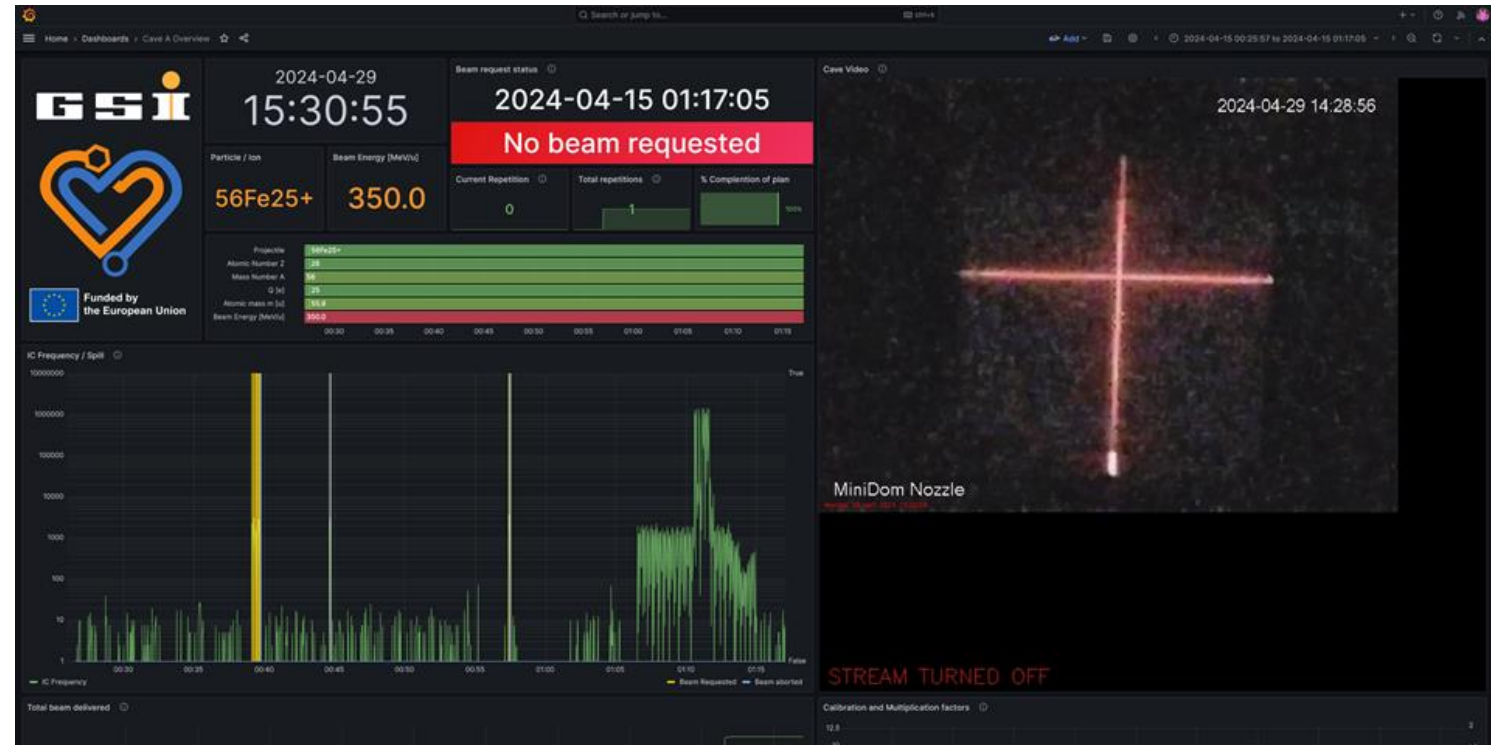
- New modular range shifters for positioning of shielding material
- Two plates / elements can be mounted to each of them
 - Three modular range shifters for a total of 6 plates / elements
- Distance between the individual range shifters can be varied for a more diverse application
- Have already been used in the April 2024 for the GCR simulator (more details in WP6)



Picture by: C. Schuy, GSI

Status Task 4.4: Target station (GSI) [4/4]

- User dashboard for easy access to information
- Shows irradiation modalities and hardware settings
- General design follows the recommendations from D5.1 (Sec. 2.2; Req. 2.2h)
- Still work in progress, as some data is not displayed yet and it will be improved

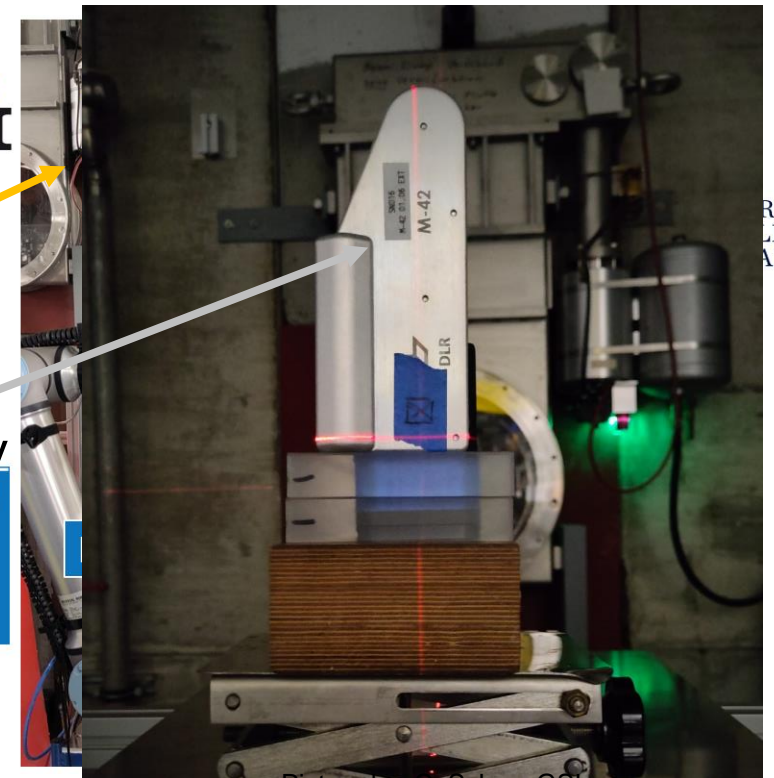


Picture by: T. Wagner, GSI

Status Task 4.5: GCR simulator dosimetry (GSI) [1/3]

- Detailed characterization of the GCR Simulator for Cave A done in April 2024
- Used various different detectors:
 - Standard dosimetry detectors
 - Microdosimetry detectors
 - Tissue Equivalent Proportional Counter (TPEC)
 - Silicon microdosimeter (courtesy of University of Wollongong)
 - Dosimeters by DLR, which have been to space already
 - etc.

GSI



UNIVERSITY
WOLLONGONG
AUSTRALIA

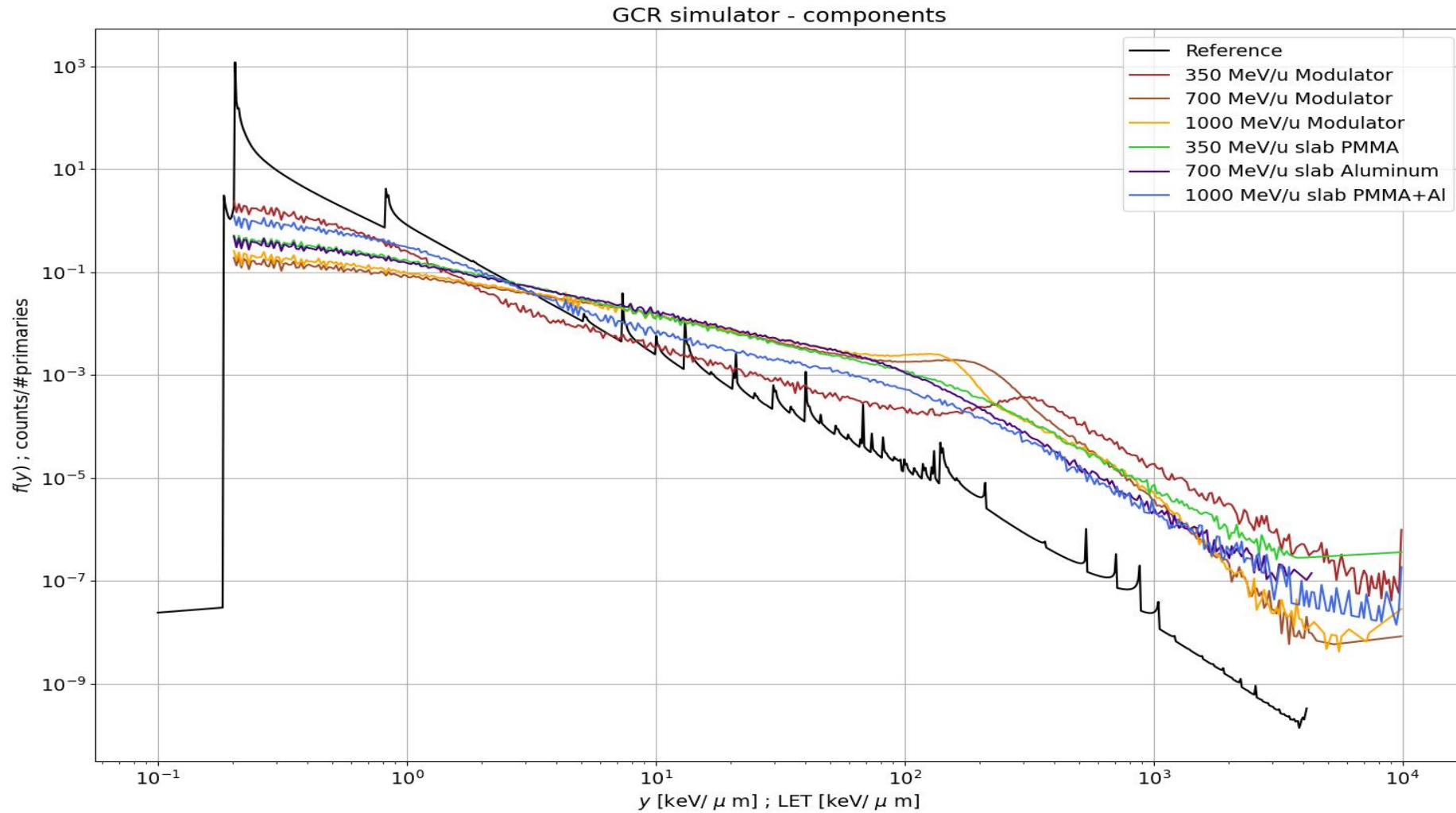
Picture by: C. Schuy, GSI

Status Task 4.5: GCR simulator dosimetry (GSI) [2/3]

- GCR field produced with six different configurations of modulators, slab targets and energies (more details see WP6)
- Estimates how to combine the six irradiation modalities based on simulators (see WP3, Task 3.3)
- Each configuration measured by the TPEC to obtain the LET spectrum

- Most of the measurements are still under analysis
- Measurements still pending:
 - Charge composition of the mixed field
 - Microdosimetry after shielding

Status Task 4.5: GCR simulator dosimetry (GSI) [3/3]



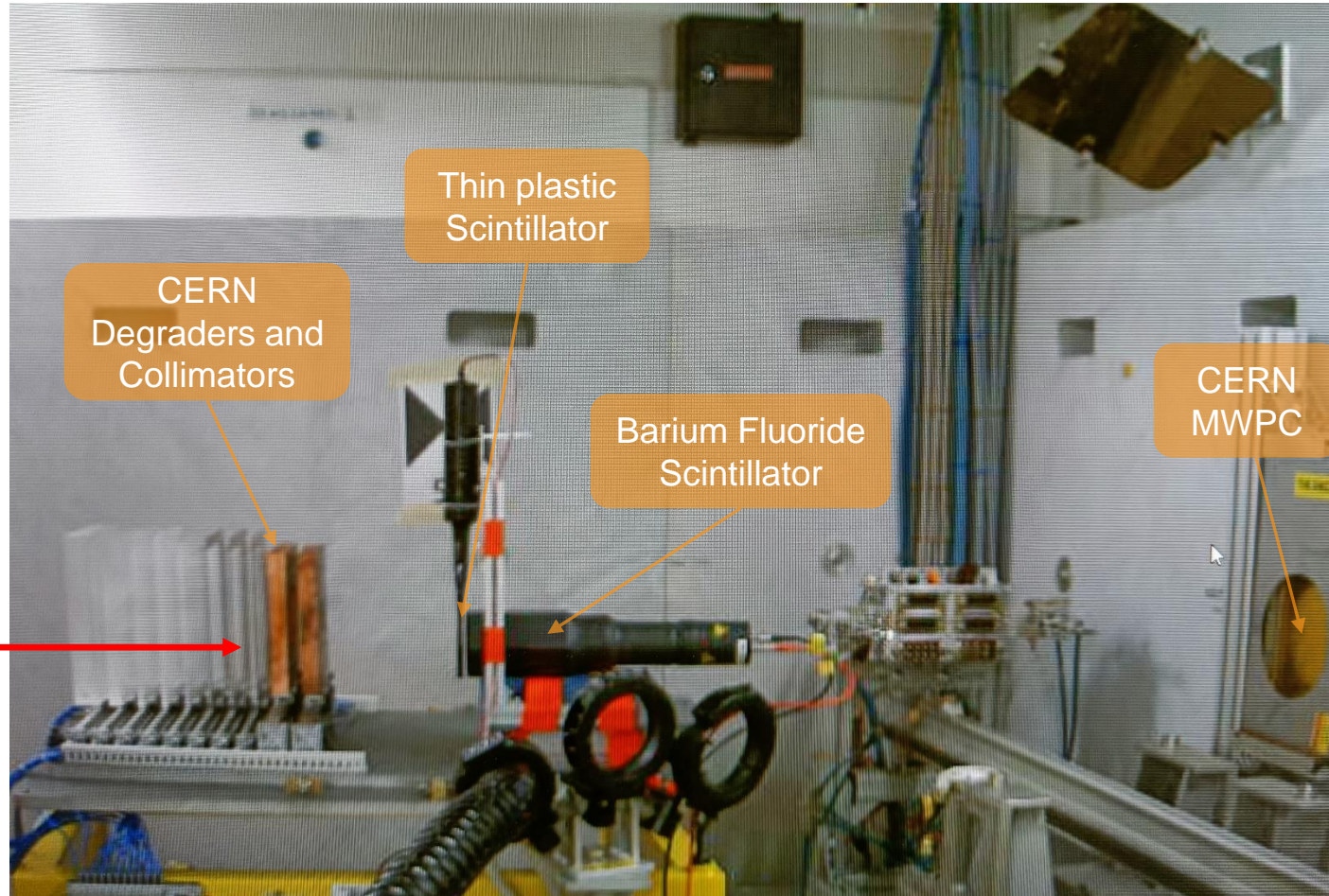
Status Task 4.6: Intercomparison between CERN and GSI (CERN & GSI) [1/3]

- Cross comparison of GSI and CERN detectors during a beamtime in October 2023 @ CERN
- Analysis of data still ongoing → Will be reported on in D4.6
 - Some spill fluctuations (possible energy shift?) complicate the analysis of the data

| Detector 1 | Detector 2 | Reason |
|---|------------------------------------|--|
| Parallel Plate Ionization Chamber (GSI) | Farmer Chamber (GSI) | Calibration of IC with an absolute detector and Cross-check of RF-gain intensity adjustments |
| Parallel Plate Ionization Chamber (GSI) | Silicon Diode (CERN) | Comparison between standard GSI and CERN detectors |
| Thin plastic Scintillator (GSI) | Silicon Diode (CERN) | Comparison between standard GSI and CERN detectors (for lower intensities) |
| Thin plastic Scintillator (GSI) | Barium Fluoride Scintillator (GSI) | Measurement of beam spectra and Characterization of the fragments |

The CERN emission chambers (XSEC and XION) were always placed in the beam.

Status Task 4.6: Intercomparison between CERN and GSI (CERN & GSI) [2/3]

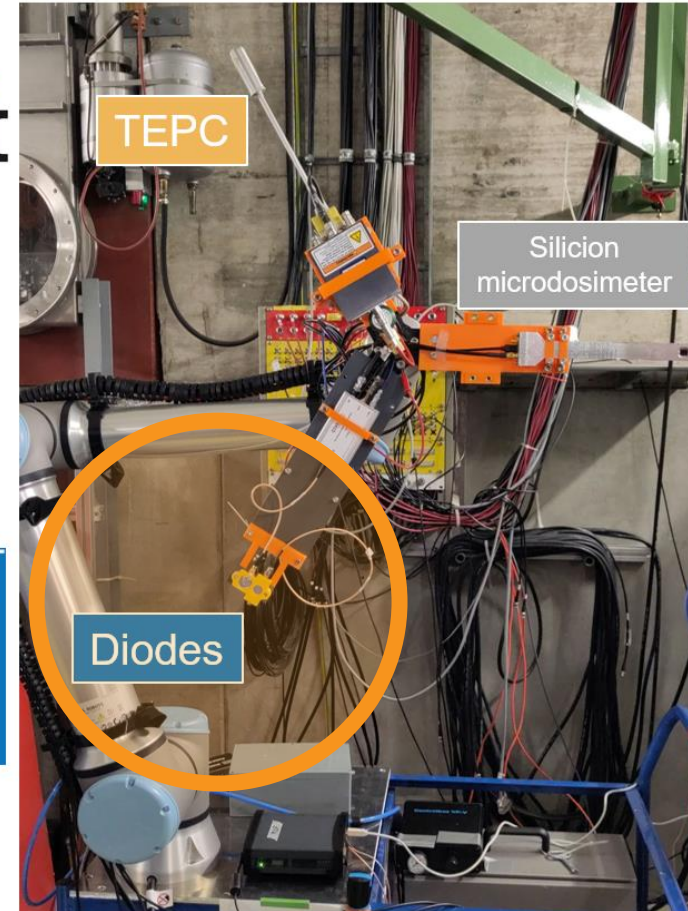


Experimental setup for the measurement of the thin plastic scintillator vs the Barium Fluoride scintillator in October 2023 at CERN.

Picture by:
T. Wagner, GSI

Status Task 4.6: Intercomparison between CERN and GSI (CERN & GSI) [3/3]

- Measurements with CERN's Silicon Diodes
 - Pure Iron beam at different energies
 - Some of the GCR irradiation conditions
 - “Automatic” comparison with GSI's Parallel Plate Ionization Chamber
- Will be reported on in D4.6



Picture by: C. Schuy, GSI



UNIVERSITY
OF WOLLONGONG
AUSTRALIA

Deliverables and Milestones in P1

| Deliv. No. | Deliverable name | Due date | Status | Summary |
|------------|--|------------|----------|--|
| D4.1 | Beam instrumentation for high-energy low intensity heavy ion beam characterization | 2023-12-31 | Achieved | A description of the beam instrumentation for high-energy low intensity heavy ion beam characterization of GSI and CERN. Each of the detectors is shortly explained alongside their typical use. |

| Milest. No. | Milestone name | Due date | Status | Summary |
|-------------|----------------|----------|--------|---------|
| - | - | - | - | - |

- No milestones were due in P1 for WP4



The achieved deliverables and milestones are available on the HEARTS website:
<https://hearts-project.eu/project/deliverables/> and <https://hearts-project.eu/project/milestones/>

Upcoming Deliverables & Milestones

| Deliv. No. | Deliverable name | Due date | Status |
|------------|--|------------|---------|
| D4.2 | Calibrated CERN beam instrumentation documented and installed in the accelerator | 2024-12-31 | Pending |
| D4.3 | Experimental measurements on GSI beam instrumentation and dosimetry | 2025-12-31 | Pending |
| D4.4 | Documentation on the target station construction and use | 2025-12-31 | Pending |
| D4.5 | Report on microdosimetry for GCR simulator calibration | 2025-12-31 | Pending |
| D4.6 | Intercomparison between CERN and GSI instrumentation and standardisation | 2026-12-31 | Pending |

| Milest. No. | Milestone name | Due date | Status |
|-------------|---|------------|---------|
| M12 | CERN beam instrumentation and dosimetry installed and running | 2024-12-31 | Pending |
| M13 | GSI beam instrumentation and dosimetry installed and running | 2025-21-31 | Pending |

Plans for the future

- **Task 4.1:** Knowledge transfer between CERN and GSI (*CERN & GSI*)
 - Completed with D4.1 ✓
- **Task 4.2:** Calibration of beam instrumentation for VHE ion beam extraction (*CERN*)
 - Verification of the calibration in the beamtime end of 2024
 - Report on the calibration → Deliverable D4.2
- **Task 4.3:** Beam delivery monitoring (*GSI*)
 - Exploration of the addition of microdosimetric spectra as part of the standard dosimetry for Cave A
 - Exploration of the addition of position sensitive detector to the beamline instrumentation

Plans for the future

- **Task 4.4: Target Station (GSI)**
 - Improve laser alignment by adding remote controlled adjustment
 - Detailed report on the GSI target station → Deliverable D4.4
- **Task 4.5: GCR simulator dosimetry (GSI)**
 - Analysis of all the collected data
 - Comparison of the results from the different detectors
 - Further measurements, e.g., behind extra shielding
- **Task 4.6: Intercomparison between CERN and GSI (CERN & GSI)**
 - Analysis of measured data from October 2023 @ CERN
 - Analysis of measured data from April 2024 @ GSI
 - Detailed report about the comparison measurements → Deliverable D4.6

Conclusion

- Work Package progressing as planned
- Several Tasks started ahead of time
 - Task 4.5: GCR simulator dosimetry (*GSI, M24 – M36*)
 - Task 4.6: Intercomparison between CERN and GSI (*CERN & GSI, M24 – M48*)
- Some tasks progress ahead of schedule
 - Task 4.4: Target Station (*GSI, M12 – M36*)

**Thank you
for your
attention.
Questions?**



**Funded by
the European Union**

HEARTS is a project funded by the European Union under GA No 101082402,
through the Space Work Programme of the European Commission.