HEARTS@CERN facility: foreseen readiness improvement

HEARTS Advisory Panel Kick-off Meeting

9 October 2023

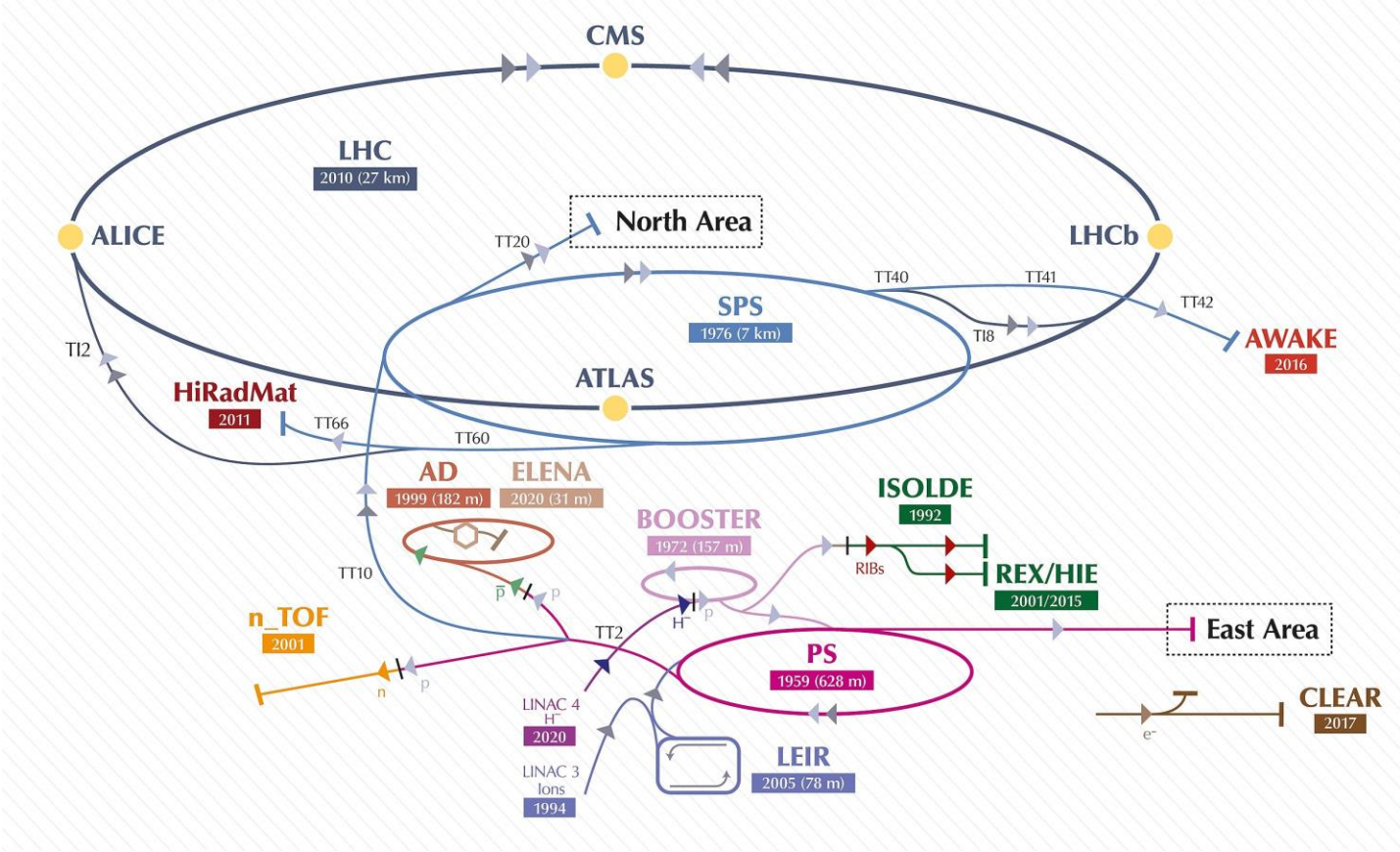
https://indico.cern.ch/event/1326703/

Rubén García Alía (CERN)
on behalf of all WP7 members and contributors

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.

What are we talking about?



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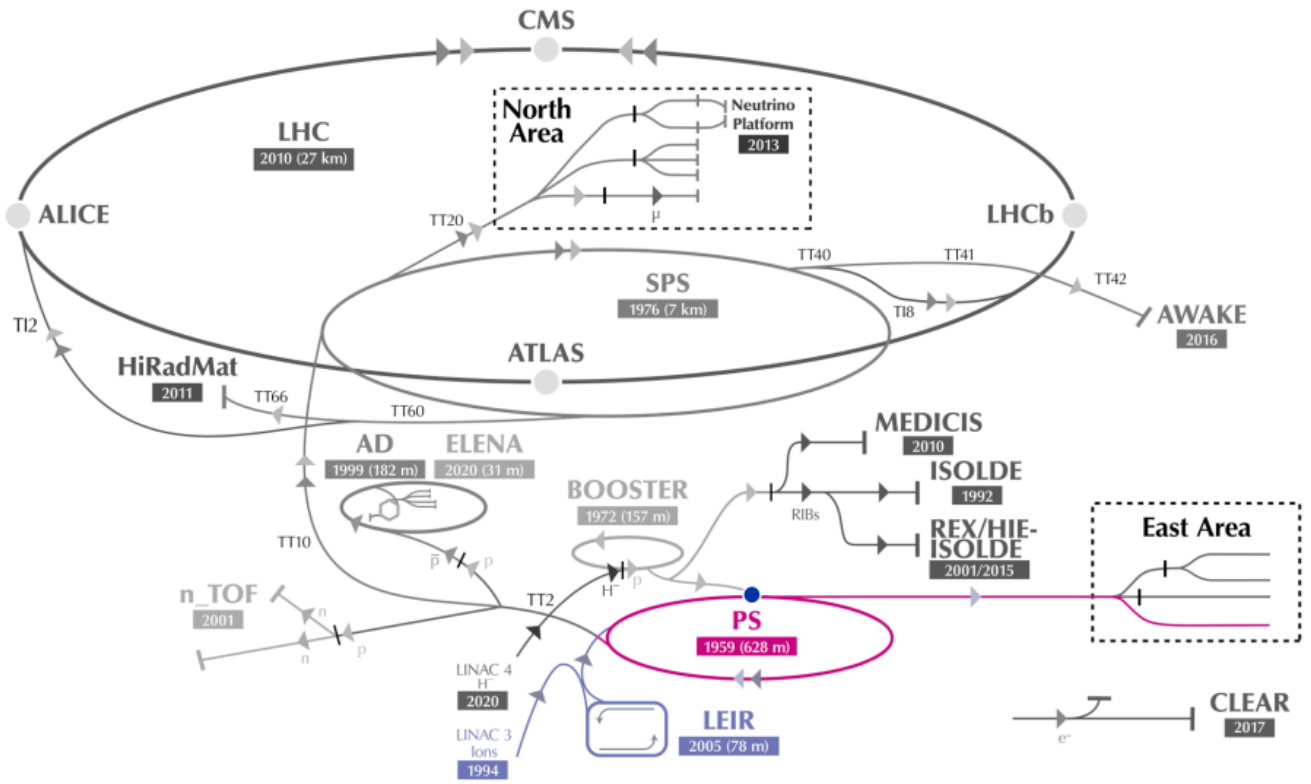

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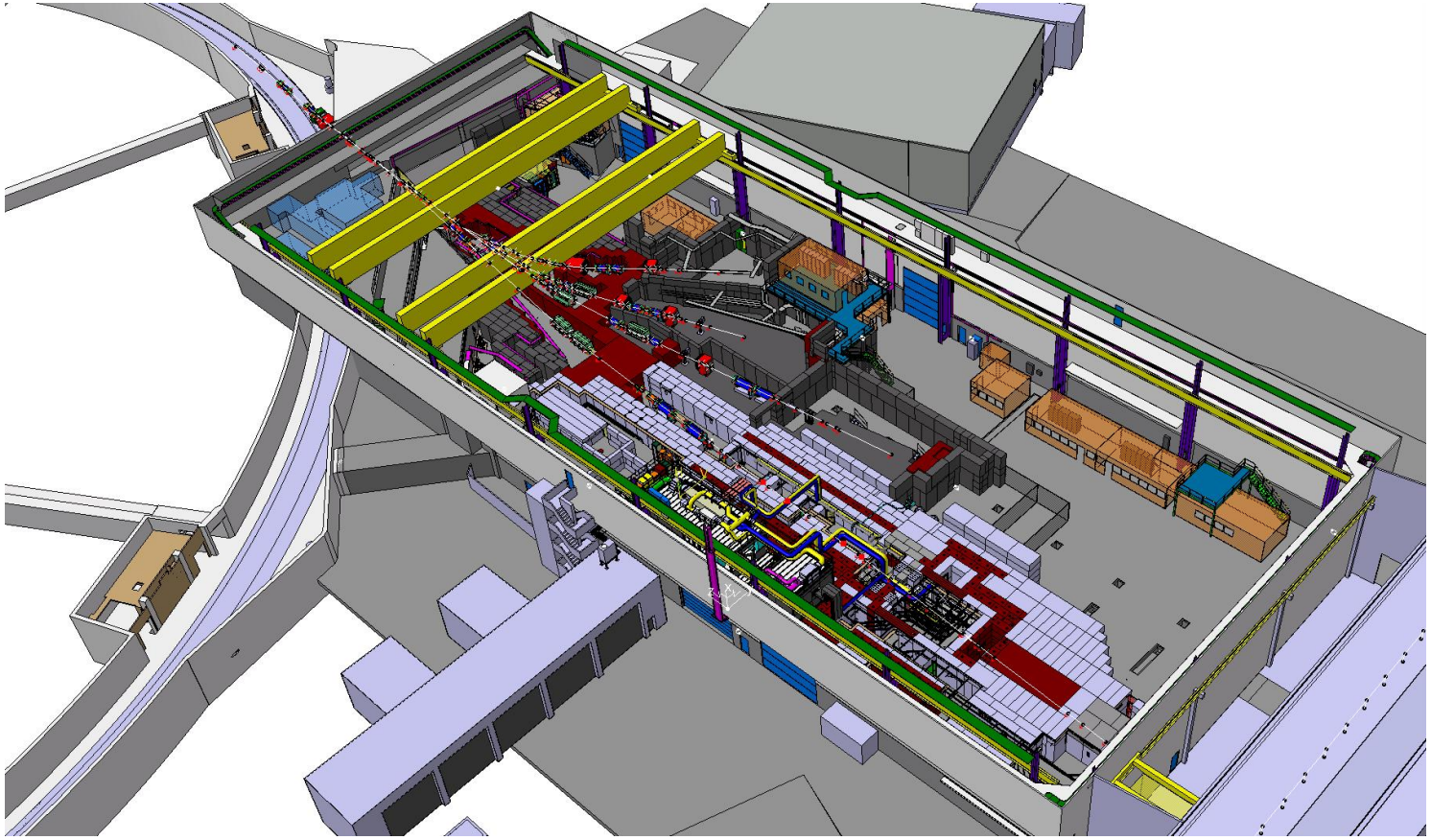
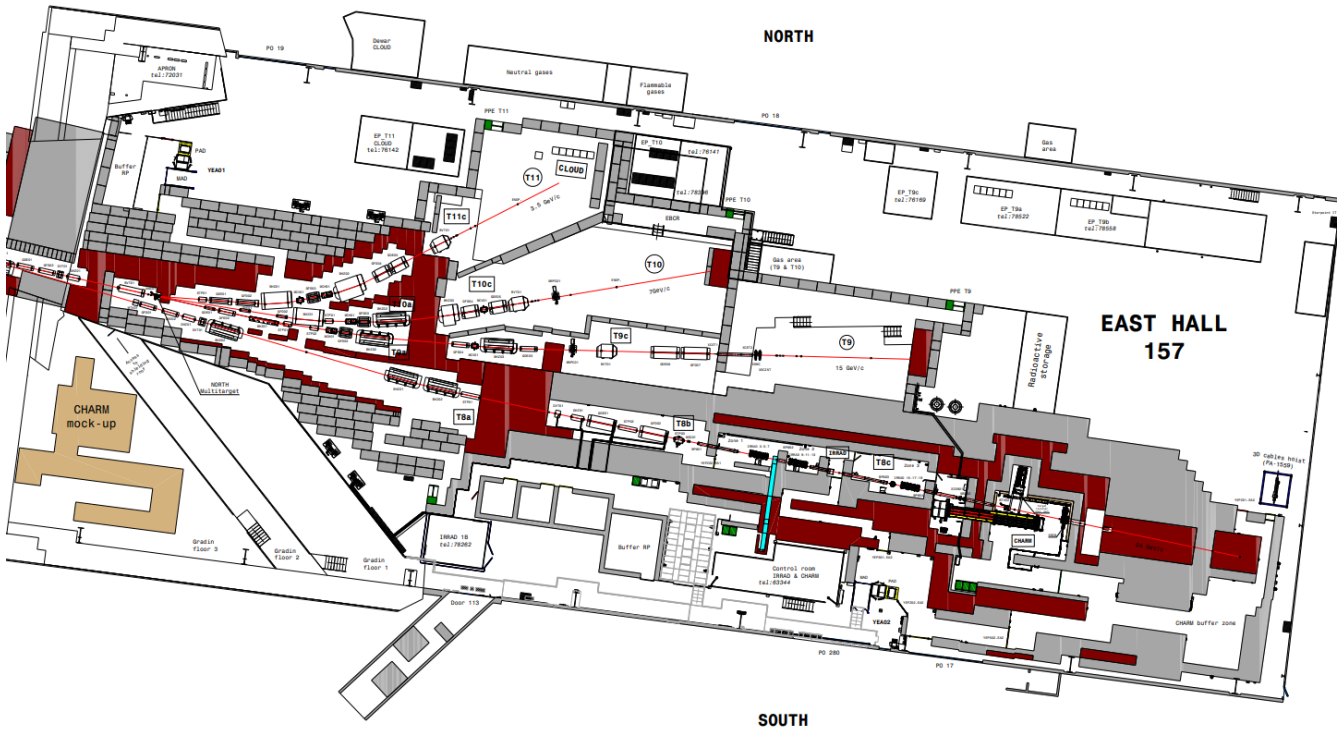


What are we talking about?

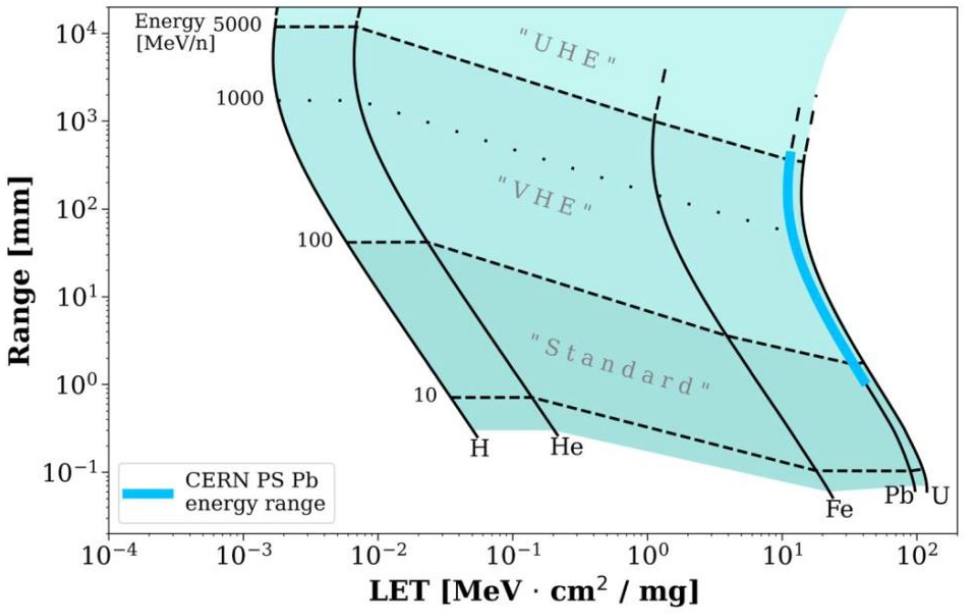
Scheduling constraints (for ions in T8): CERN accelerator complex needs to be in operation (Long Shutdowns, End-of-Year shutdowns); ions need to have been setup in PS for that given operational year; T8 line used with protons for IRRAD and CHARM (core activity of the line) or ions (HEARTS@CERN, typically 2 weeks/operations year)

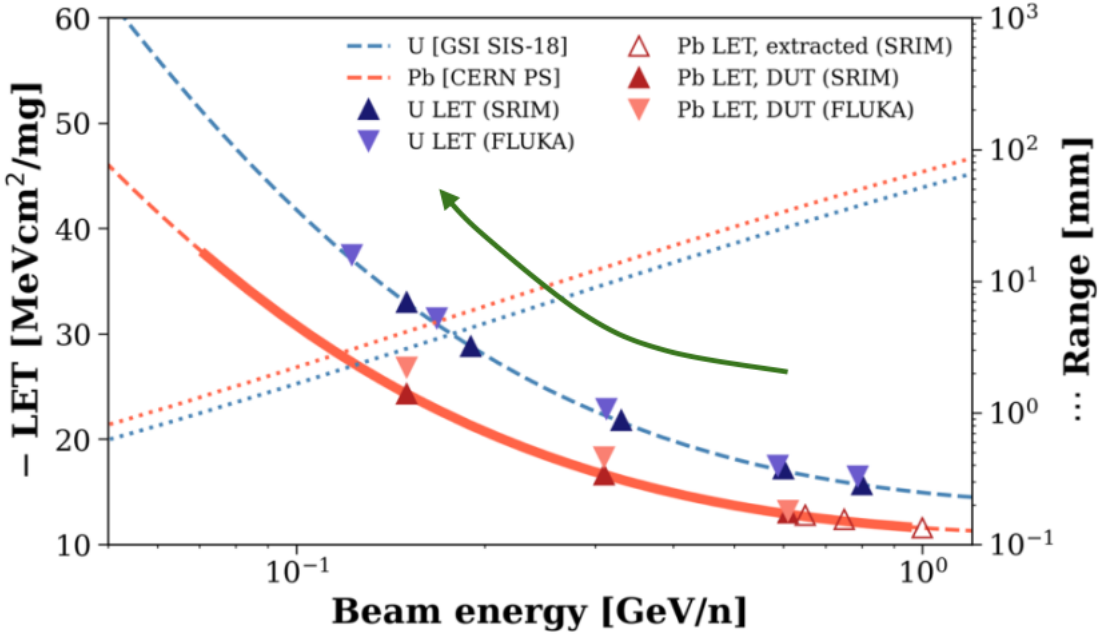
2 weeks per year for high-energy heavy ion testing of electronics (i.e. HEARTS objective) is already a substantial improvement with respect to the current situation – still, ideas to increase this in the longer term (i.e. beyond the scope/timeline of HEARTS) are in consideration and discussion within CERN



What are we talking about?

Within HEARTS, the CERN infrastructure and related research and development activities focus on **electronics testing**
GSI covers shielding and radiobiology, as well as electronics, for which CERN and GSI will complement each other





Single species (lead) beam of variable energy and LET, covering the ~10-40 MeVcm^2/mg range with high energies/penetration
Lighter ions are being considered to cover lower LET region

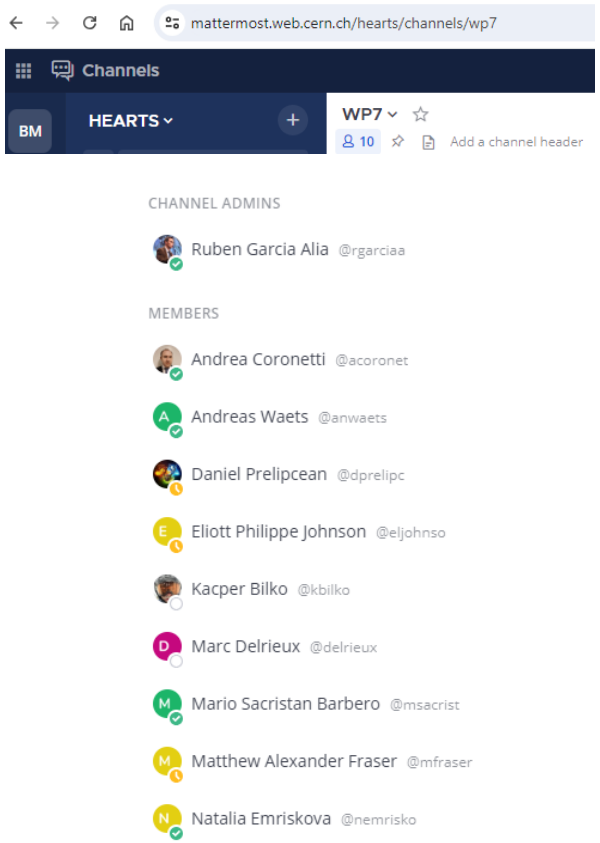
WP Structure and Members

- Matthew Fraser (beam physics, staff)
- Rubén García Alía (radiation environment & effects, staff)
- Andrea Coronetti (radiation environment & effects, postdoc)
- Natalia Emriskova (radiation environment & effects, postdoc)
- Eliott Johnson (beam physics, fellow)
- Kacper Bilko (radiation environment & effects, doctoral student)
- Andreas Waets (radiation environment & effects, doctoral student)
- Marc Delrieux (beam operation, staff)
- Daniel Prelipcean (radiation environment & effects, doctoral student)
- Mario Sacristán Barbero (radiation environment & effects, doctoral student)

WP Structure and Members

E-group: *hearts-wp7 (Static)*

Name
BILKO, Kacper (SY-STI-BMI)
CORONETTI, Andrea (SY-STI-BMI)
DELRIEUX, Marc (BE-OP-PS)
EMRISKOVA, Natalia (SY-STI-BMI)
FRASER, Matthew Alexander (SY-ABT-BTP)
GARCIA ALIA, Ruben (SY-STI-BMI)
JOHNSON, Eliott Philippe (SY-ABT-BTP)
PRELIPCEAN, Daniel (SY-STI-BMI)
SACRISTAN BARBERO, Mario (SY-STI-BMI)
WAETS, Andreas (SY-STI-BMI)



indico

2023 HEARTS@CERN run - Sept/Oct weekly meetings

October 2023

- 03 Oct — HEARTS@CERN 2023 weekly meeting #6

September 2023

- 18 Sept — HEARTS@CERN 2023 weekly meeting #5
- 12 Sept — HEARTS@CERN 2023 weekly meeting #4
- 05 Sept — HEARTS@CERN 2023 weekly meeting #3
- 01 Sept — HEARTS@CERN 2023 weekly meeting #2

August 2023

- 29 Aug — HEARTS@CERN 2023 weekly meeting #1

WP Milestones and Deliverables

Work Package 7

Upgrade of CHARM beam line at CERN for VHE ion testing

Participants

- CERN

Objectives

This work package aims at adapting the existing CHARM beam line infrastructure at CERN to accommodate very high energy (VHE) heavy ion beams for radiation effects testing on electronics. This requires 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. Furthermore, this WP will also 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.

Tasks

- **Task 7.1:** Methodology for extracting variable energy ion beams to ensure parallel operation of the VHE ion facility (CERN, M1-12)
- **Task 7.2:** Achievement of the required beam parameters for microelectronics SEE testing (CERN, M12-24)
- **Task 7.3:** Framework for user access (CERN, M24-48)

Deliverables

- **D7.1 (M12):** Definition of extraction methodology for parallel use of the heavy ion beamline for different energies
- **D7.2 (M24):** Demonstration of the achievements in terms of beam parameters (energy, LET, range, size)
- **D7.3 (M48):** Established framework for user access to the CHARM ion facility

Milestones

- **M20:** First external users at CHARM
- **M21:** Routine access for external users at CHARM

- Methodology for extracting variable energy ion beam
  - Mostly achieved already in 2022
  - Still, we should work on defining how to do this routinely, minimizing OP overheads and ensuring coherence between selected and actually set energy
  - A HEARTS report related to this methodology will need to be written, incorporating the progress achieved in 2023, and to be finalized in November 2023 → Eliott as main contributor
- Demonstration of beam parameter achievement
  - Very much along the lines of what we did in 2022, and what we plan to extend in 2023
  - Timeline-wise, the deliverable report could also include results from 2024, but it might not be strictly necessary
- Established framework for user access to the CHARM ion facility
  - Both technical and administrative
  - Some incremental progress being already achieved, but no need to treat it with high urgency/priority for the time being

Upcoming deliverable 7.1

https://hearts-project.eu/project/deliverables/

https://hearts-project.eu/project/work-packages/wp7/

Deliverables

Show 10 entries Search:

Deliverable	Deliverable Name	Work Package	Lead Beneficiary	Due Date	Status
D2.1	Communication and dissemination plan	WP2	CERN	30 Jun 2023	Pending
D5.1	Finalised list of beam parameter requirements concurring to establish a TRL 6-7 for the CHARM facility	WP5	ADS	30 Jun 2023	Pending
D1.1	Assessment of high-energy heavy ion operation in CHARM during CERN proton physics periods	WP1	CERN	30 Jun 2024	Pending
D2.2	Exploitation and data management plan	WP2	CERN	31 Dec 2023	Pending
D4.1	Beam instrumentation for high-energy low intensity heavy ion beam characterization	WP4	GSI	31 Dec 2023	Pending
D7.1	Definition of extraction methodology for parallel use of the heavy ion beamline for different energies	WP7	CERN	31 Dec 2023	Pending

Work Package 7

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Tasks

- **Task 7.1:** Methodology for extracting variable energy ion beams to ensure parallel operation of the VHE ion facility (CERN, month 1-12)
- **Task 7.2:** Achievement of the required beam parameters for microelectronics SEE testing (CERN, month 12-24)
- **Task 7.3:** Framework for user access (CERN, month 24-48)

Deliverables

- D7.1: Definition of extraction methodology for parallel use of the heavy ion beamline for different energies
- D7.2: Demonstration of the achievements in terms of beam parameters (energy, LET, range, size)
- D7.3: Established framework for user access to the CHARM ion facility

Upcoming deliverable 7.1

Deliverable D7.1

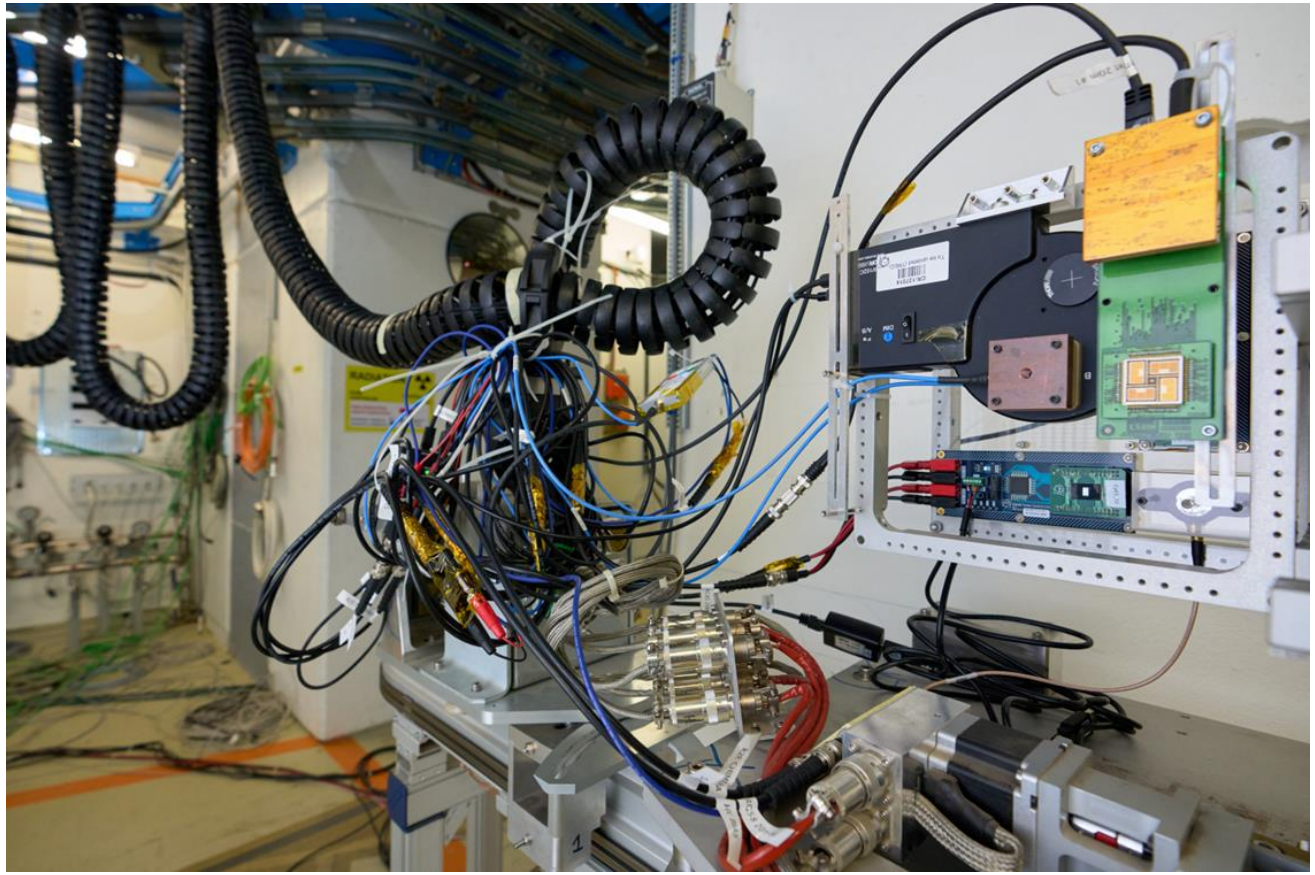
Definition of extraction methodology for parallel use of the heavy ion beamline for different energies

Description

This report will include the methodology that has been followed by the Proton Synchrotron (PS) operators and beam physicists to enable the parallel low-rigidity operation of the CHARM beamline to that at the standard, higher rigidity available. In this respect, the report will detail the beam optics and instrumentation used as well as the various settings needed to achieve the required energies and LETs.

Successful 5-day CHIMERA 2022 run

CHIMERA: ESA co-funded (and technically supported) activity, from 2020 to 2022



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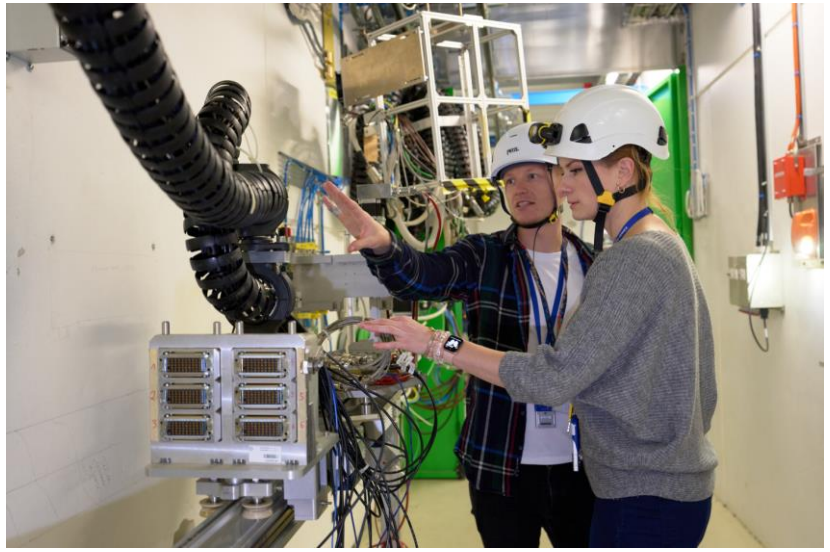
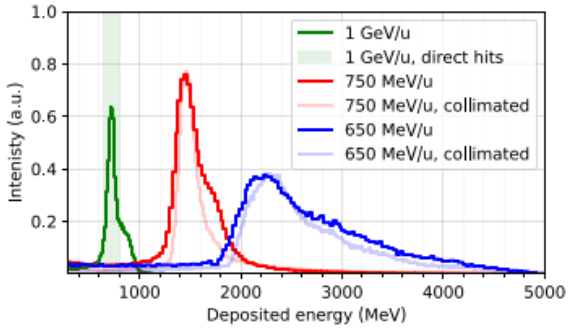


Core experimental team: Eliott, Kacper, Natalia, Andrea, Andreas (also in charge of aspects, e.g. studies, that go beyond the experimental activity)

Very direct involvement in experimental activities: PS OP team, IRRAD and CHARM teams, Radiation Protection, Beam Instrumentation…

Highlight example: intensity control and (accurate) flux measurement



RADECS 2023
TOULOUSE - 25-29 September

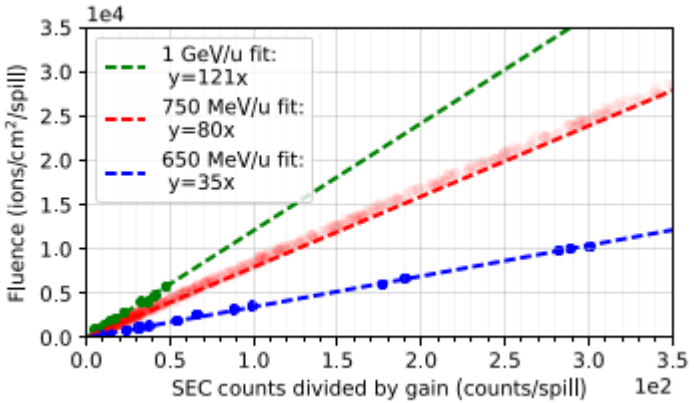
CHARM High-energy Ions for Micro Electronics Reliability Assurance (CHIMERA)

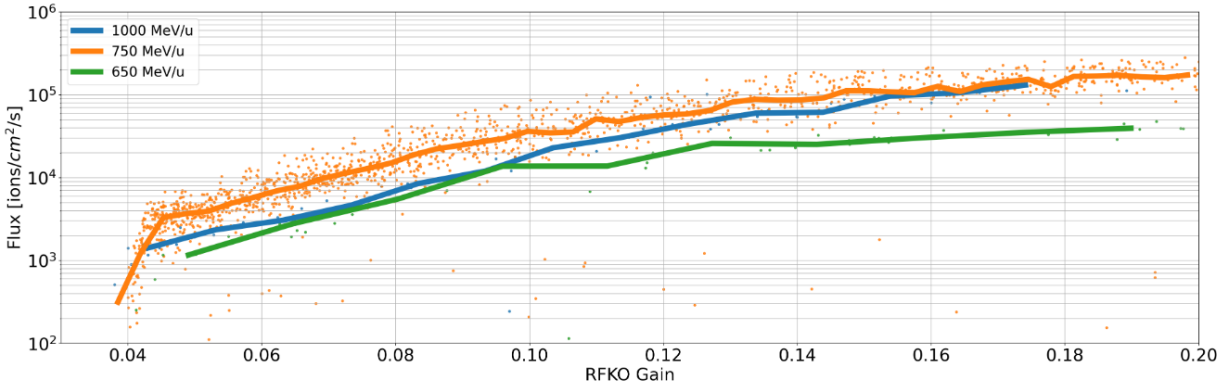
Kacper Bilko[1,2], R.G. Alía[1], A. Coronetti[1], S. Danzeca[1], M. Delrieux[1], N. Emriskova[1], M. A. Fraser[1], S. Girard[2], E. Johnson[1], M. Sebban[2], F. Ravotti[1], A. Waets[1]

[1]CERN, Geneva, Switzerland [2]UJM, St-Etienne, France

CERN Radiation to Electronics

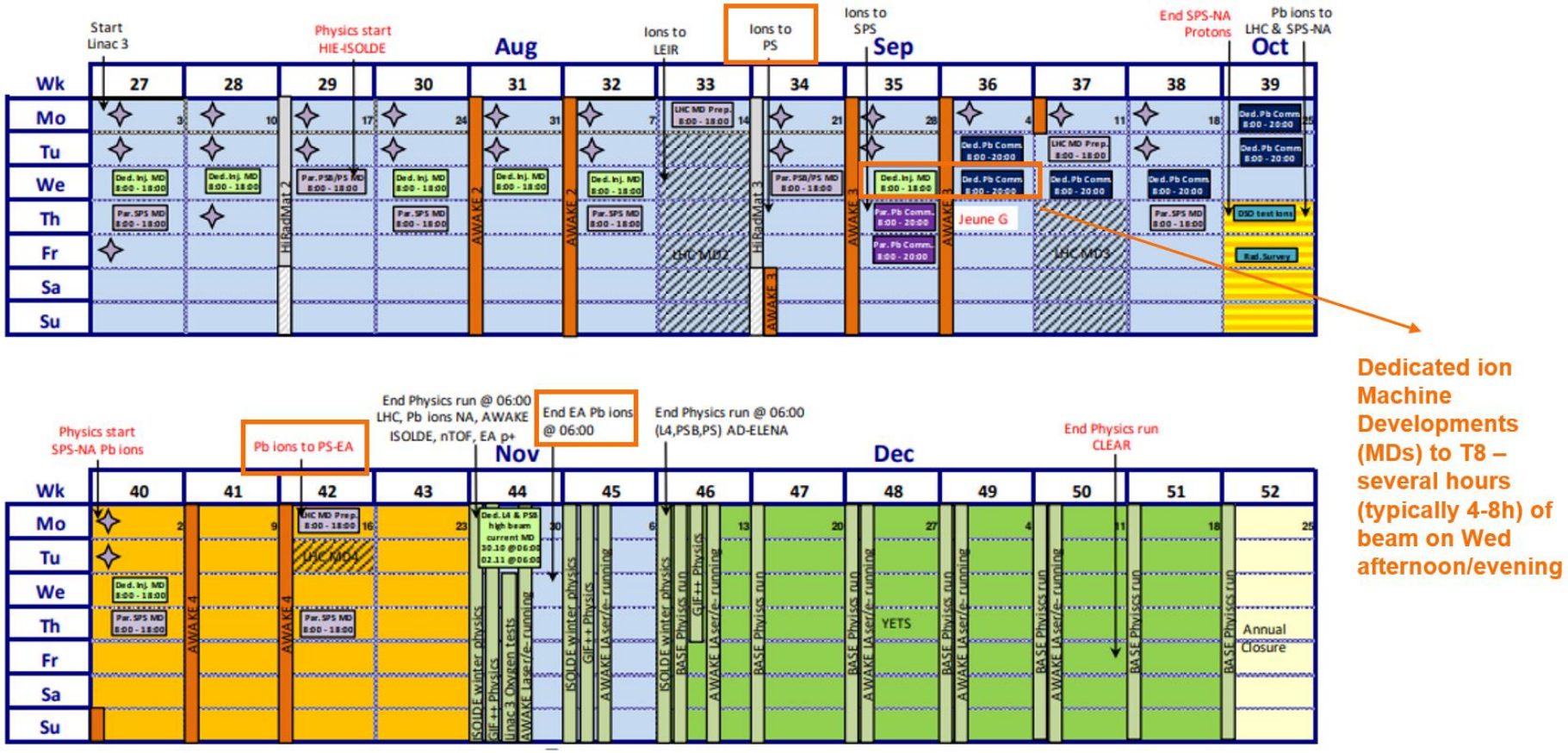
Université de Lyon — Université Jean Monnet Saint-Étienne





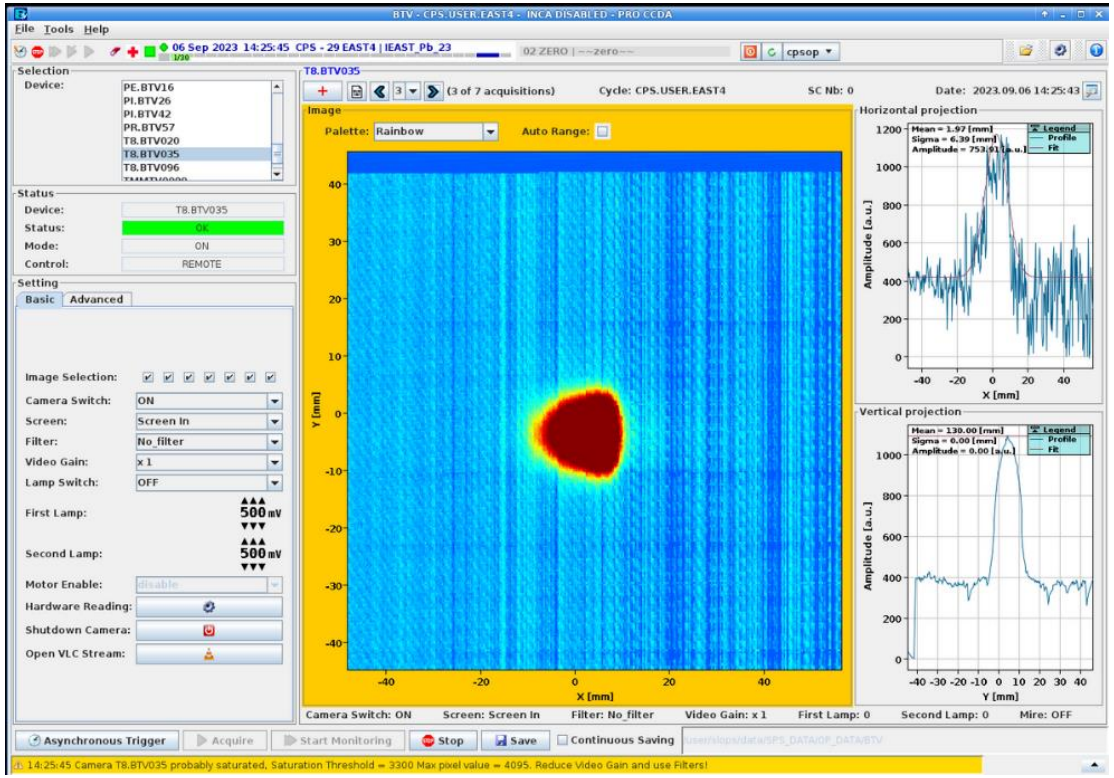
Note: RFKO technique developed and employed for ion slow extraction now also used to improve proton spill quality

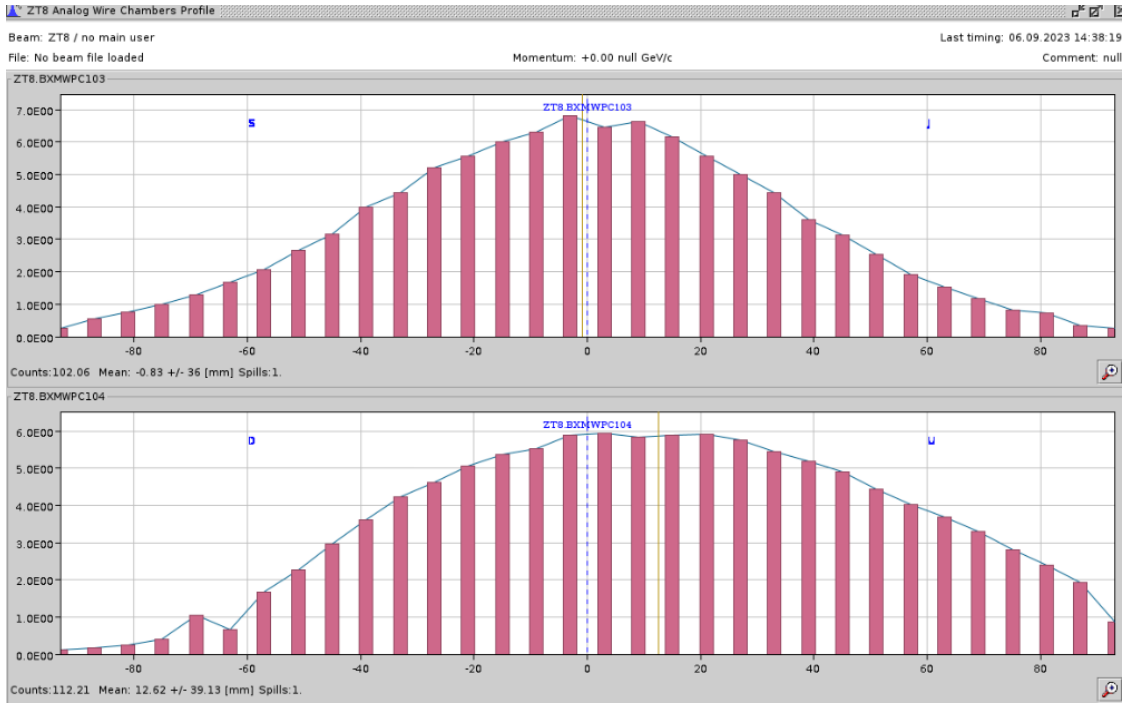
WP7 progress in 2023



Dedicated ion Machine Developments (MDs) to T8 – several hours (typically 4-8h) of beam on Wed afternoon/evening

WP7 progress in 2023: beam commissioning in T8 (September 6th)



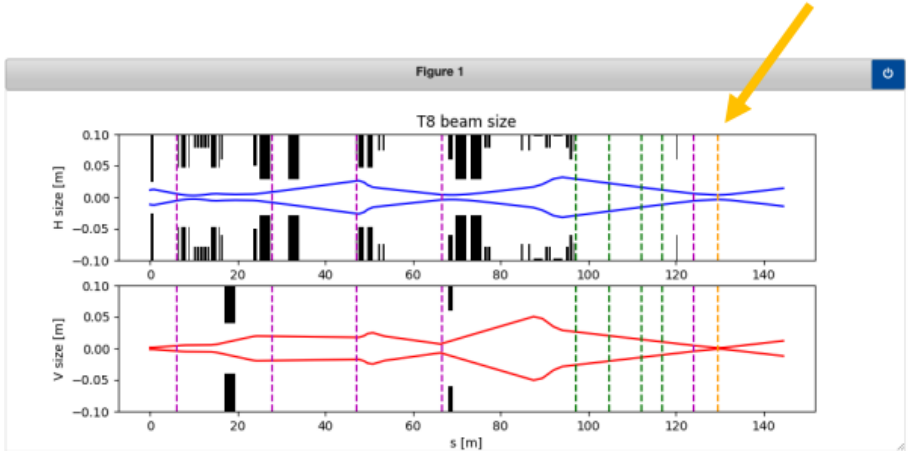


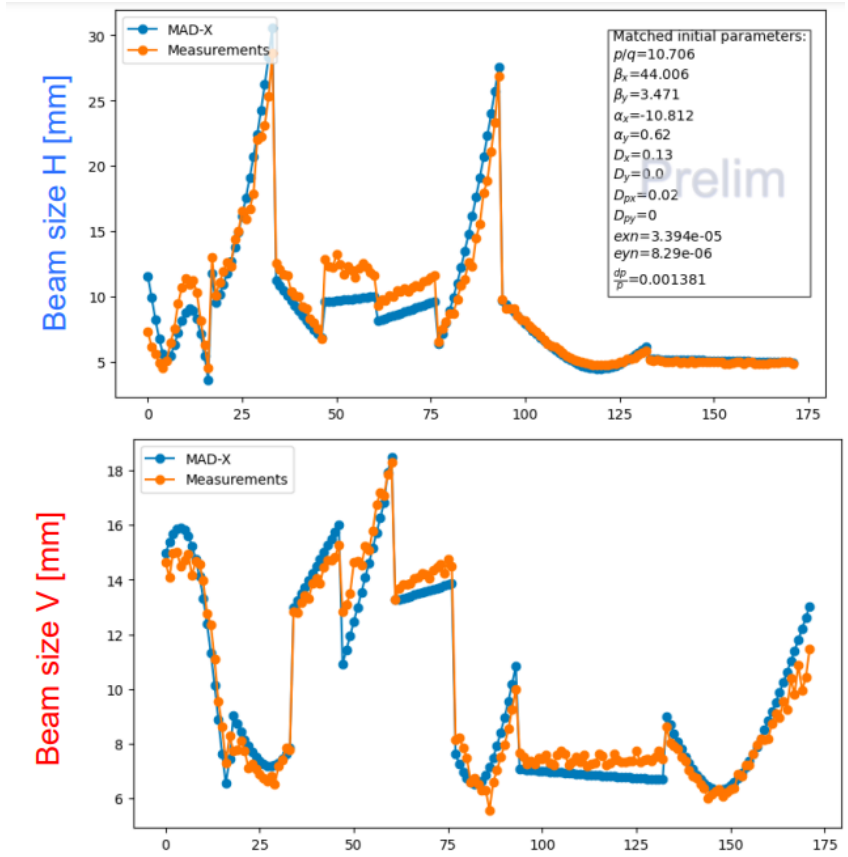
WP7 progress in 2023: beam characterization

Beam optics studies and measurements, to gain better control of the beam position and shape

Strong link with FLUKA simulations in WP3

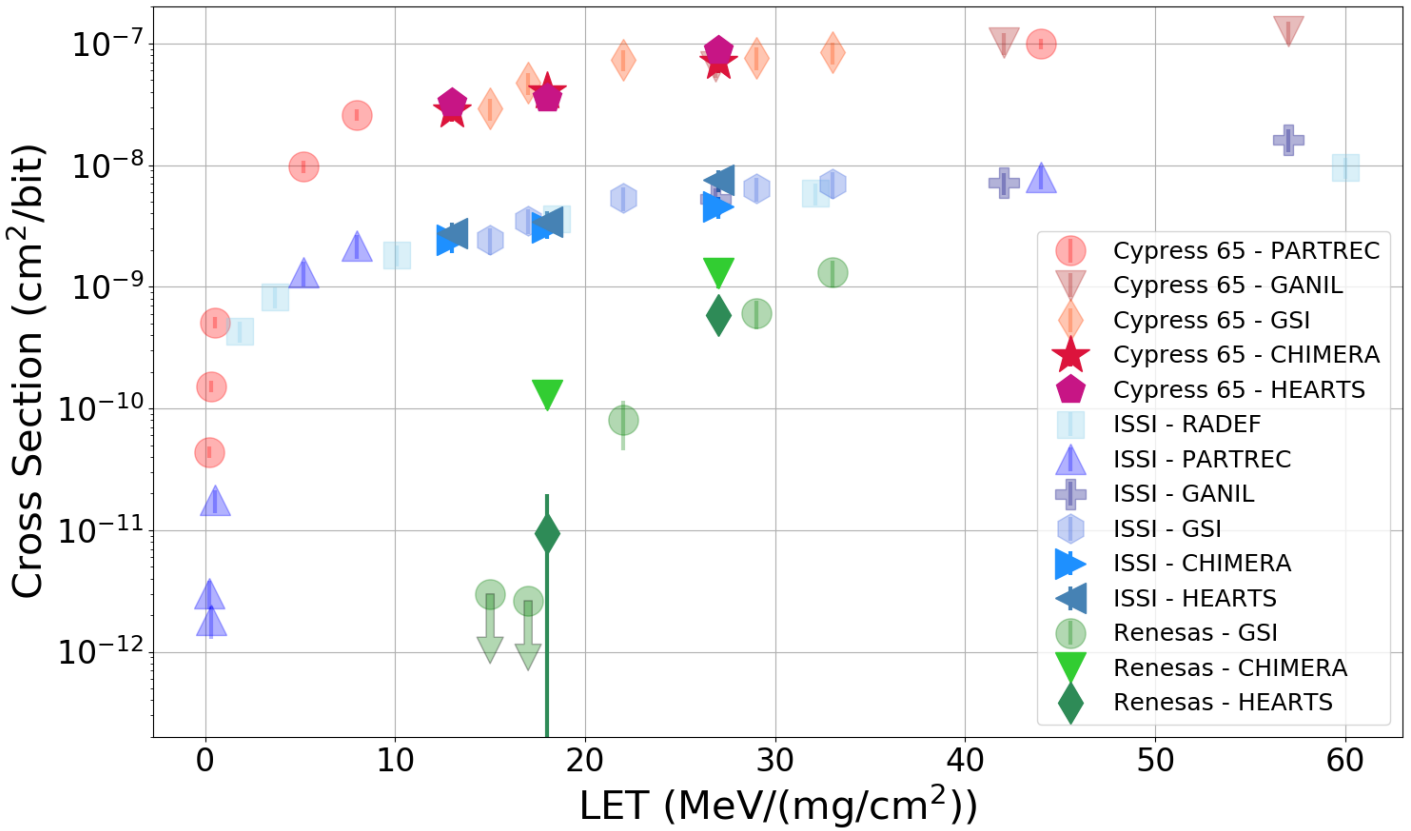
- **This example: Min beam size on MWPC**





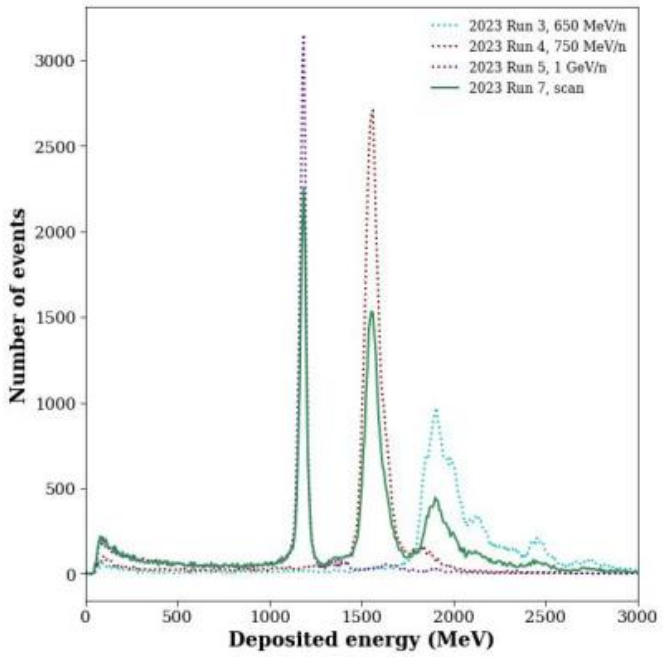
WP7 progress in 2023: beam characterization

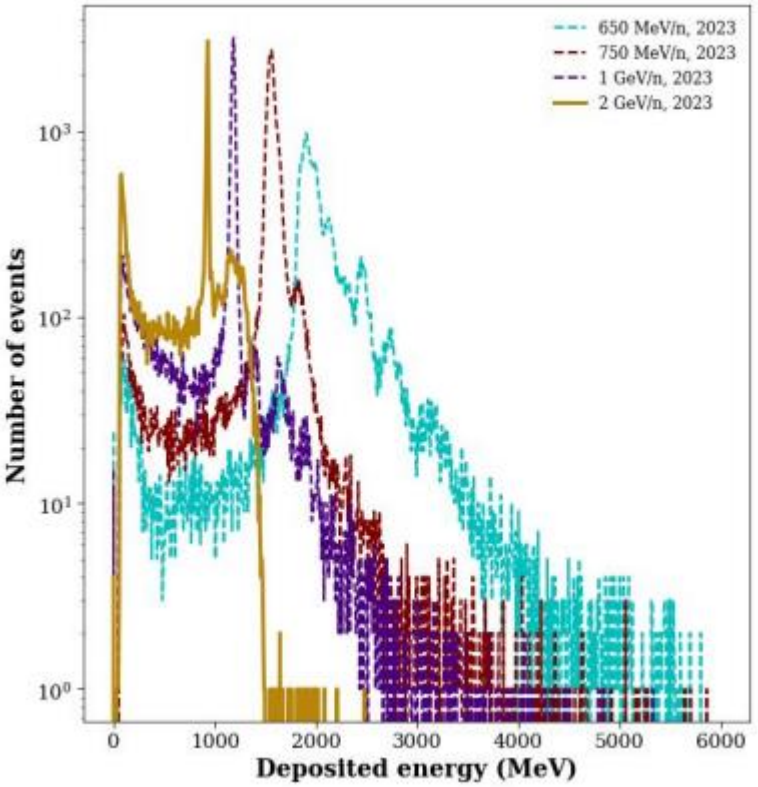
"Golden chip" SEU measurements (only preliminary data for 2023 – calibrations need to be updated with more precise runs, etc. – but, overall, situations looks comparable to 2023)



WP7 progress in 2023: beam characterization

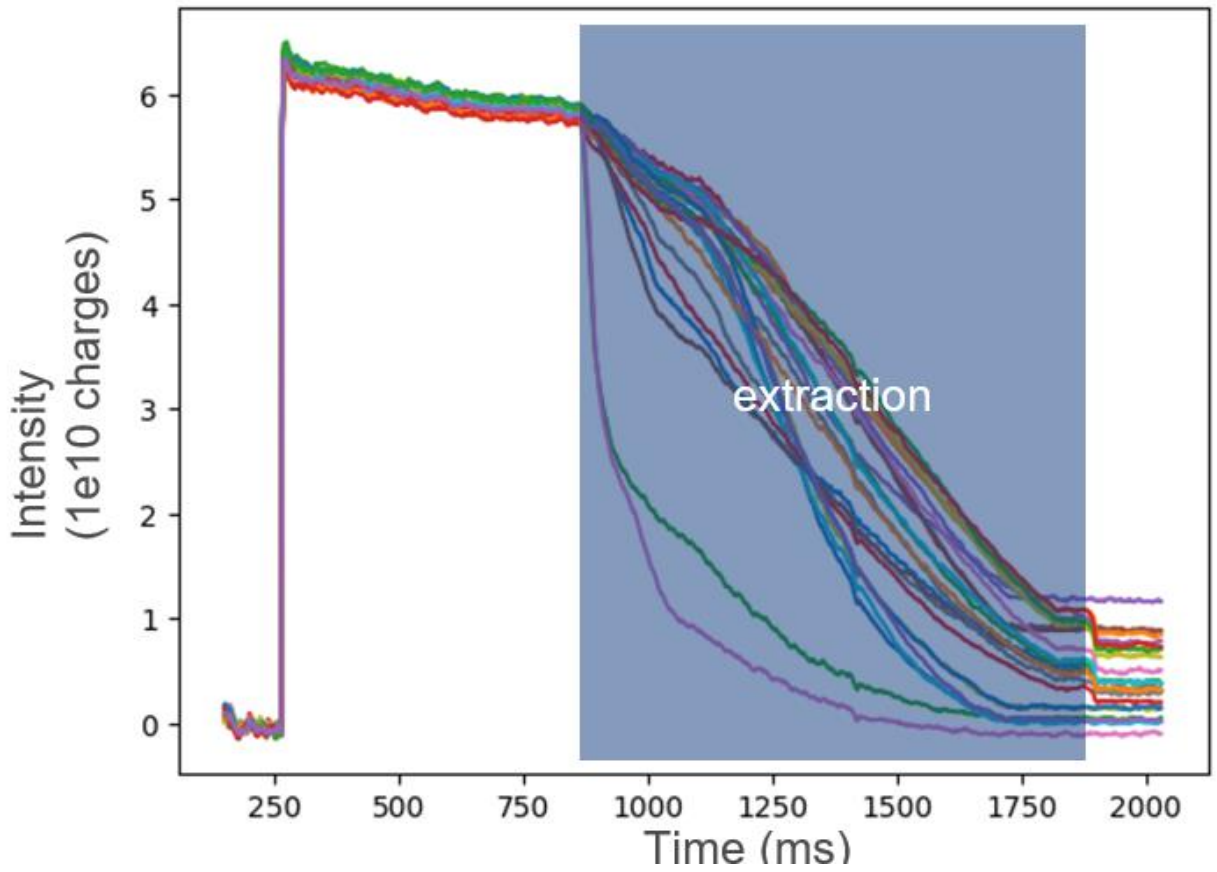
Solid state silicon detector as ion counter, but also to check energy deposition distribution (long ranged particles, i.e. higher energy means lower LET, and lower deposited energy)





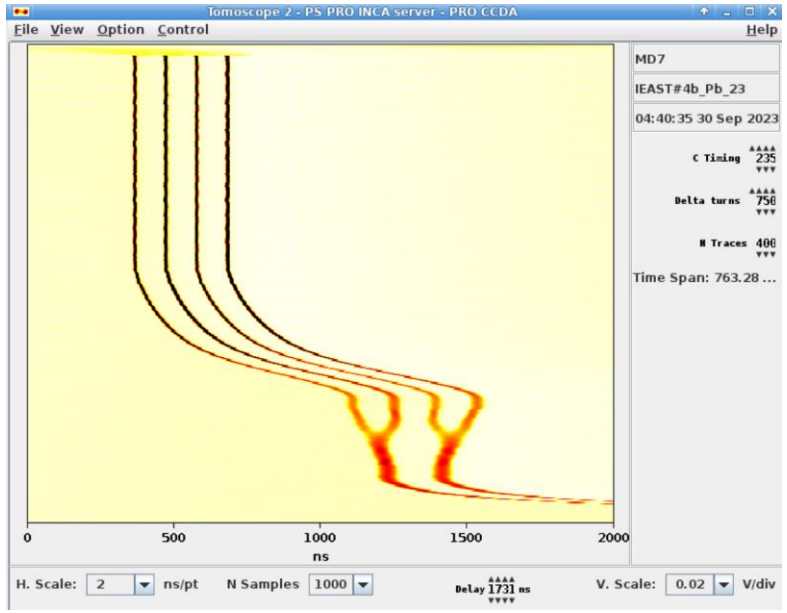
WP7 progress in 2023: beam development

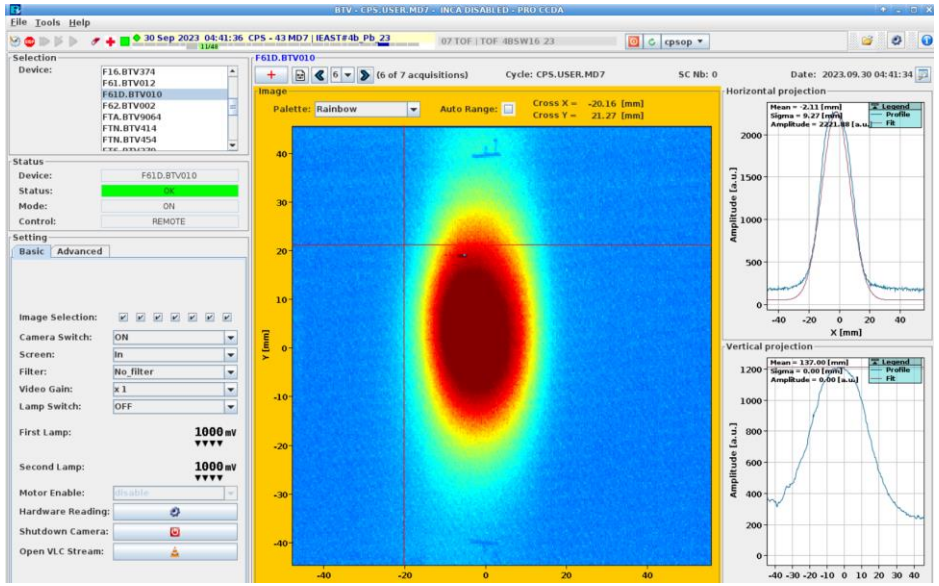
Longer, 1s spill (as opposed to 300 ms)



WP7 progress in 2023: beam development

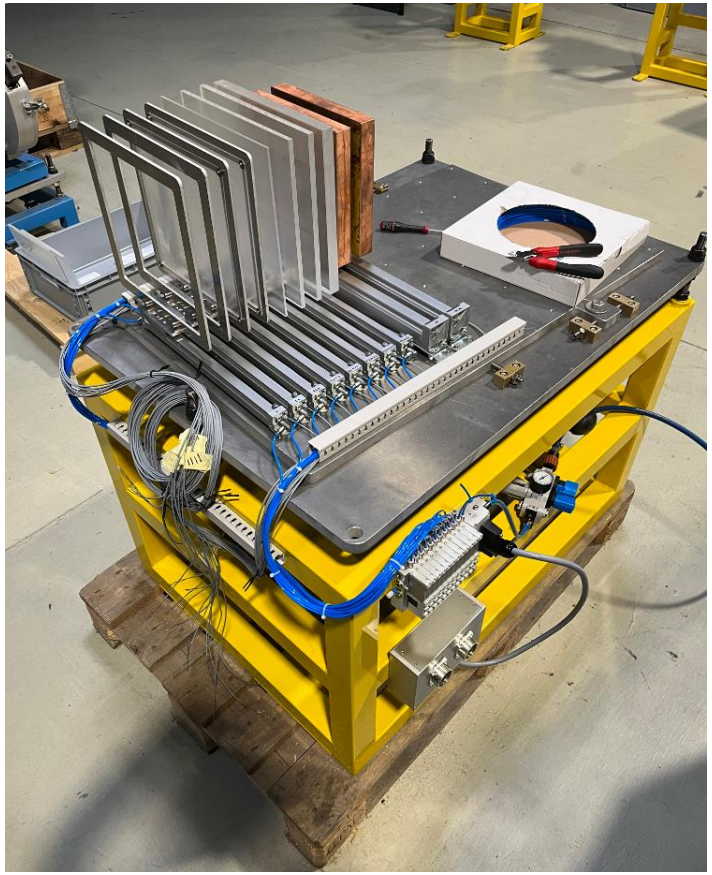
Improved transmission along cycle, in view of reaching higher maximum intensities: now the RF and first part of the B-field come from the ILHC#4b cycle, with a LEIR intensity of roughly 7e10 charges





WP7 progress in 2023: experimental target station

Remote degrader and mask (for cutting beam edges) system



Activities foreseen for HEARTS 2023: beam development and characterization

- Demonstration of reproducibility of 2022 beam conditions; → already largely achieved during MD runs
- Studies and (if applicable) improvement of beam transmission in T8 line;
- Beam size modification, if possible including also the removal of the beam edges (i.e. square/rectangular beam) with a mask;
- Slow extraction RFKO related points:
- Variable gain during slow extraction
- Larger chirp frequency
- Beam energy scans (also in view of better determining the energy at DUT level);
- Determination of highest ion energy at which PS is still scalable → 2.7 GeV/n, from 2023 MD observations
- Characterization of radiation environment outside of the beam (e.g. where ancillary electronics would typically be placed)
- Characterization of fragmented ion beams;
- Improved accuracy in beam energy distribution characterization;
- Beam optics studies; → already started in MDs
- Determination of energy straggling through horizontal beam position measurements; → already started in MDs
- Increase of spill duration; → ~1s already achieved during MDs

Activities foreseen for HEARTS 2023: beam exploitation

- Single Event Effects
  - Collection of SEE data (SEU, SEB, SEL) for comparison with other facilities
  - Quasi-continuous LET cross section curves
  - Sub-LET threshold SEE cross section as a function of energy (only possible for high LET threshold parts) → requires high intensity beams
  - SEE results with fragmenters
- External (non-CERN) users, mainly for dosimetry/beam characterization aspects
  - GSI
  - Oldenburg University and PTW (in the process of becoming HEARTS partners – without budget, but still “officially” part of the project)
  - University of Wollongong, for micro-dosimetry measurements

A lot of work (and fun!) ahead with 2023 HEARTS@CERN run (17 October – 1 November)

Thanks for your attention!

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