RADNEXT facility network & CHIMERA heavy-ion beam line

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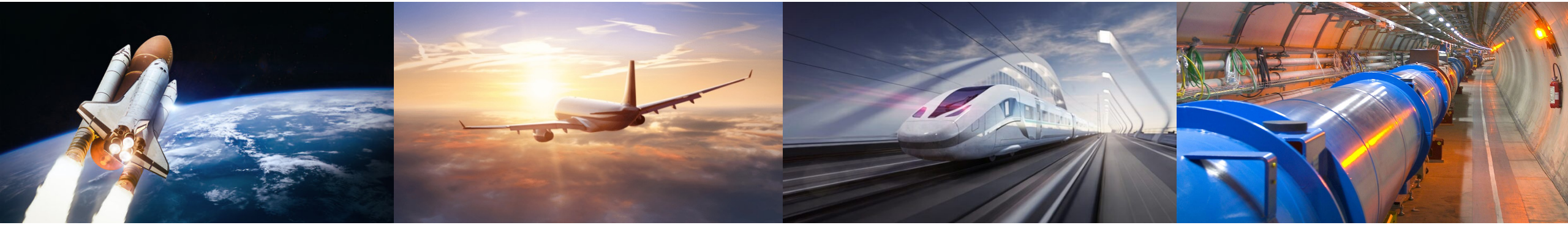
on behalf of the RADNEXT project and CHIMERA working group

The European Space Components Conference (ESCCON) - March 7th, 2023

Increasing need for radiation testing



- **Radiation effects** in semiconductor devices ⟶ major role in the performance and reliability of today's electronics.
- Testing in ground-based **irradiation facilities** is key to radiation hardness assurance.
- Demand for radiation testing is increasing, while the availability of irradiation facilities providing **beam time is limited.**
- Plus, traditional testing **methodologies can be obsolete** for new technologies and applications.
- To adress these challenges the RADNEXT project has been conceived as a **facility network capable of satisfying a very broad range of irradiation applications, including notably space, high-reliability atmospheric applications, high-energy accelerators (both scientific and medical) and fusion.**

The RADNEXT project

RADiation facility **N**etwork for the **EX**ploration of effects for indus**T**ry and research

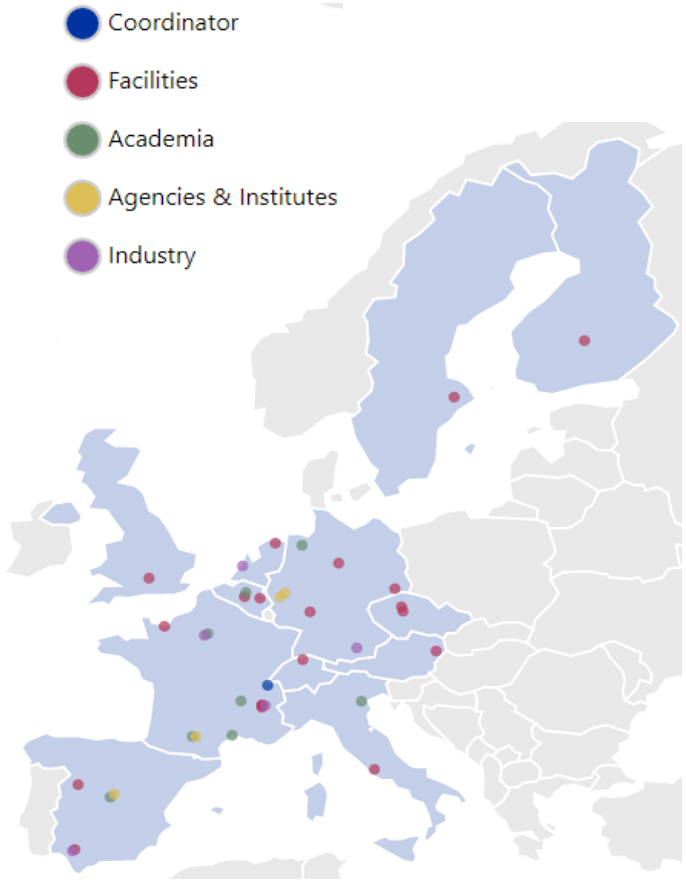
RADNEXT is a H2020 INFRAIA-02-2020 infrastructure project aiming at **enhancing accessibility to irradiation facilities** for research on radiation effects in electronics.

To this end, RADNEXT provides:

- a rich **quantity and variety of facilities**, targeting at satisfying user needs in terms of beam characteristics and timeline,
- a **centralized access point and procedure** for requesting beam time for research on radiation effects in electronics,
- **6000h of beam time awarded over 4 years**, free-of-cost to users via a competitive proposal process,
- an ambitious **research program** devoted to improving radiation effects testing, both on the facility and user side.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No **101008126**

RADNEXT network & contact



Coordinator:

- 21 **irradiation facilities**
- 8 **academic partners** and 9 academic supporters
- 4 **agencies and research institutes**
- 5 **industrial partners** and over 20 industry supporters

Contact us:

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RADNEXT

Networking activities | Joint research activities | Transnational access

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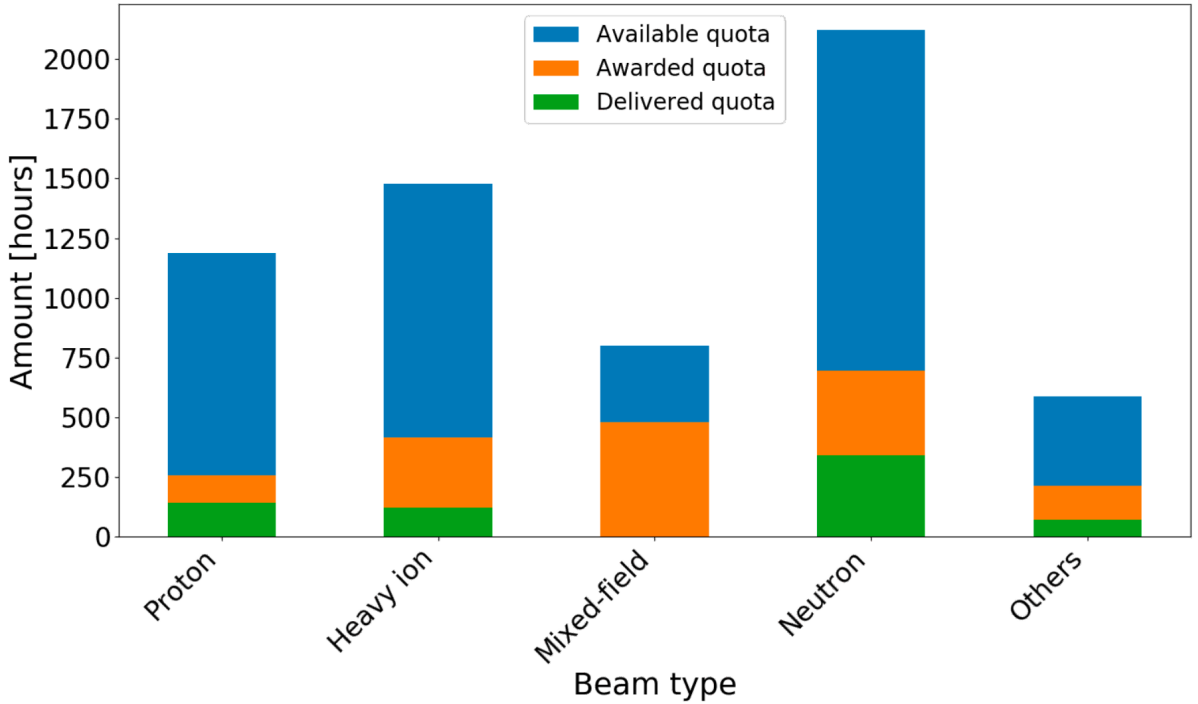
Transnational access

The next 8th call for proposals

May 2023

- More than **6000 beam time hours** to be awarded in 2021-2025,
- **free of cost** to users,
- via a competitive proposal process.
- Quarterly calls for proposals, evaluated by experts.
- Both academic and industrial groups are eligible.
- Types of beams: proton, neutron, heavy ion, muon, mixed-field, photon, electron.

Status as of: November 30, 2022 - R. Garcia Alia et al., RADECS 2022



Joint research activities

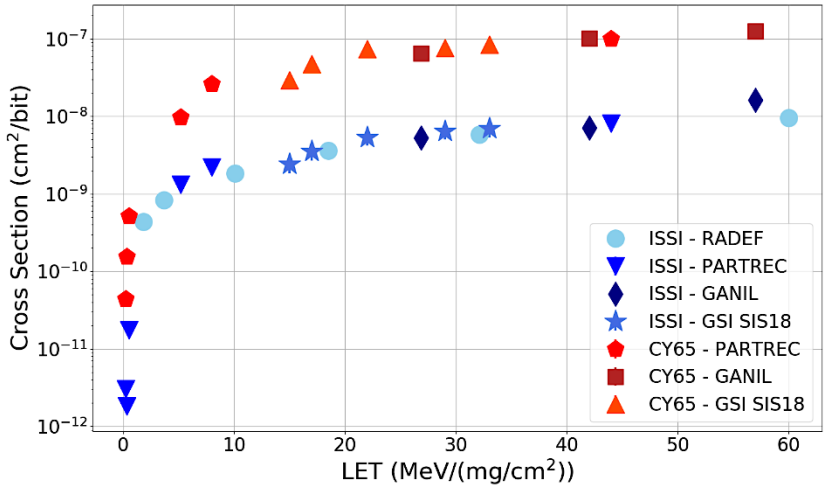
In addition to the research activities deriving from the user access to RADNEXT, there are a variety of research efforts within RADNEXT itself, linked to:

- beam characterization and dosimetry,
- testing of complex components and full systems,
- cumulative radiation effects and
- radiation effect modelling.

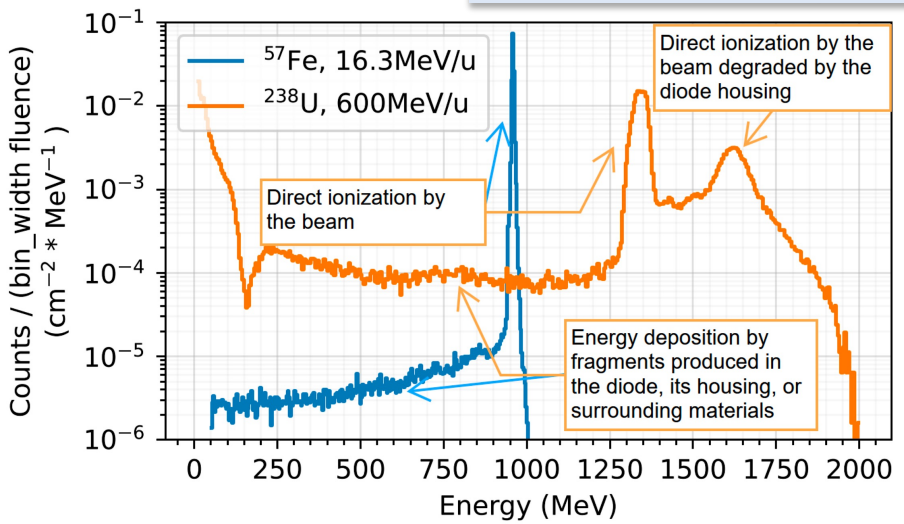
Two examples:

- SEU cross section measured for two commercial SRAMs at different RADNEXT facilities
- Silicon diode spectroscopy for beam characterization

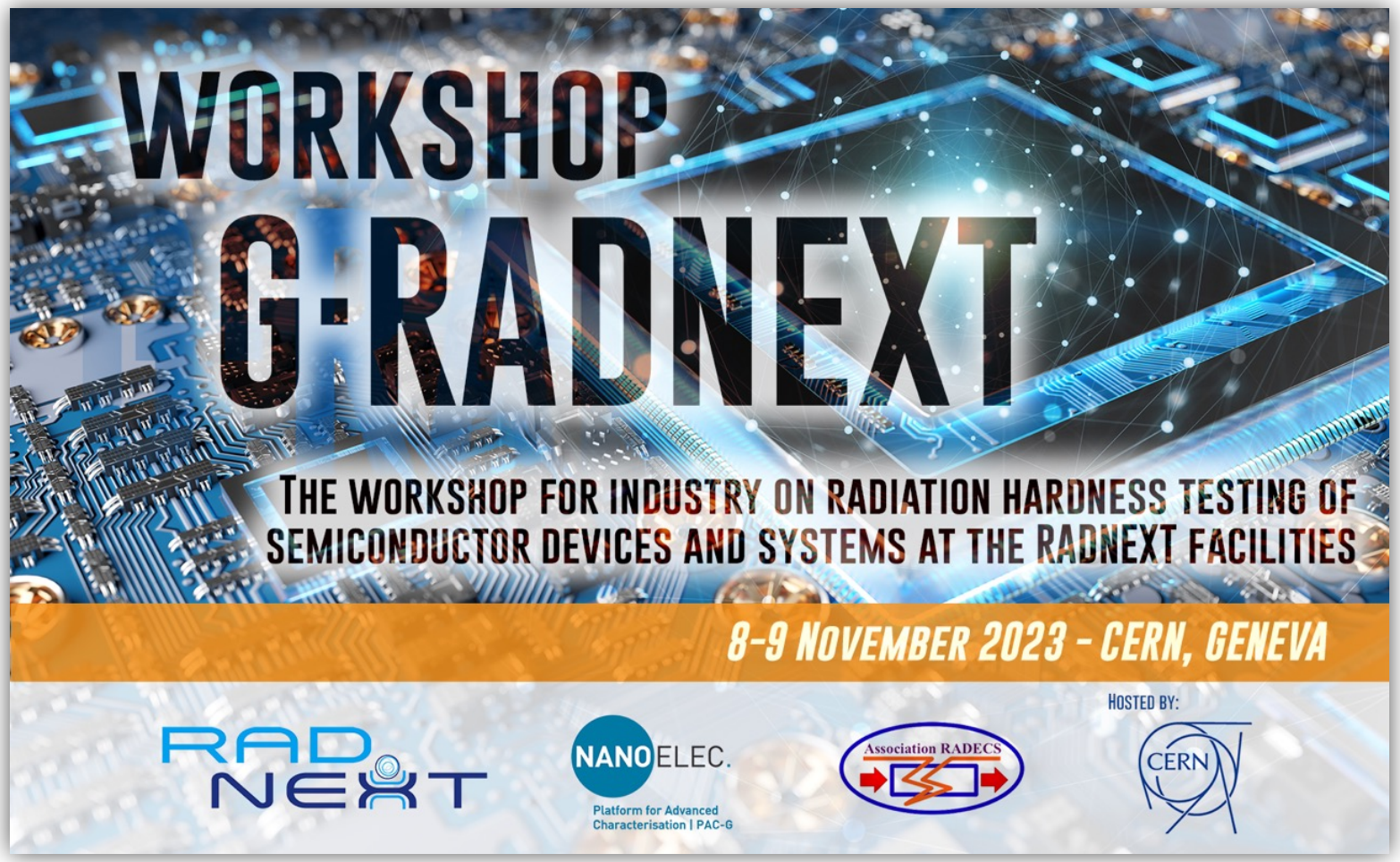
Memory-based dosimetry



Silicon Diode Spectroscopy



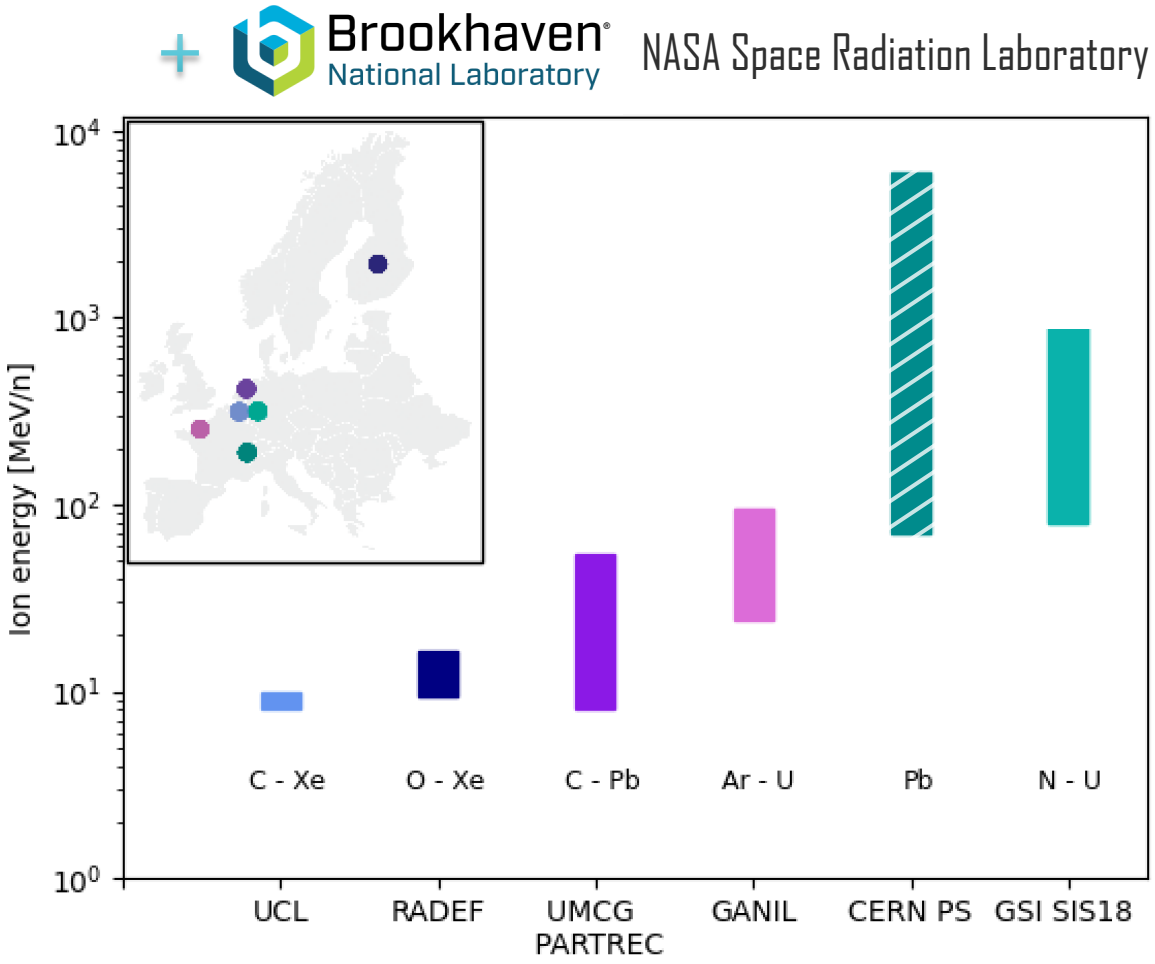
G-RADNEXT Workshop 2023



- **Attendance**: In-person event
- **Registration fee:** free of charge
- **Date:** November 8th – 9th, 2023
- **Location:** CERN (Meyrin, Switzerland)
- **Organizers:** PAC-G (IRT nanoelec), RADECS association, RADNEXT, CERN
- **Information & registration:** https://indico.cern.ch/event/1251241/

Focus on Heavy ions

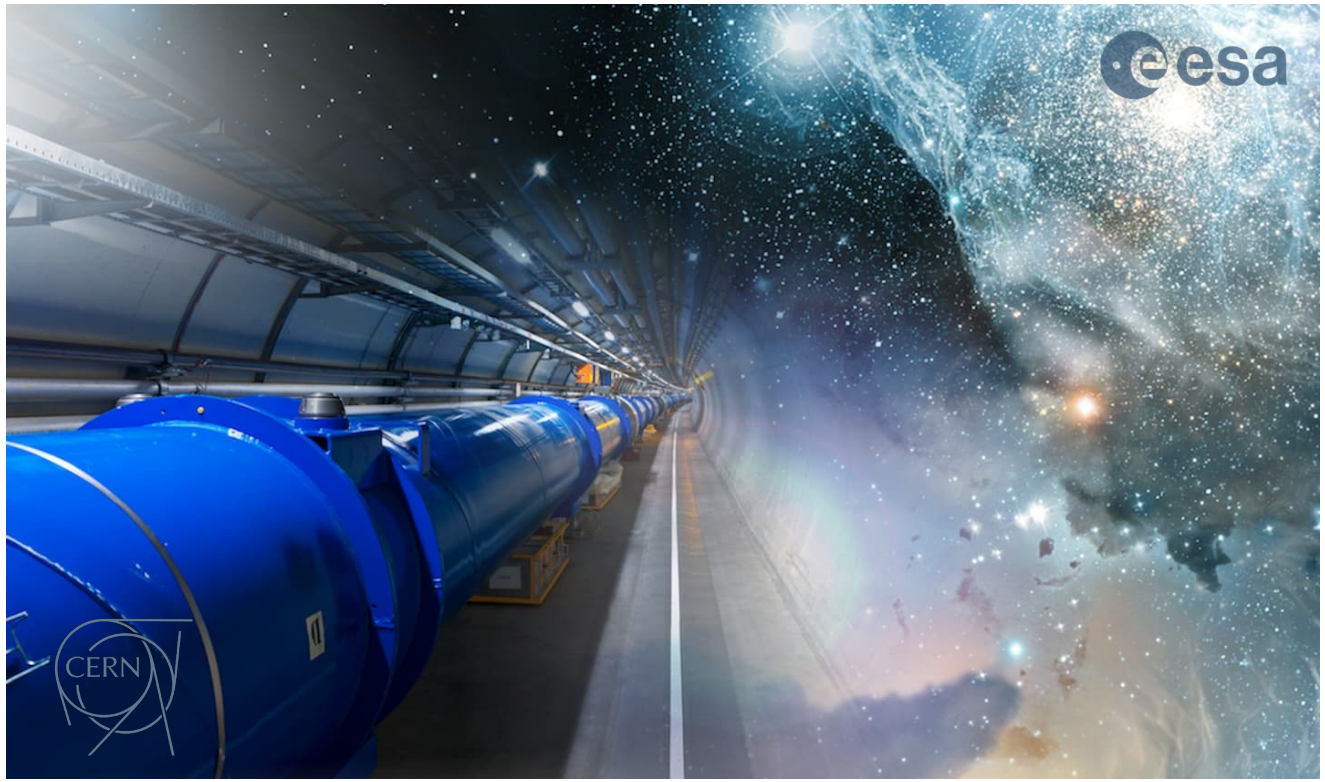
- Single Event Effect (SEE) testing strongly relies on **heavy ion testing**, for which the SEE cross-section is extracted as a function of the deposited energy or Linear Energy Transfer (LET).
- Heavy ion beam time seem today the most wanted, but also, the most limited radiation type.
- The **availability of very high-energy ion beams for radiation testing is very scarce** in Europe and worldwide.
- The **accessibility** is not well tailored for external users.
- Ion beam at CERN, used for physics, could complete the picture, adding one more facility.



Courtesy: A. Waets

The CHIMERA activity

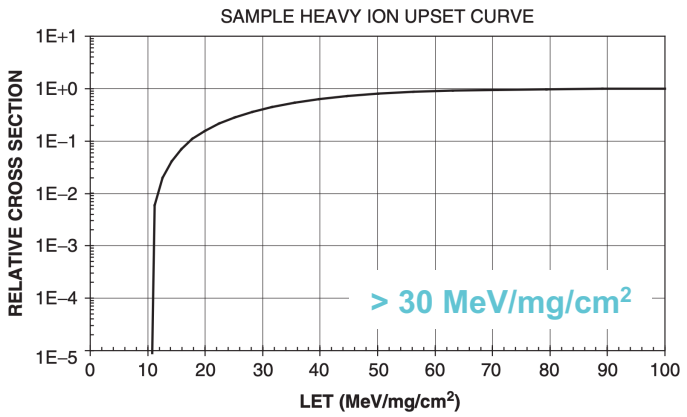
CHIMERA = **C**HARM **H**igh-energy **I**ons for **M**icro **E**lectronics **R**eliability **A**ssurance



- working group at CERN
- collaboration with European Space Agency (2021 – 2022)
- investigating the feasibility of **delivering very high-energy, heavy-ion beams to the CHARM facility for the study of radiation effects to electronic components**
- aiming at providing a proof of concept

Beam requirements

High LET

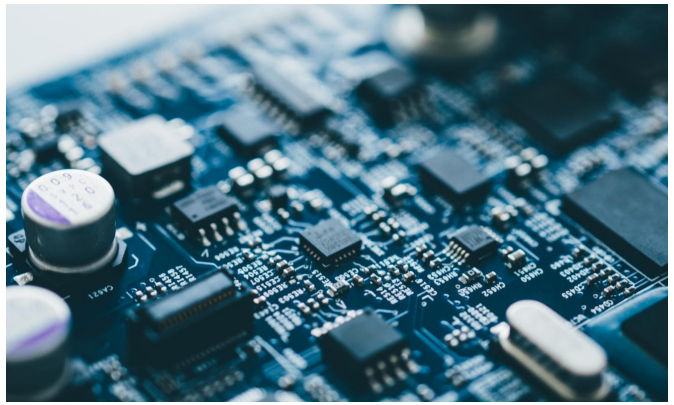


- Radiation environment represented by Linear Energy Transfer (LET) spectrum
- Standard SEE tests
  ⟶ cross section vs. LET

High penetration

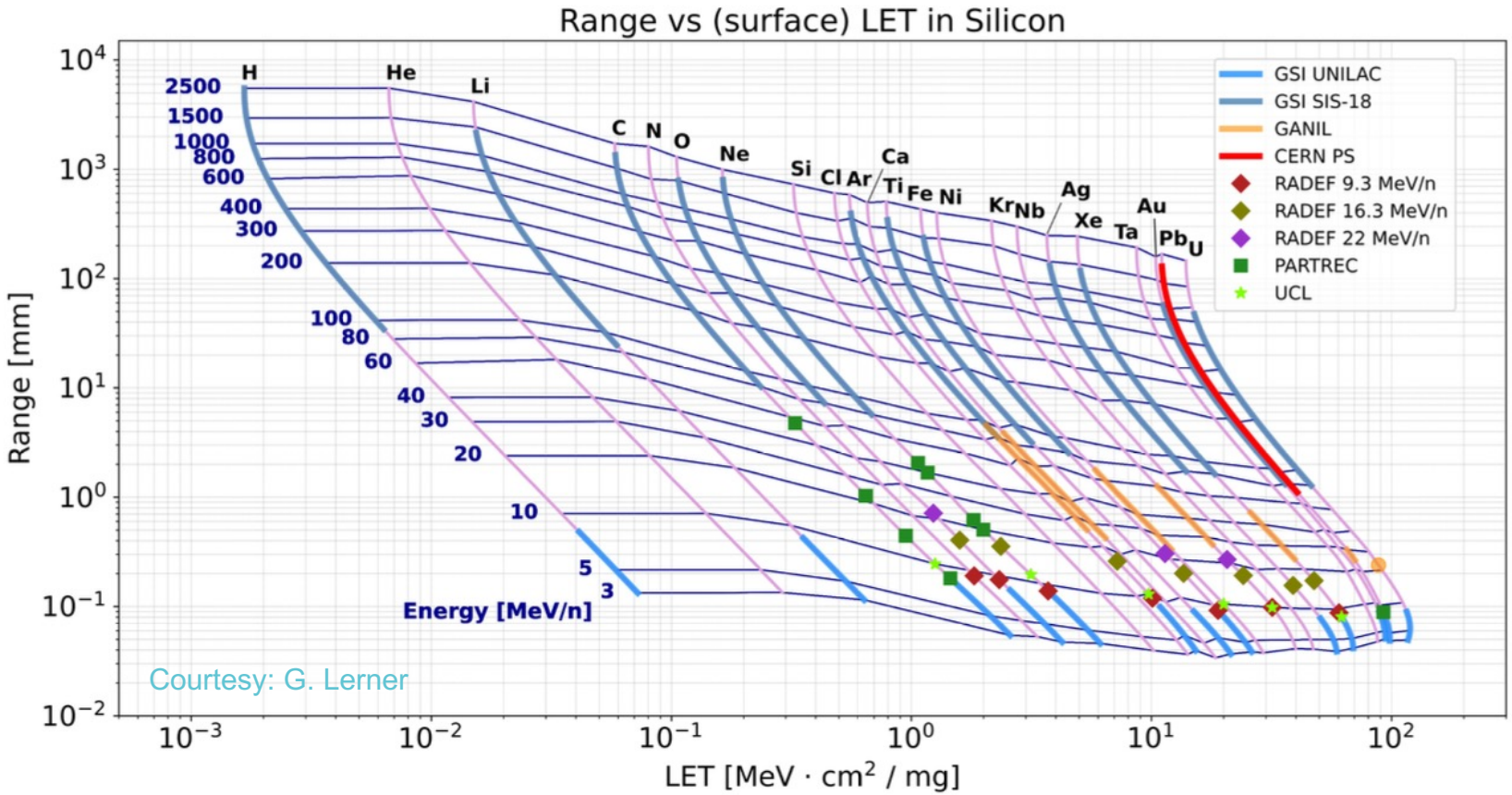
- Low penetration beams:
  ⟶ tests performed in vacuum
  ⟶ need for package delidding
  (difficult, sometimes almost impossible)
- Power elec., 3D devices, systems-on-chip

Large & uniform beam



- Board (system) level testing
- Irradiation of several components or boards at the same time
  ⟶ time / cost efficiency

Beam requirements

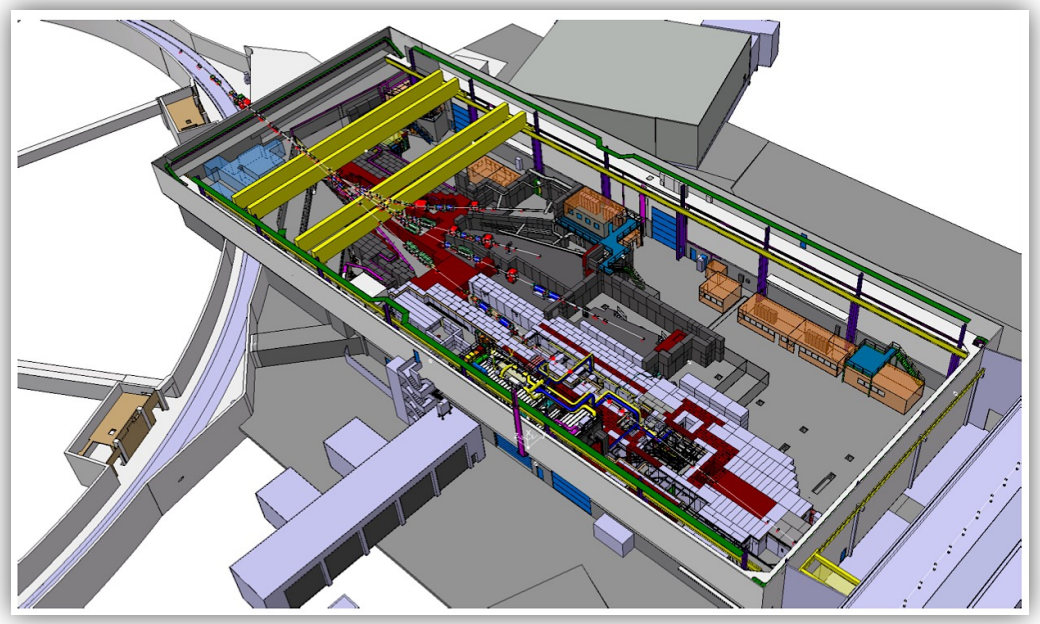


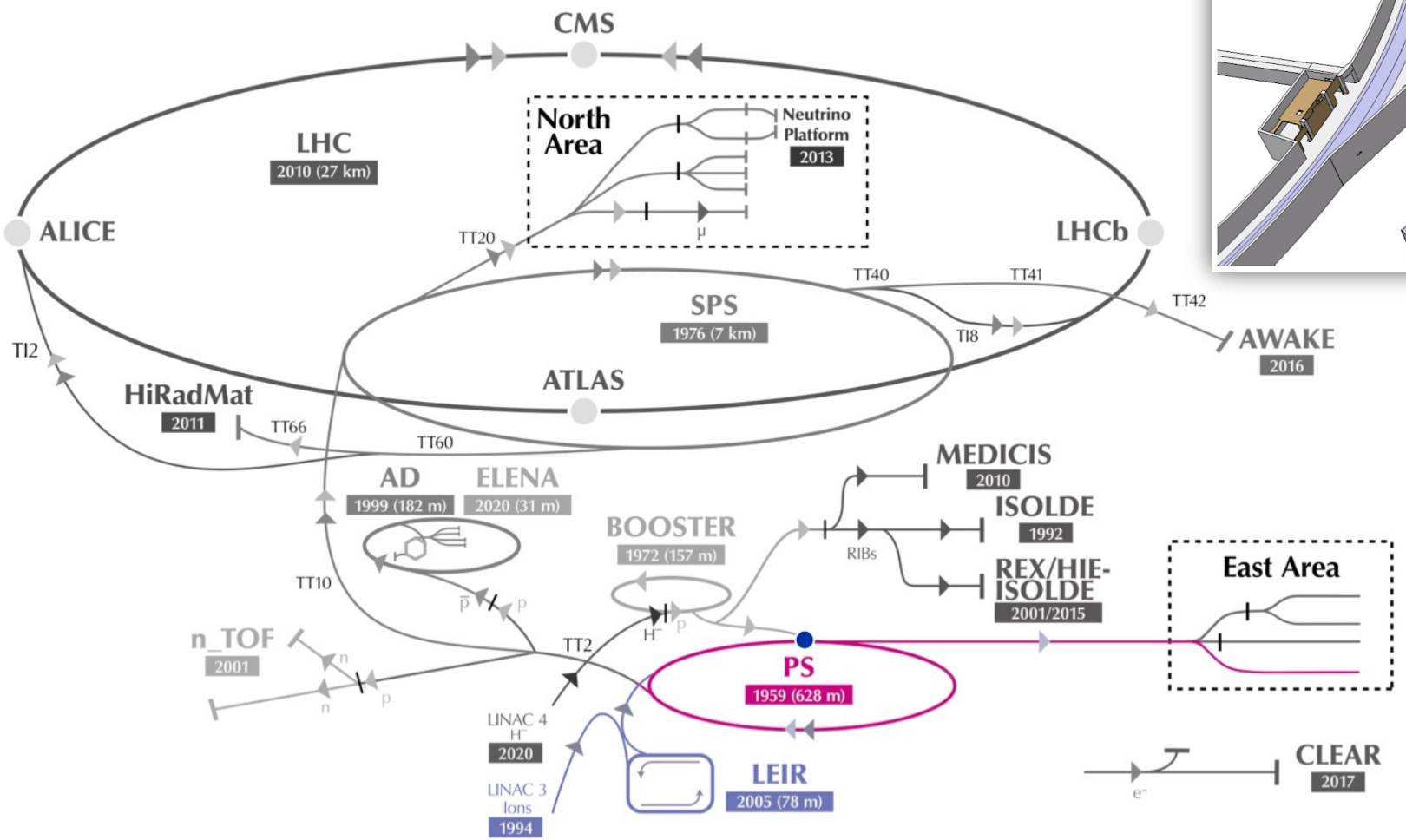
Target beam characteristics:

Parameter	CHIMERA spec.
Ion species	lead (Pb)
Kinetic energy [MeV/u]	70 - 5400
LET [MeV cm^2/mg]	10 - 40
Beam spot area	up to 20 × 20 cm^2
Beam spot homogeneity [%]	uniform, ±10
Average flux [ions/cm^2/s]	10^2 - 10^5
Spill length [ms]	~ 400
Spill uniformity [%]	±20

- CERN Pb beam can offer a nice combination of high LET and high range.

East Area and T8 beam line

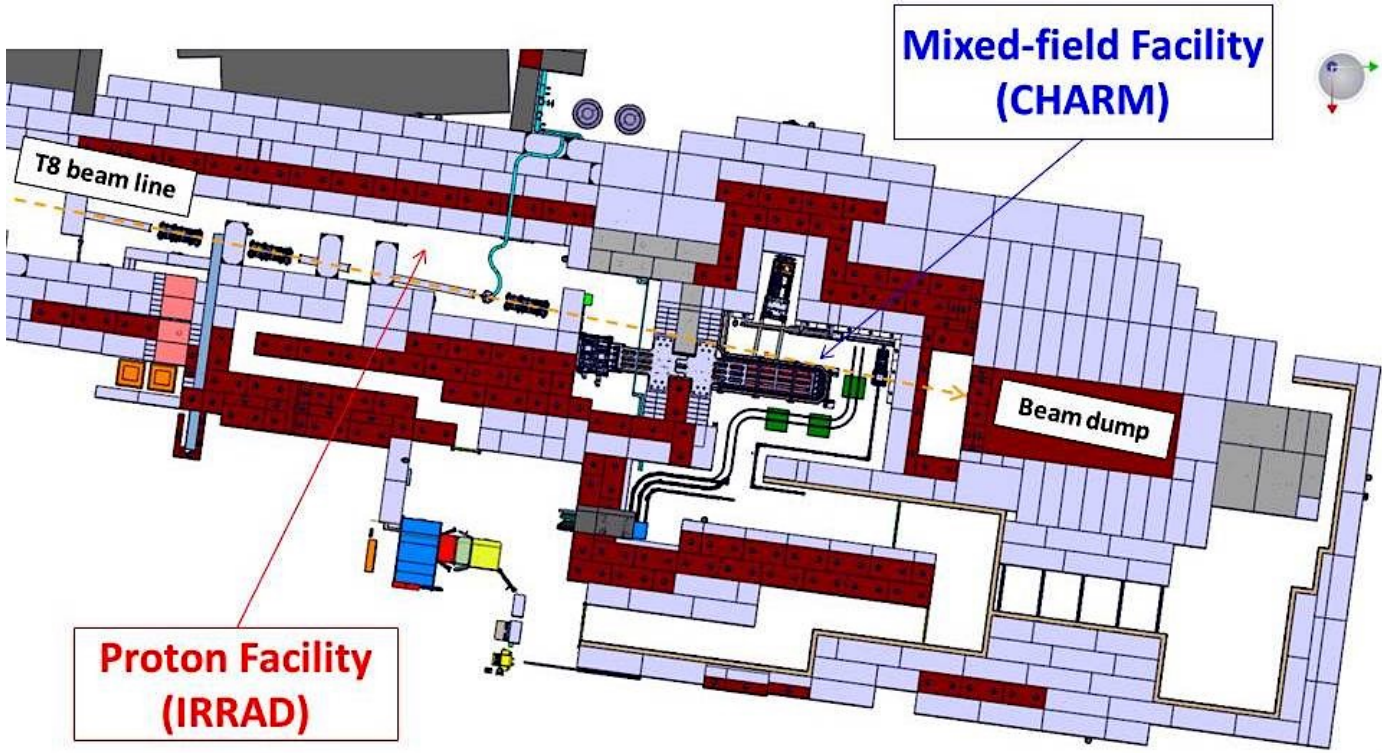




Lead ions:

- evaporated from source
- LINAC 3
- LEIR
- **Proton Synchrotron (PS)**
- Extraction to PS **East Area** (optimal energy range)

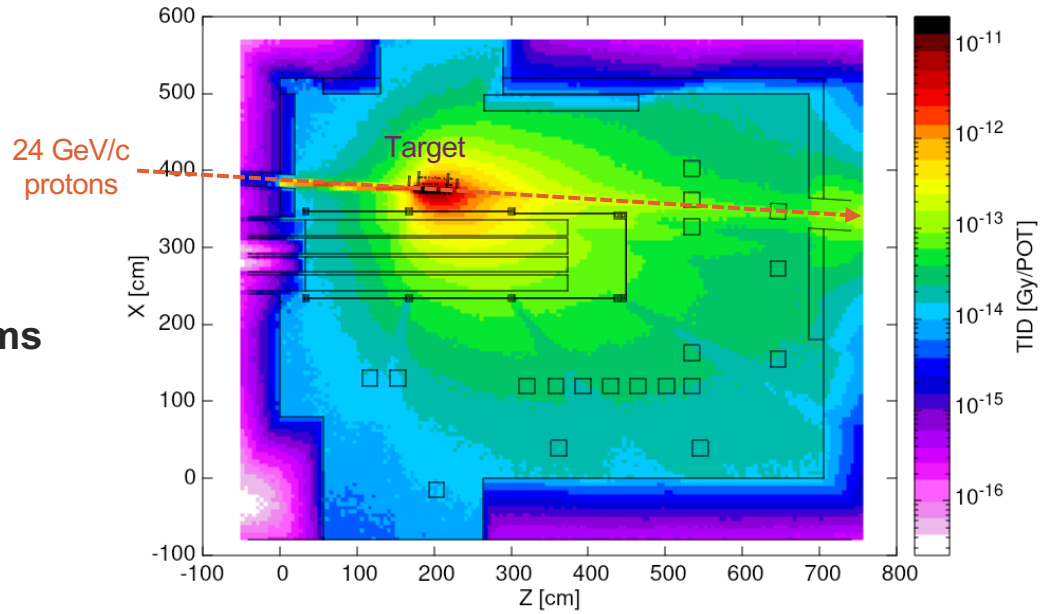
East Area and T8 beam line

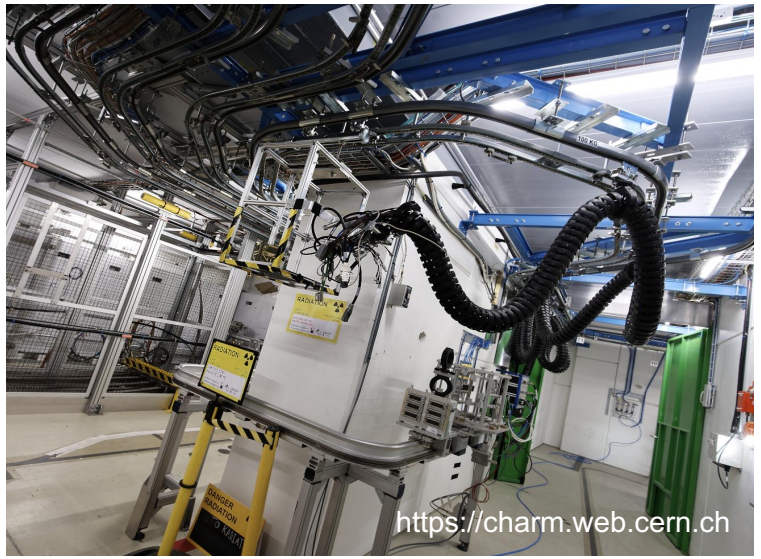


- Beam from the Proton Synchrotron (PS) extracted to East Area
- Beam lines: T8, T9, T10 and T11
- On T8, two existing irradiation facilities:
  - **IRRAD**: sample irradiation with protons
  - **CHARM**: electronics testing in a mixed field.

CHARM Facility

- CHARM = CERN High-energy AcceleRator Mixed field
- Is a radiation test facility at CERN **used to qualify components and systems** mainly for Large Hadron Collider (LHC) accelerator applications.
- The radiation field is generated through the interaction of a 24 GeV/c proton beam from the PS with a metallic target.
- The **mixed-field environment** resembles that present in the vicinity of a high-energy accelerator and can be adapted to the application conditions by selecting different test configurations/locations.
- **Existing infrastructure for electronics testing** interesting for CHIMERA.
- Heavy ion beam extracted from the PS sent to CHARM in-beam position.

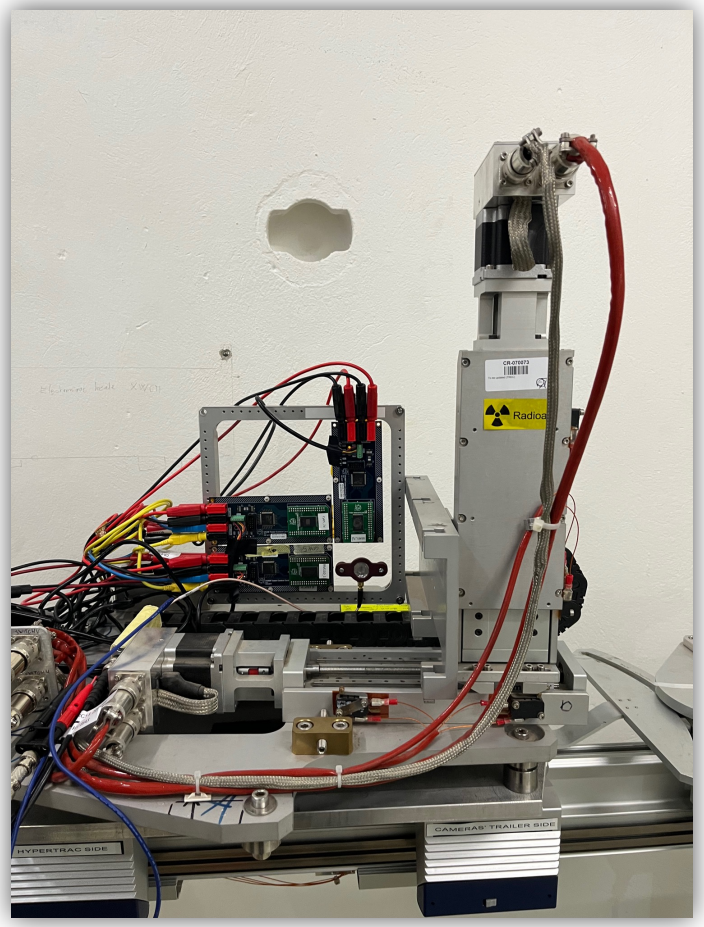




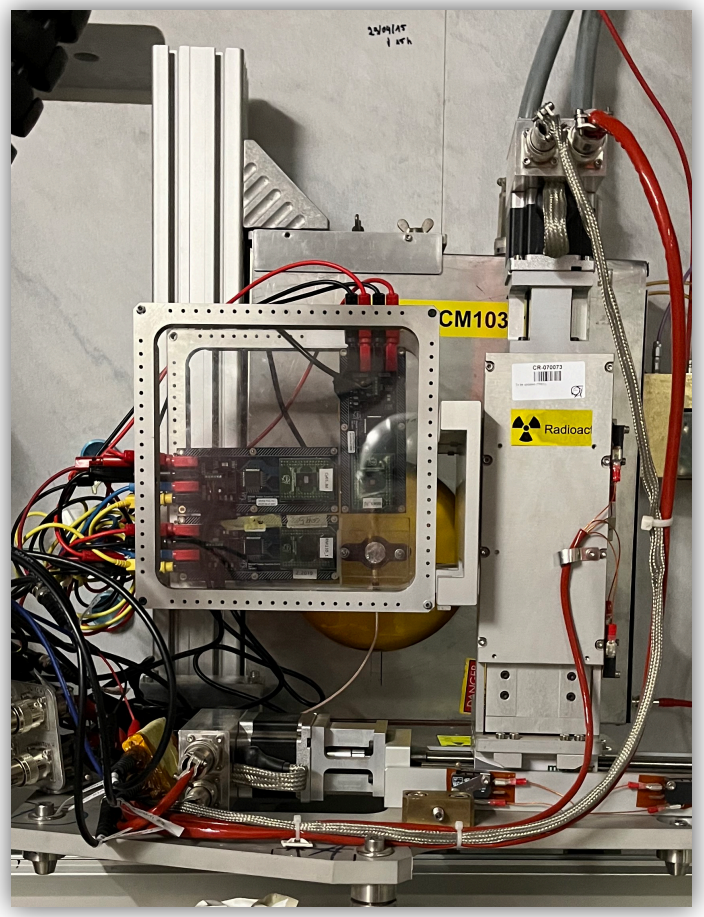
D. Prelipcean *et al.*, "Benchmark Between Measured and Simulated Radiation Level Data at the Mixed-Field CHARM Facility at CERN," https://ieeexplore.ieee.org/document/9762483

Device integration in CHARM

The Montrac conveyer connected to the patch pannel with a cable chain.

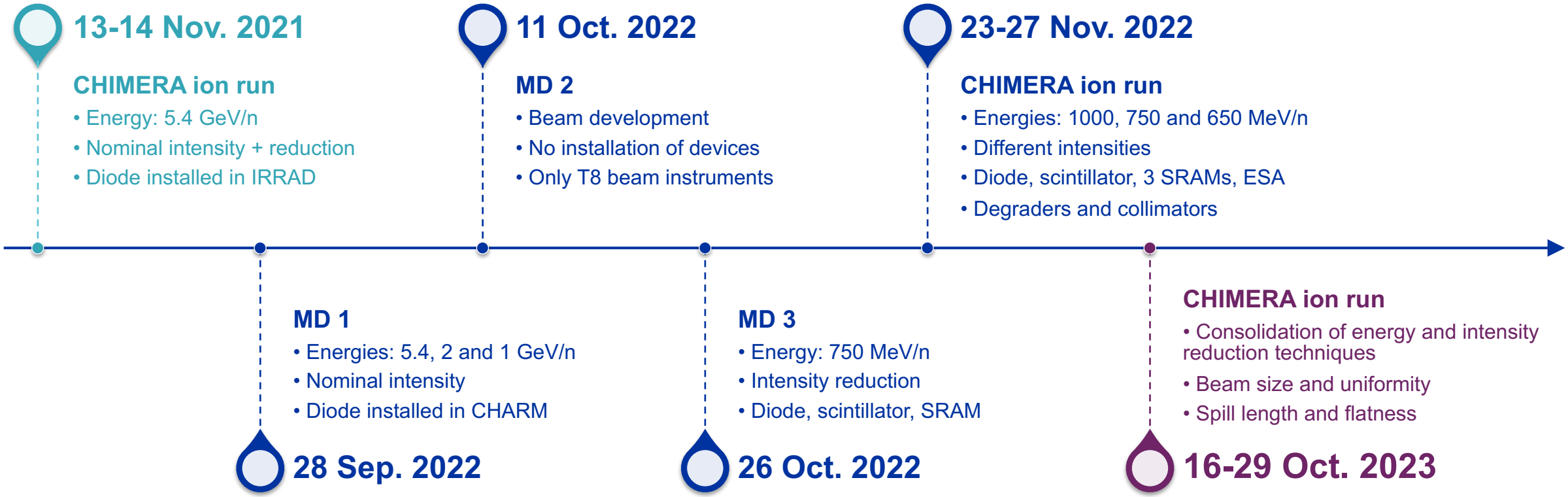


Silicon diode and SRAMs on a movable table on the CHARM Montrac conveyer.



Devices in place in-beam position in CHARM, diode centered to the beam.

CHIMERA Irradiation progress timeline



(* MD = Machine Development run)

Future of CHIMERA

HEARTS

High-Energy Accelerators for Radiation Testing and Shielding

aims at developing and establishing a European infrastructure for research and industrial access to high-energy heavy ion facilities for the fields of radiation effects in electronics, shielding and radiobiology.

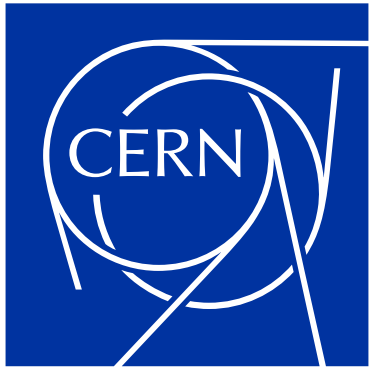
Funded by the European Union

The HEARTS project is funded by the European Union under Grant Agreement No. 101082402, through the Space Work Programme of the European Commission.

HEARTS Kick-off meeting:

- January 20th, 2023
- https://indico.cern.ch/event/1216205/

https://hearts.web.cern.ch



Thank you.

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