



# HEARTS P1 Review Meeting

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25 September 2024

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



**Funded by  
the European Union**

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WP 6  
Christoph Schuy

# Outline

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- WP6 Tasks
- Status
- Deliverables and Milestones
- Conclusions

# Tasks

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## Quantitative estimates of shielding effectiveness with GCR/SPE simulator

**Task 6.1:** Standardized setup for the GCR/SPE simulation experiments (GSI, TAS)

- simulation of different space mission scenarios
- studies on secondary radiation produced after shielding, including neutrons

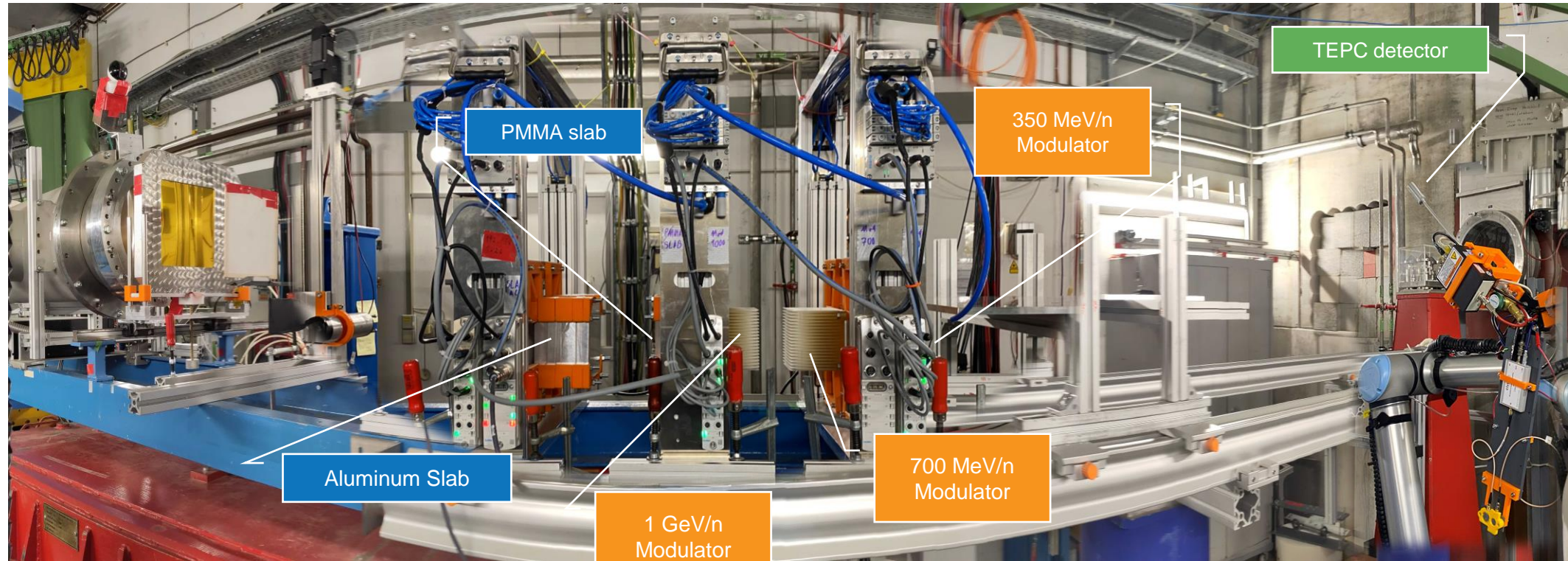
**Task 6.2:** Quantitative measurement of shielding effectiveness (GSI, TAS)

- behind shielding of different materials and thickness
- inside a phantom

**Task 6.3:** Radiobiological characterization (GSI)

- biological effectiveness of GCR/SPE simulator irradiations

# Task 6.1: Standardized setup for the GCR/SPE



## Irradiation Setups:

- 1 1 GeV/n  $^{56}\text{Fe}$  + Modulator
- 2 700 MeV/n  $^{56}\text{Fe}$  + Modulator
- 3 350 MeV/n  $^{56}\text{Fe}$  + Modulator
- 4 1 GeV/n  $^{56}\text{Fe}$  + Al + PMMA slabs
- 5 700 MeV/n  $^{56}\text{Fe}$  + Al slab
- 6 350 MeV/n  $^{56}\text{Fe}$  + PMMA slab

# Task 6.1: Standardized setup for the GCR/SPE



1

1 GeV/n  $^{56}\text{Fe}$   
+  
Modulator



2

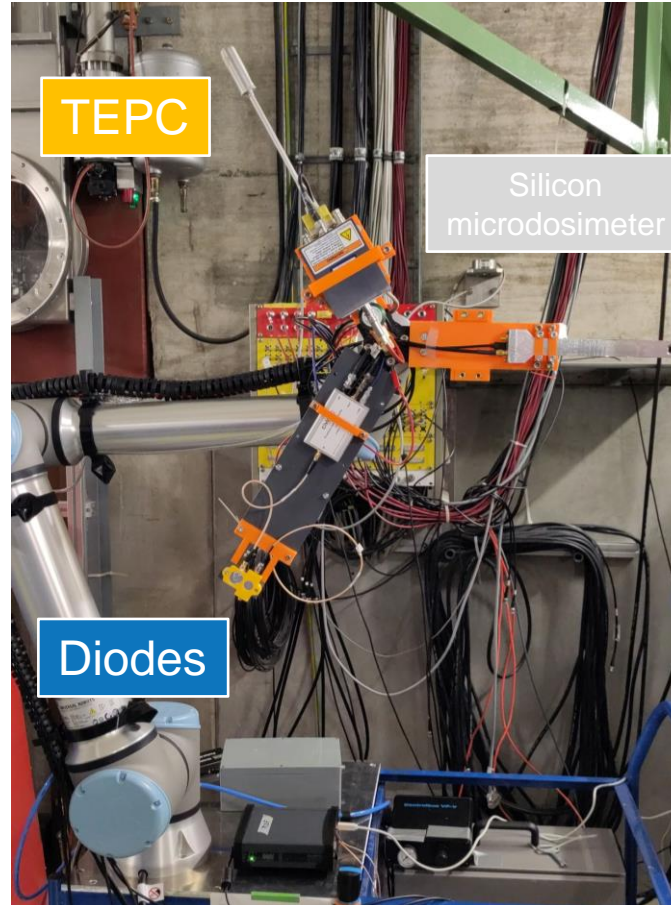
700 MeV/n  $^{56}\text{Fe}$   
+  
Modulator



3

350 MeV/n  $^{56}\text{Fe}$   
+  
Modulator

# Task 6.1: Standardized setup for the GCR/SPE



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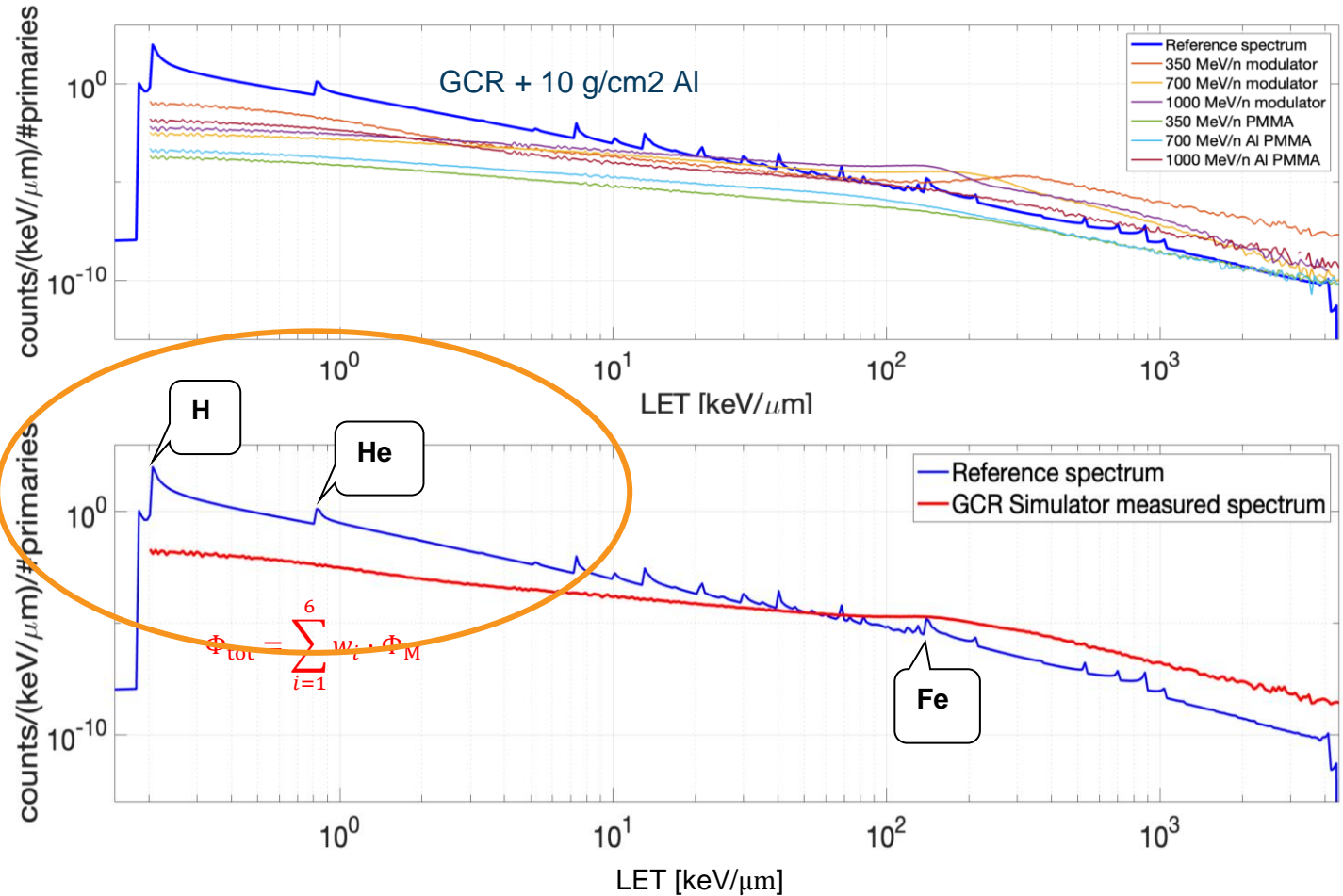
# Task 6.1: Standardized setup for the GCR/SPE

## Before the Optimization

- Reference spectrum
- 6 components ( $\Phi_M$ ) of the GCR Simulator spectrum ( $\Phi_{tot}$ ) as measured by the TEPC detector

## After the Optimization

- 6 weights ( $w_i, i = 1, \dots, 6$ )
- GCR Simulator overall spectrum as measured by the TEPC detector
- Iron peak is clearly visible

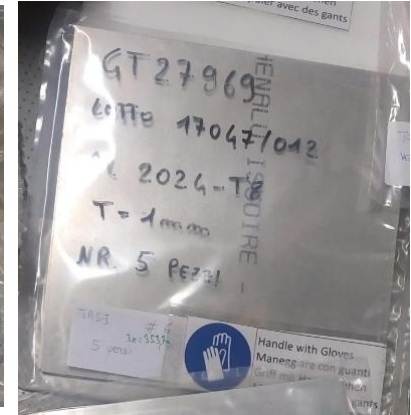


# Task 6.1: Standardized setup for the GCR/SPE

## TAS-I relevant materials survey

A survey of various potentially interesting materials to be tested has been carried out by TAS-I:

- **Structure materials**
  - Al6064
  - Al7075
  - Composite innovative materials
  - Multilayer innovative materials
  - Honeycomb panels (still under evaluation)
- **Materials with different functions**
  - MLI materials
  - Polyethylene
  - Inflatable materials
- **On-site available materials**
  - Lunar regolith (in PMMA container) and concrete
  - Mars regolith (in PMMA container) and concrete

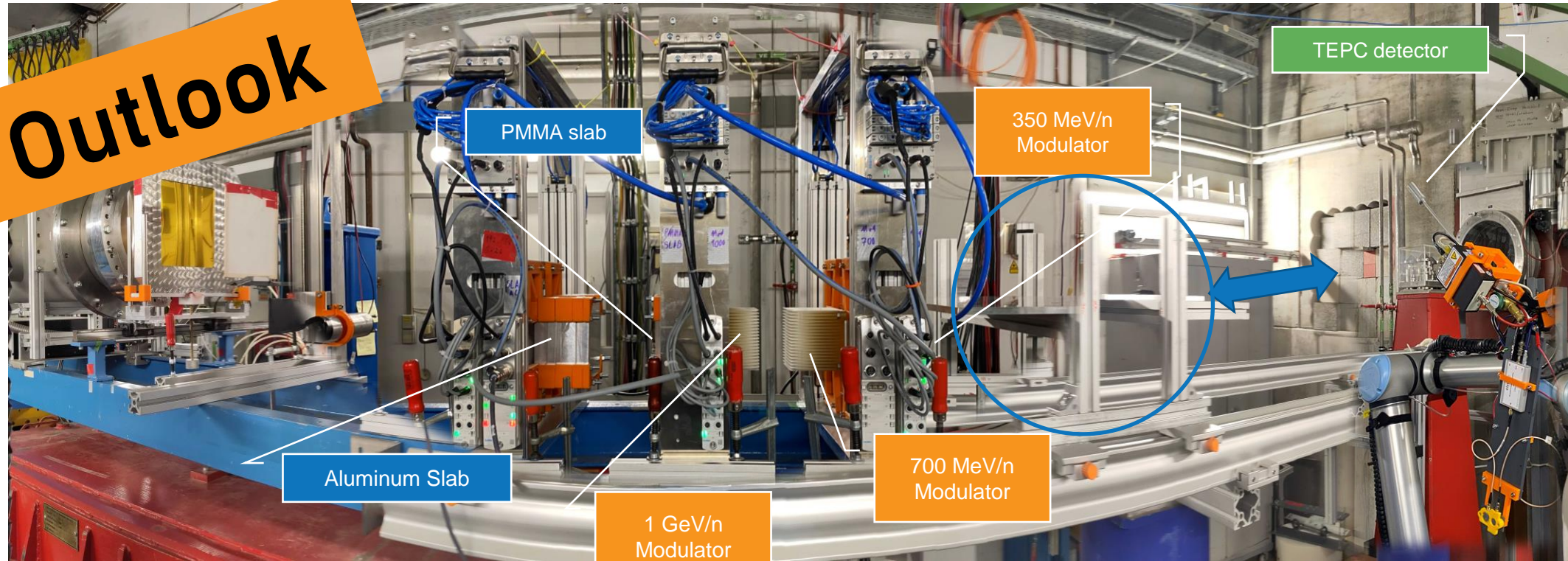


Example of ROSSINI space materials



# Task 6.1: Standardized setup for the GCR/SPE

Outlook



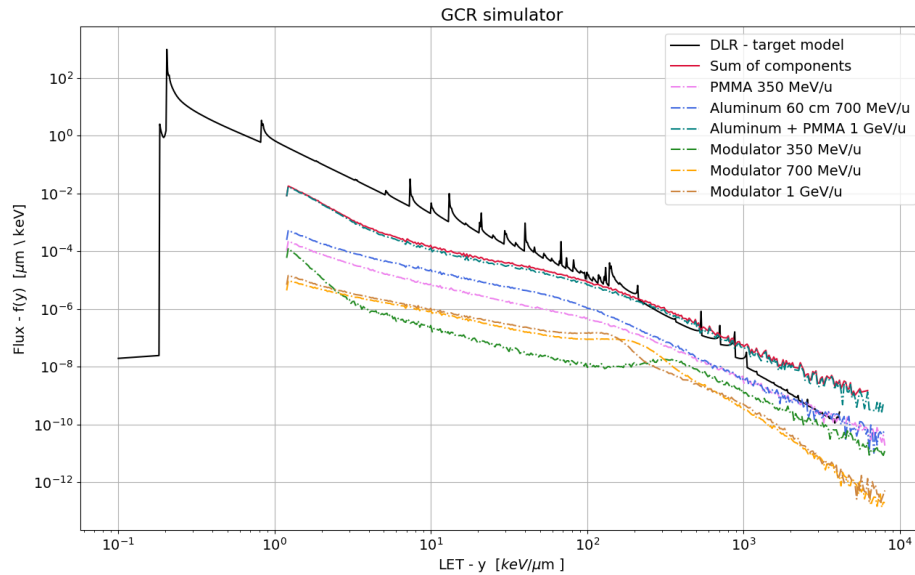
Irradiation Setups:

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- 2 700 MeV/n  $^{56}\text{Fe}$  + Modulator
- 3 350 MeV/n  $^{56}\text{Fe}$  + Modulator
- 4 1 GeV/n  $^{56}\text{Fe}$  + Steel
- 5 700 MeV/n  $^{56}\text{Fe}$  + Al slab
- 6 350 MeV/n  $^{56}\text{Fe}$  + PMMA slab

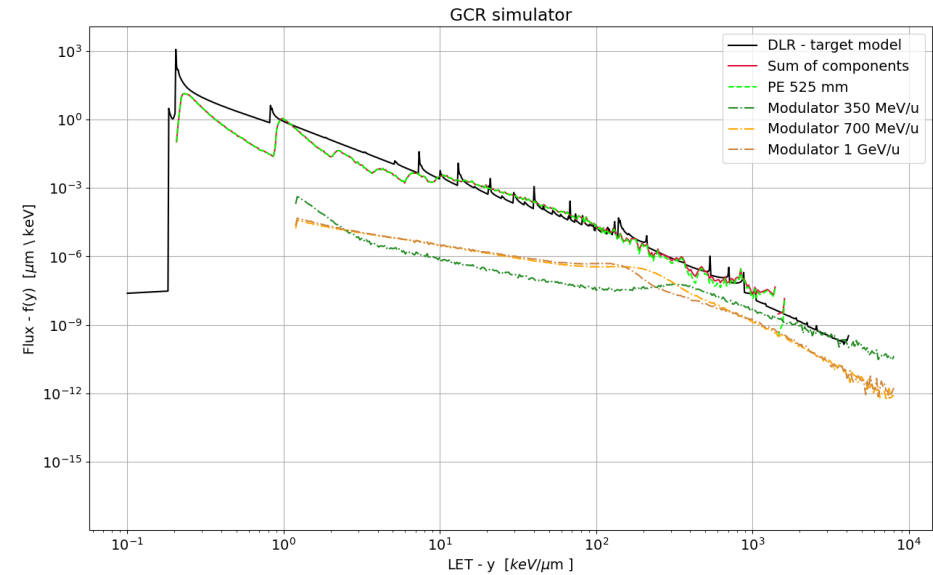
# Task 6.1: Standardized setup for the GCR/SPE

**Outlook**

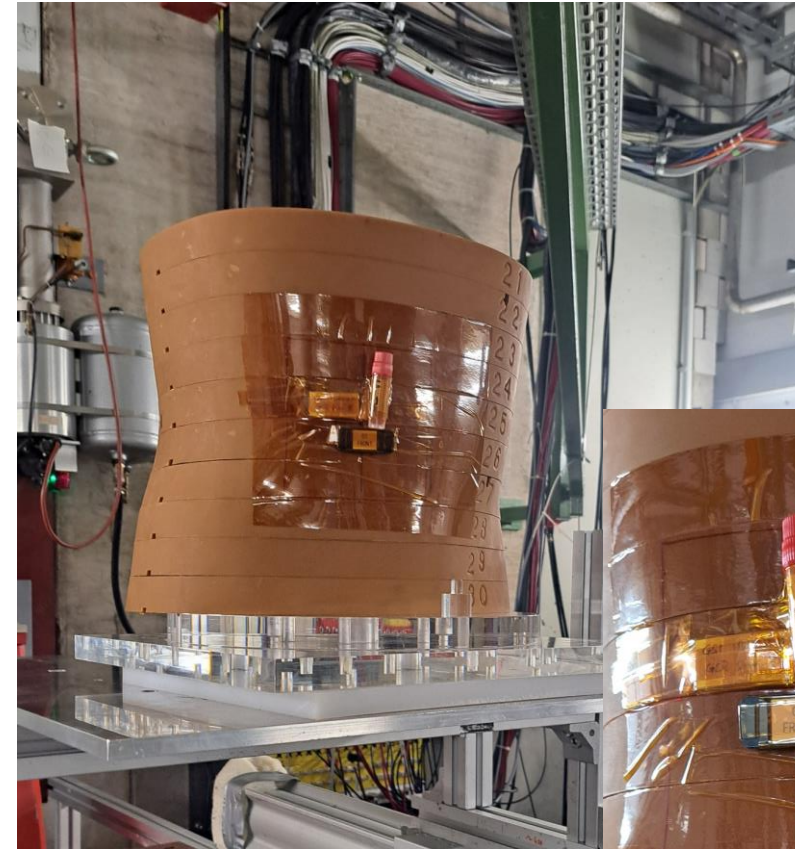
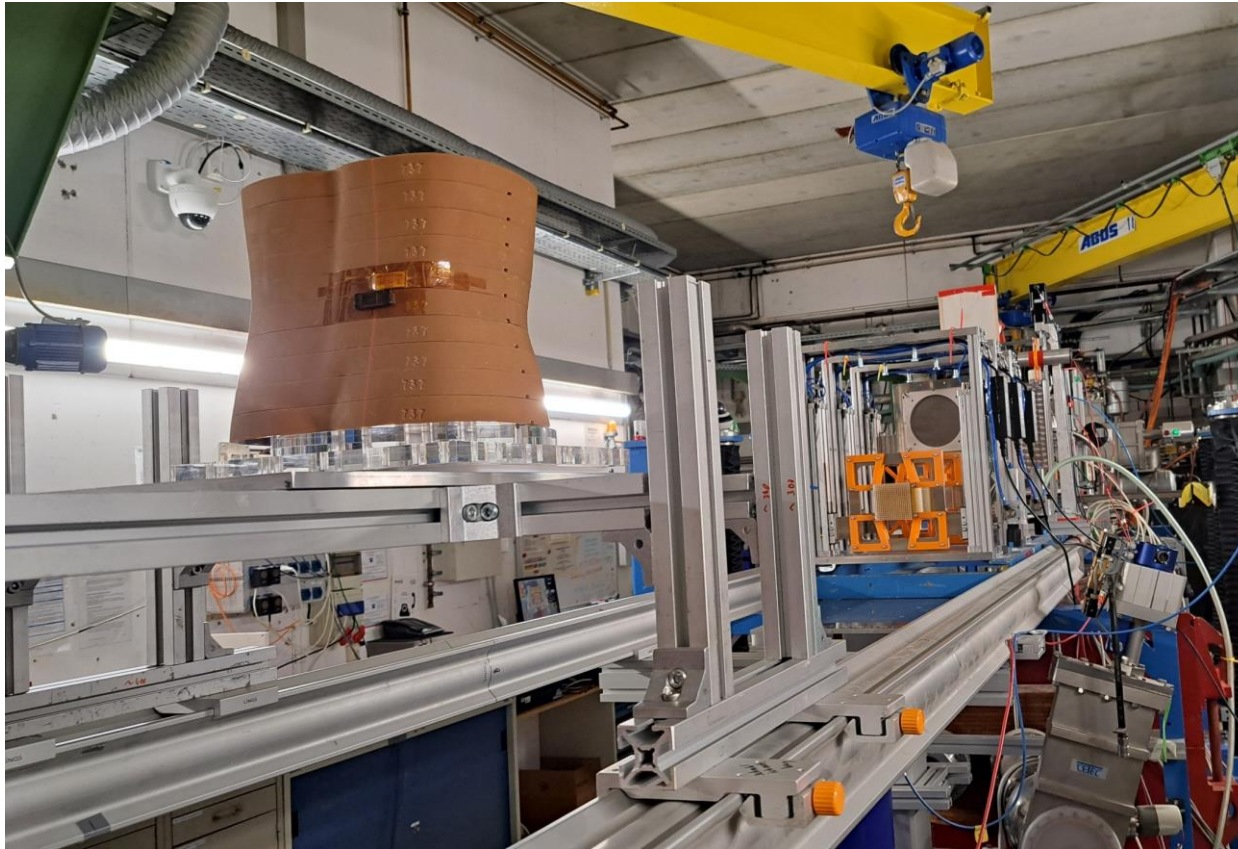
Old



New

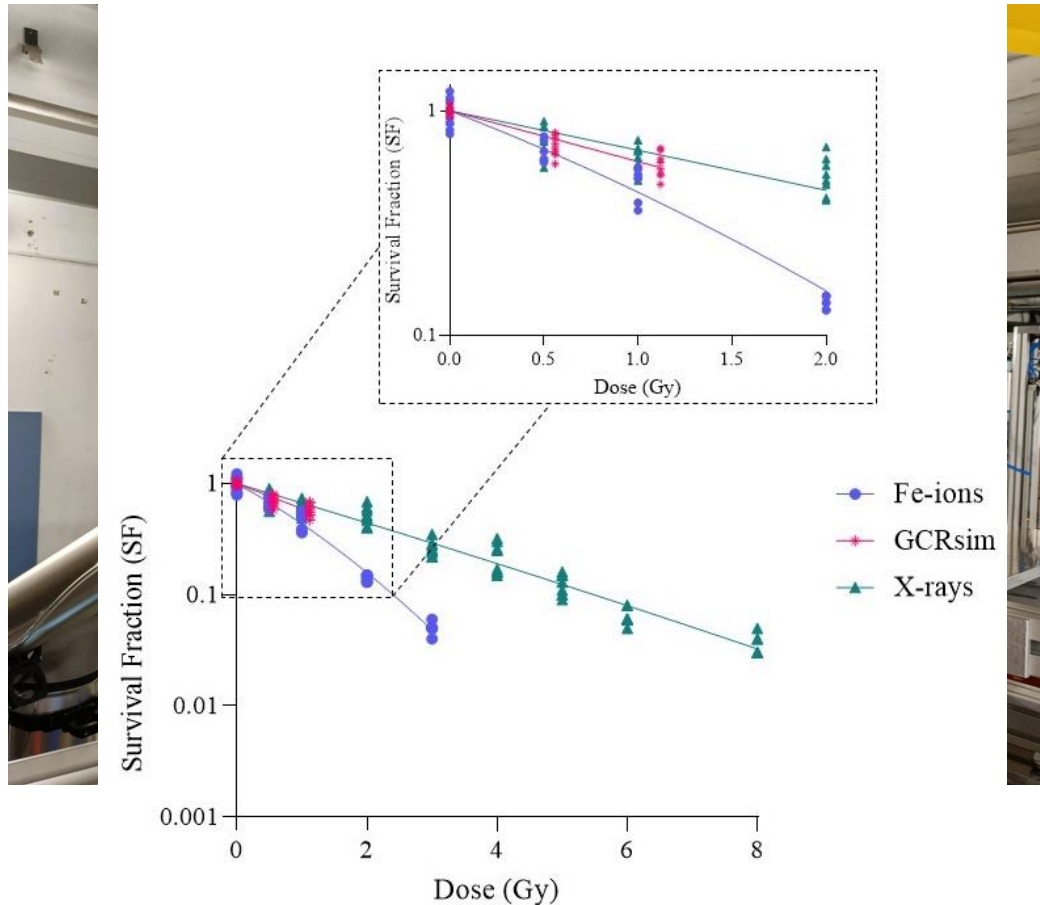


# Task 6.2: Quantitative measurement of shielding effectiveness



Irradiation of biological samples with the GCR simulator on the skin and inside the Matroschka Phantom. (Doses:  $\sim 1$  Gy and  $\sim 0.5$  Gy)

# Task 6.3: Radiobiological characterization



## Biological exposure

- primary iron beam
- GCR simulator exposures (2 doses)
- exposure behind shielding (1 dose)

**CHO clonogenic survival results following the irradiation with three modalities: 1 GeV  $^{56}\text{Fe}$ -ions, GCRsim, and 250 kVp X-rays**

# Deliverables and Milestones in P1

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No milestones or deliverables were due in P1 for WP6

*The achieved deliverables are available on HEARTS website page:*

*<https://hearts-project.eu/project/deliverables/>*

# Upcoming Deliverables & Milestones

Deliv. No.	Deliverable name	Due date	Status
D6.1	GCR/SPE simulator setup	2024-12-31	Pending
D6.2	Dosimetry of the GCR/SPE simulator with shielding	2025-12-31	Pending
D6.3	Radiobiology of the GCR/SPE simulator with shielding	2026-12-31	Pending

Milest. No.	Milestone name	Due date	Status
MS18	First experimental demonstration of dose increase behind thick shields in Europe	2025-12-31	Pending
MS19	Achievement of TRL6-7 for the SIS18 GCR/SPE simulator	2025-12-31	Pending

# Conclusions

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- Hardware worked as intended and individual software worked as intended
  - Automation necessary to limit operator error
  - Modified tool alignment for the robotic arm
- Slab target configuration did not produce enough light ions
  - Switch to single 1 GeV/u steel slab
- Neutron measurements after thick shielding
  - NEMUS might not be the best tool due to large number of measurement permutations
- Full GCR exposure time was longer than expected
  - Particle difference between modulators and slab target must be optimized
  - Single slab target will mitigate this as well

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



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