Strategia europea della fisica delle particelle, Catania, 30 Ottobre 2024

Contributo del Gruppo 5

Francesco Romano

INFN CATANIA
Istituto Nazionale di Fisica Nucleare
Sezione di Catania

Linee di ricerca Gruppo 5 e sigle Sezione di Catania

FTE nazionali	FTE
Interdisciplinary and Computing	**293 (48.8%)**
Detectors , Electronics	**196 (32.6%)**
Accelerators and related technology	**112 (18.6%)**

Nome sigla	Periodo attività	Responsabile Locale
AIM_MIA *	**2025-2027**	Maurizio Marrale
HIDRA2 (call) **	2022-2024	Sebastiano Albergo
FRIDA (call) **	2022-2024	Francesco Romano
FUSION	2023-2025	Antonio Trifirò
IONO_TRACK	2023-2025	Maurizio Marrale
Geant4INFN	2024-2026	Francesco Romano
MIRO	2024-2026	Francesco Romano

...possibili contributi teconologici dal know-how e R&D sviluppati nei progetti di CSN5?

Artificial Intelligence in Medicine: focus on Multi-Input Analysis (AIM_MIA)

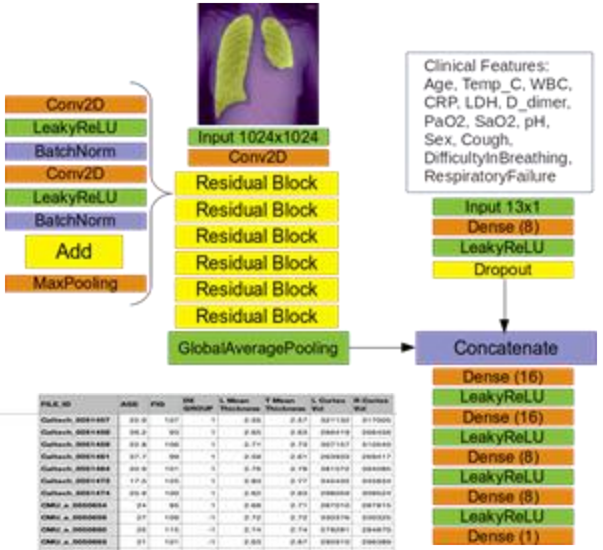
General goal: *to take a step forward in the development and validation of AI-based tools for medical data analysis*

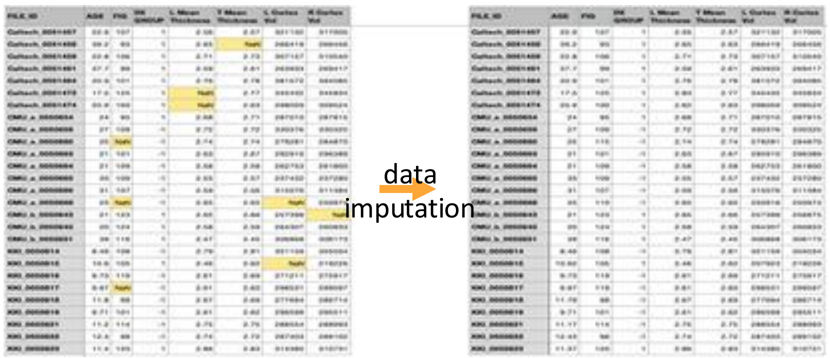
Outline

- Research context
- State of art @ INFN
- The AIM_MIA project
  - **Objectives**
  - Methods
  - Implementation
  - Connections
  - Expected impact
- Impact on INFN

Objectives

1. Mining multi-modal information (various image techniques and/or clinical data)
2. Handling incomplete/missing/limited datasets
3. Development of a dedicated data and computing platform



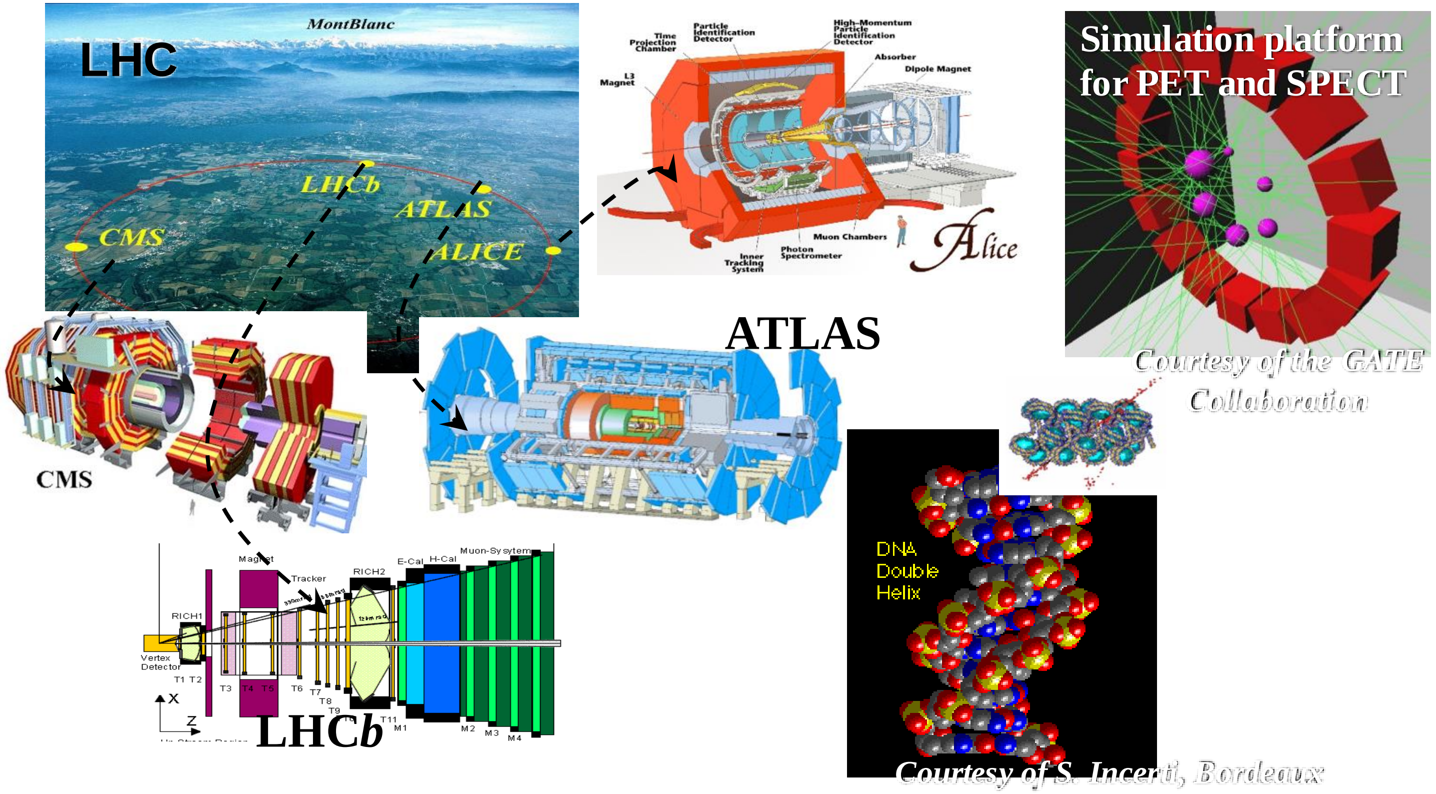


Extensible Neuroimaging Archive Toolkit https://www.xnat.org/

Responsabile Nazionale: Luciano Pandola (INFN-LNS)
Responsabile Locale: Francesco Romano (INFN-CT)

GEANT4 ⇨ Geometry and Tracking

1974: First version of the code released at CERN for high energy particles
1983: Geant3 written in Fortran language
1998: Geant4 written in C++ object oriented language was released for the simulation of large scale HEP experiments at CERN (Geneva)



HiDRa2

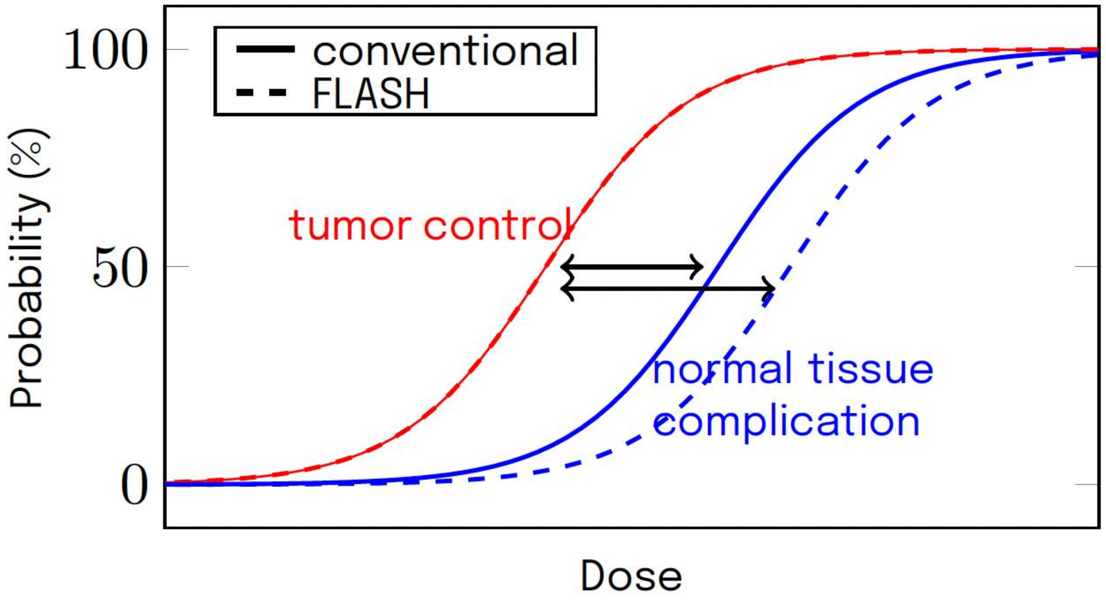
(vedi slide S. Albergo)

FRIDA e MIRO

FLASH and Minibeam Radiotherapy

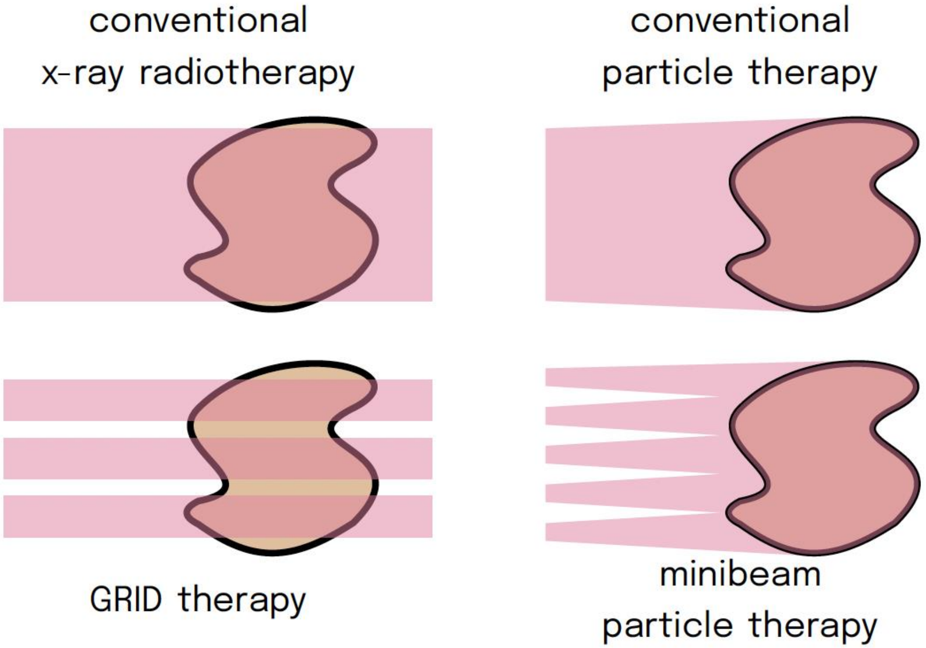
FLASH Radiotherapy

Conventional	FLASH
dose rate: 5 Gy/min	dose rate: > 40 Gy/s
Irradiation time: few min	Irradiation time: < 200 ms



Minibeam Radiotherapy

Spatially fractionated dose, utilizes parallel beams with each width around 500-1000 μm and beam space around 1 to 3 mm.



Biological mechanism producing the FLASH effect and minibeam effect are not yet fully understood. Dosimetric challenges are still present.

The INFN "FRIDA" project

INFN CSN5 funded 3 (+1) years call project:

- 8 INFN Divisions
- > 25 FTE (> 100 Researchers)
- 990 k€
- PI: A. Sarti (INFN-RM1)

WP1 The FLASH mechanism

WP2 Beam delivery

WP3 Beam/dose monitoring

WP4 Treatment planning

Units

CT – F. Romano
LNS – G. Cirrone
MI – D. Giove
PI – G. Bisogni
RM1 – A. Sarti (PI)
TIFPA – E. Scifoni
TO – A. Vignati

Goal of "FRIDA" (FLASH Radiotherapy with hIgh Dose-rate particle beAms) **is to make a step forward in all the crucial areas... Four WPs** [mechanism modelling & rad-bio experiments; beam delivery; beam monitoring; treatment planning] **working in parallel, >25 FTEs, 7 INFN units with know-how in the fields and a solid international network of research centres and companies (SIT, STLab) are the resources to accomplish the research program.**

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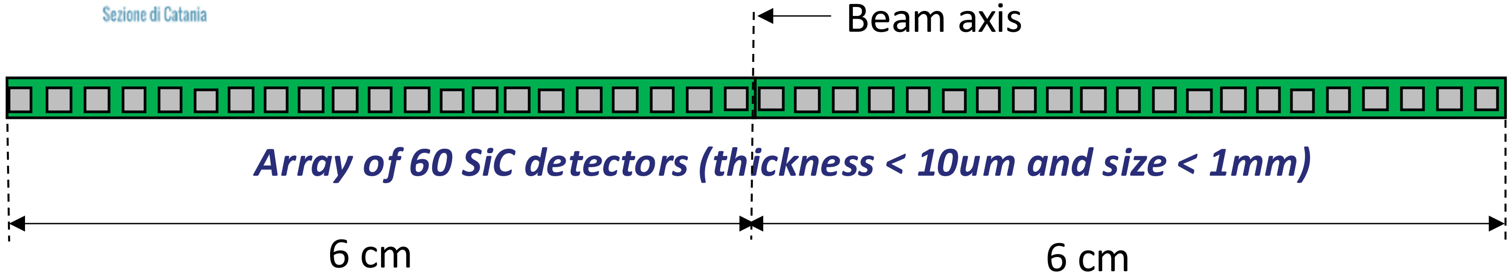
Silicon carbide array **D**etecto**R** for dose profil**E** me**A**sure**M**ents at FLASH regimes **(DREAM)**



R4I Research for Innovation

INFN CNTT funded 1 (+1/2) year project:

- 1 INFN Division (INFN-CT)
- > 2 FTE (5 Researchers)
- 40 k€
- PI: F. Romano (INFN-CT)

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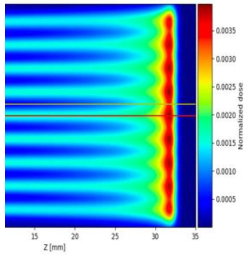
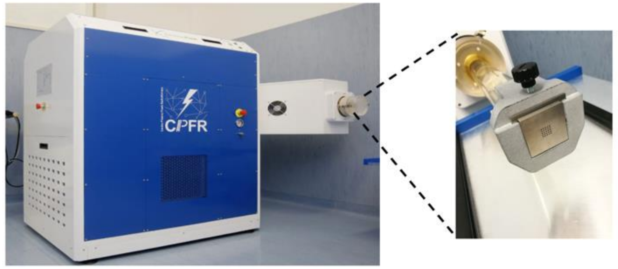
MIRO
Minibeam Radiotherapy



FLASH + minibeams at CPFR in Pisa



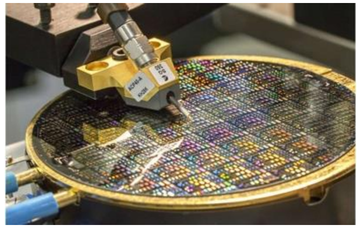
INFN CSN5 funded 3 years project:

- 6 INFN Divisions
- > 18 FTE (> 50 Researchers)
- 280 k€
- PI: F. Di Martino (INFN-PI) and F. Romano (INFN-CT)

Silicon carbide detectors

STLAB ↔ INFN CATANIA, Istituto Nazionale di Fisica Nucleare, Sezione di Catania

Silicon



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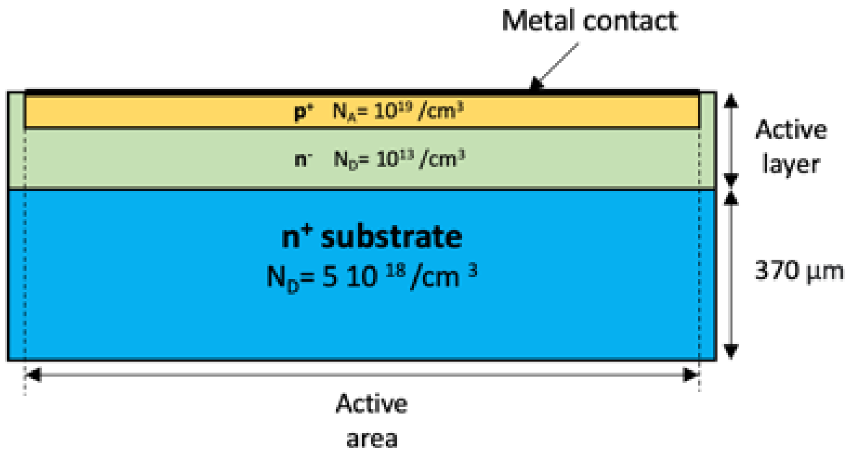
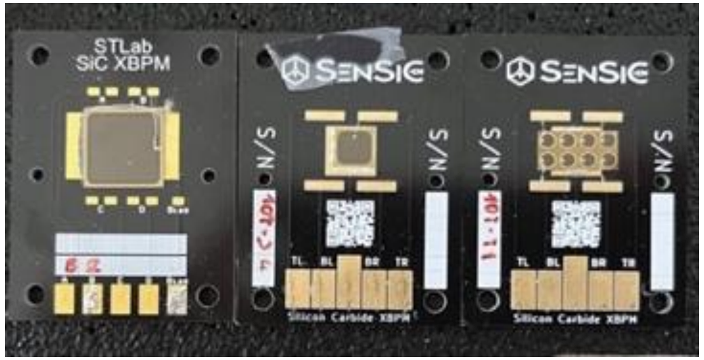
Diamond

→ **SiC**

- Radiation **hardness**
- High signal to noise ratio
- High **time resolution (ns)** and fast collection time
- **Large area devices**



10x10 mm^2 5x5 mm^2 2x2 mm^2



Silicon carbide (SiC) detectors have been realized at the STLab company. The devices are semiconductor PIN junctions: a thin p+, highly doped layer and a n-low doped layer on top of a n+ thick substrate. In case of the free-standing membranes the substrate n+ is removed by electrochemical etching

Characterization with Electron FLASH Linac accelerator @ CPFR

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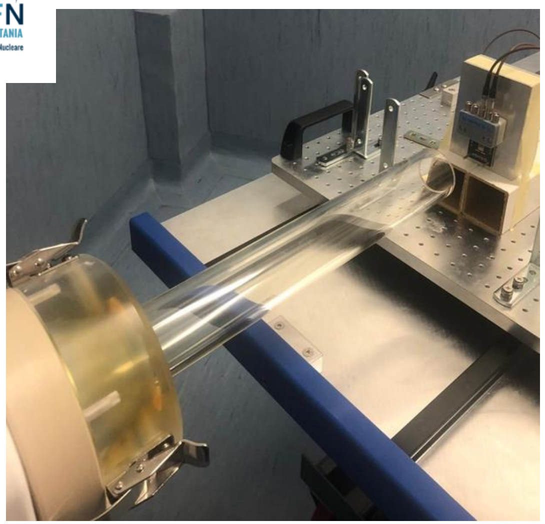
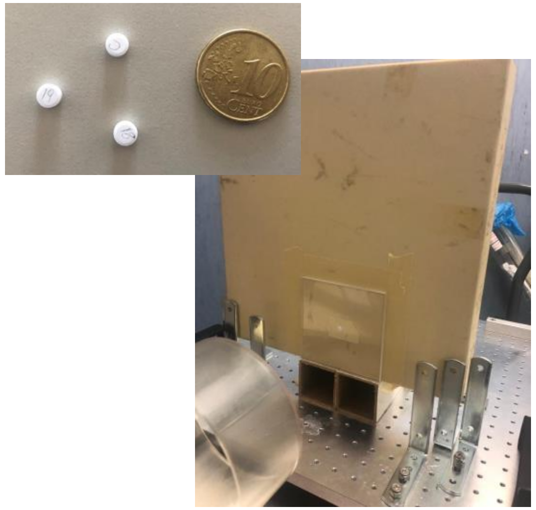
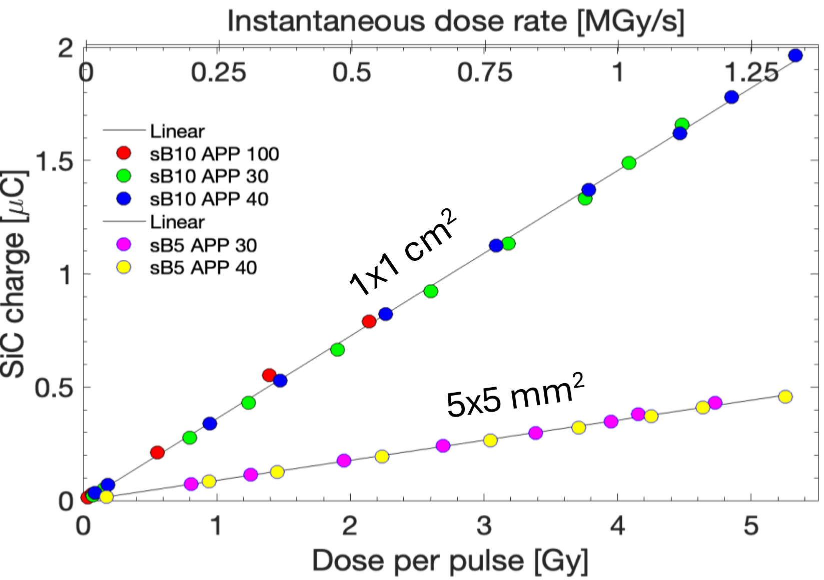


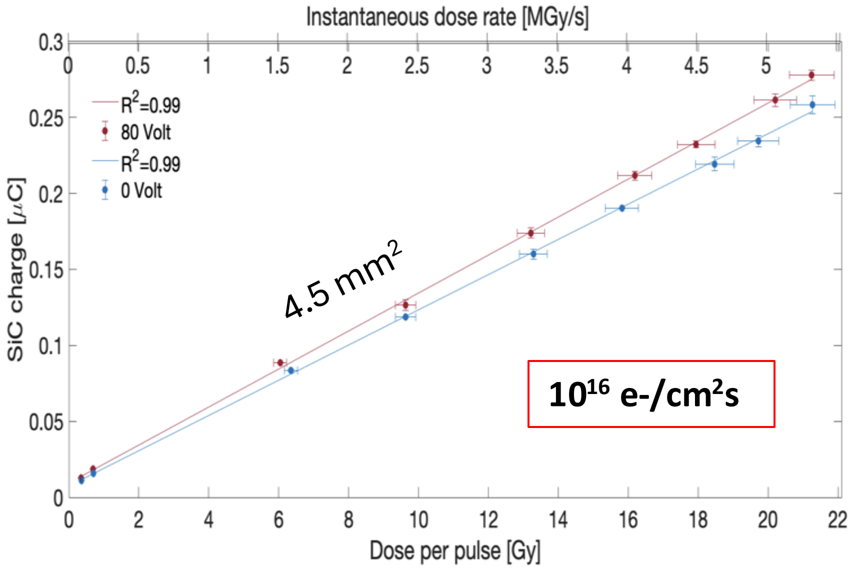
Experimental setup

- Detectors: 10x10, 5x5, 4.5 mm^2 10 um thick SiC at the build-up
- Acquisition: Keithley electrometer
- Reference dosimeters: **Alanine dosimeters**
- Single pulse duration: 0-5-4 us
- Dose per pulse: from 0.1-20 Gy
- Average instantaneous dose rates in the single pulse up to 5 MGy/s

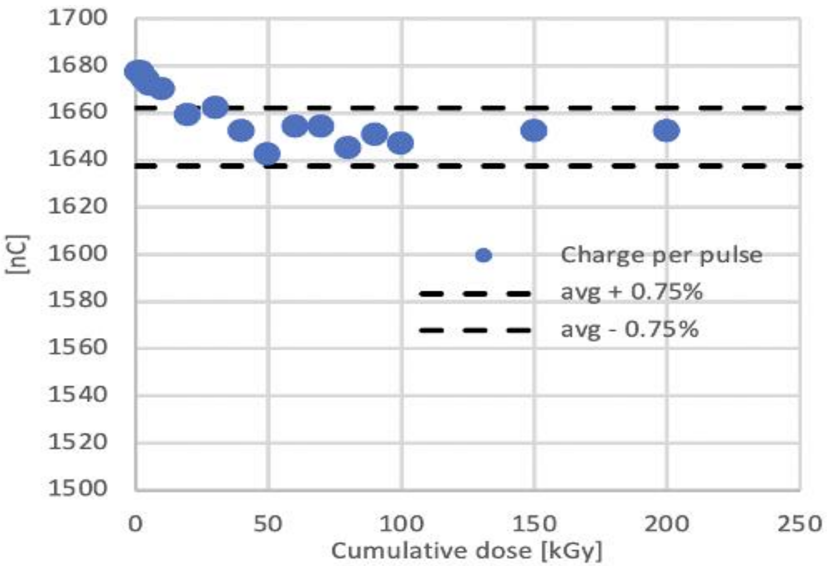


Linear response with the Dose per pulse





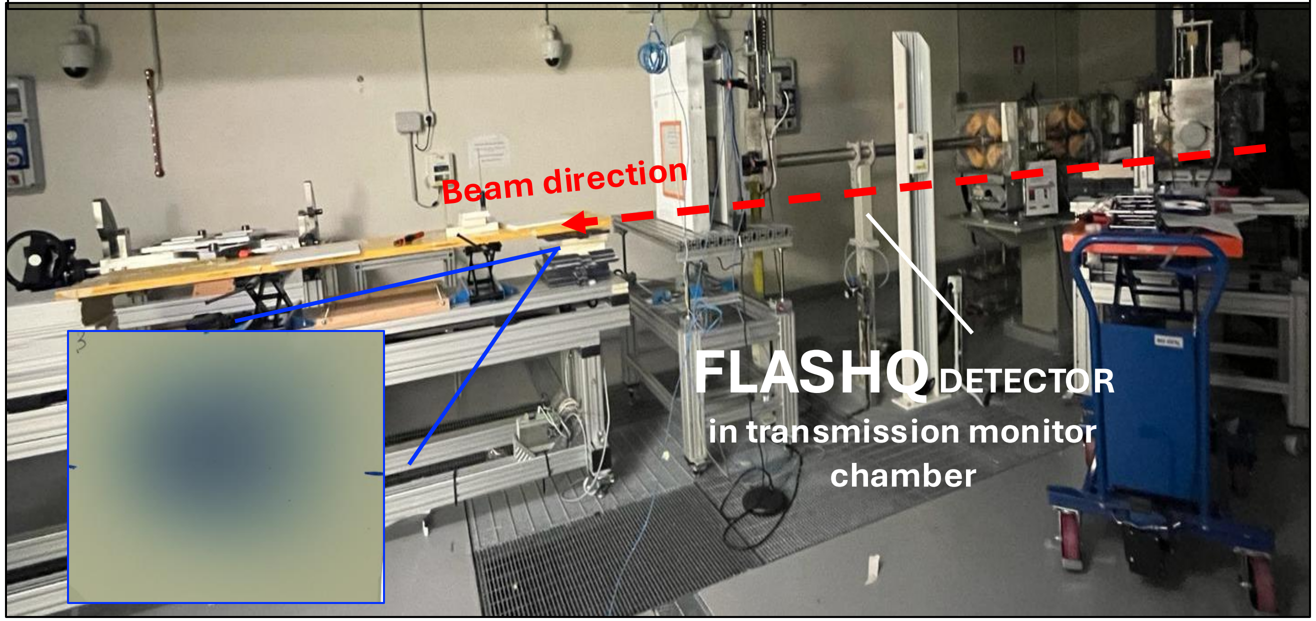
First measurement of radiation hardness

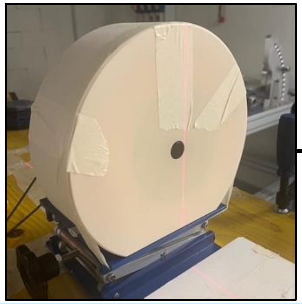


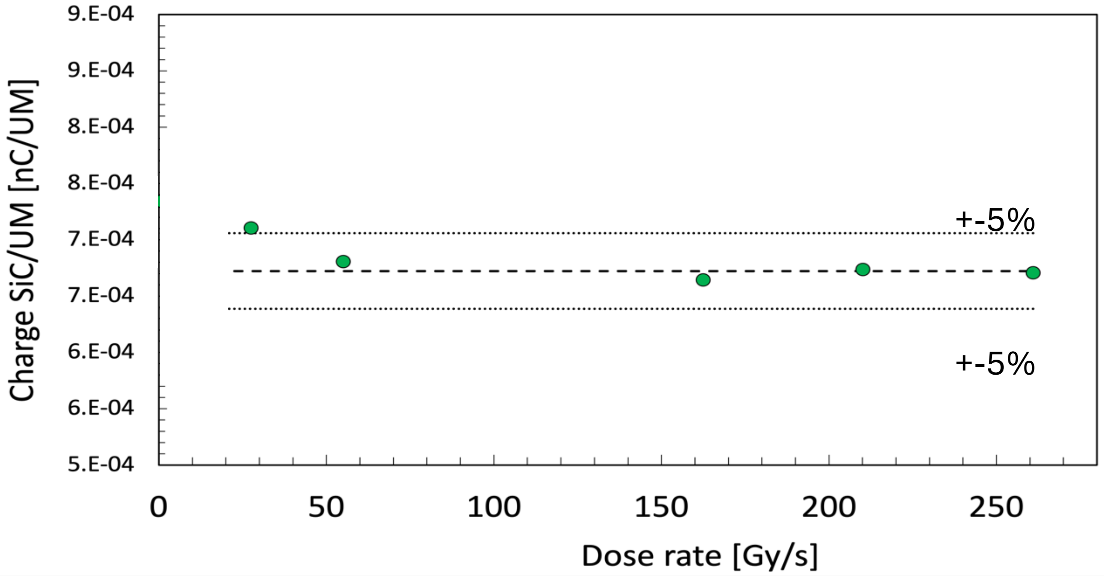
Dosimetric characterization@ Trento Proton beam line facility with UHDR proton beams

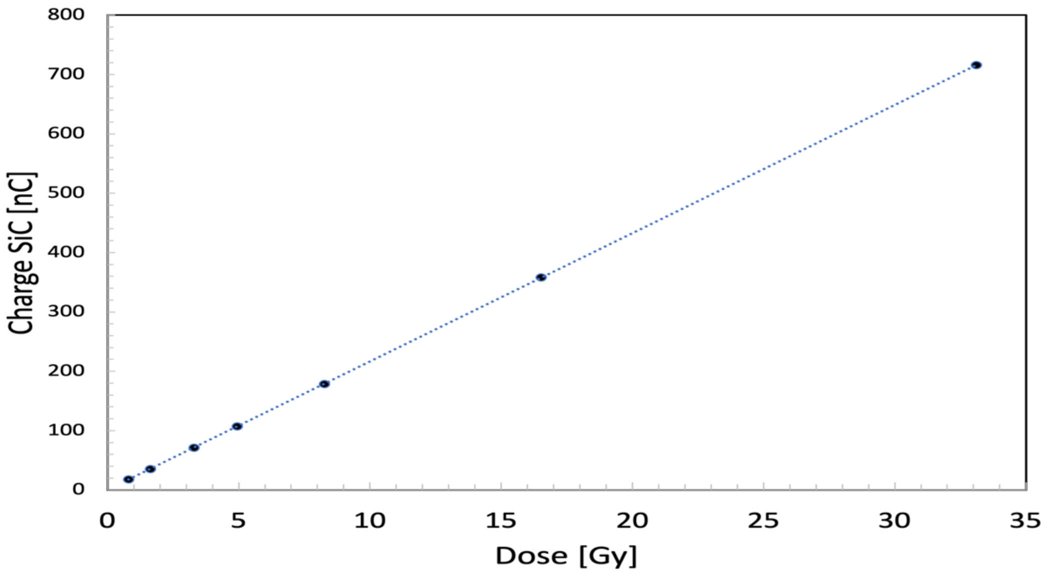
p+

Proton beams @ 228 MeV
Variable beam current from 1 nA up to 500 nA
Variable irradiation time from 10 ms up to seconds



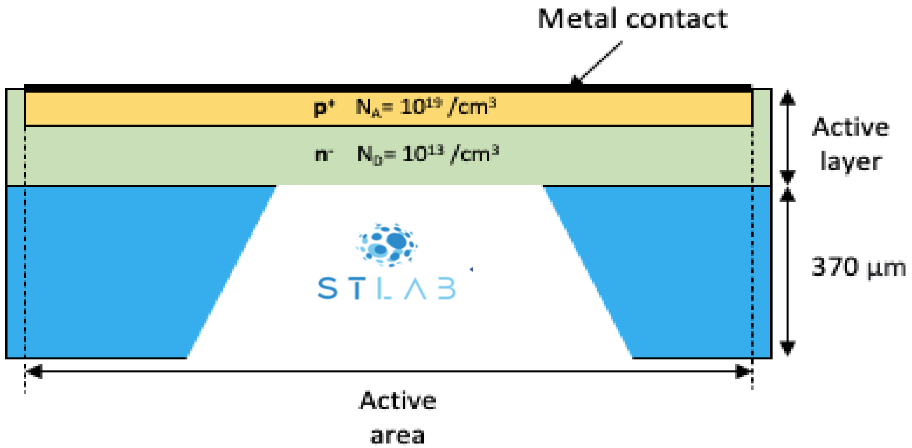




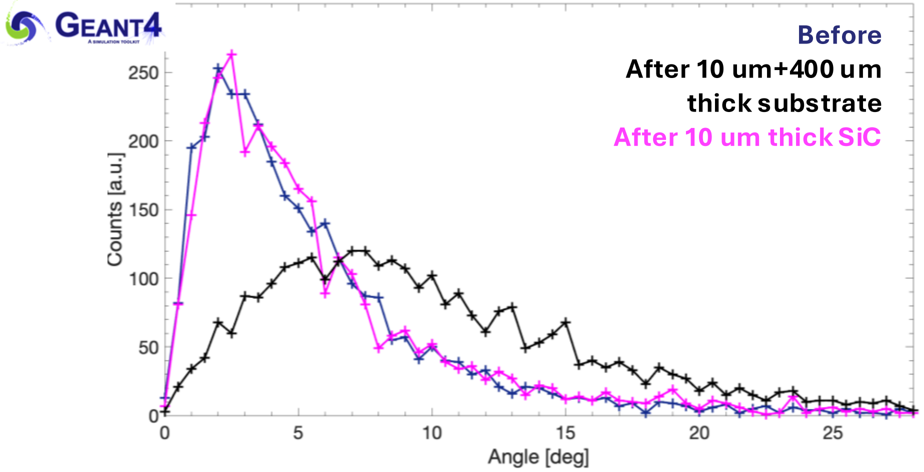


Ultra-thin SiC free-standing membranes for beam monitoring

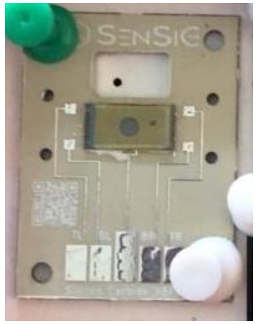
Thick substrate bulk electrochemically removed from the back of the detector

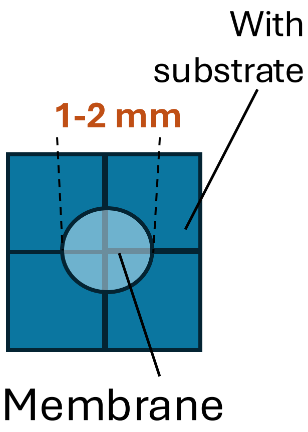


Energy & Angular distribution spread: improving the transparency



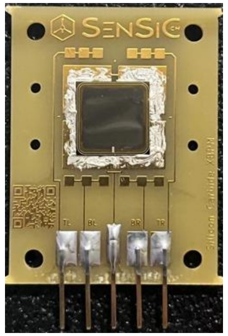
First version

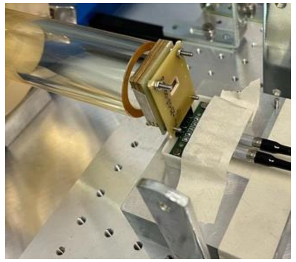


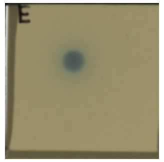


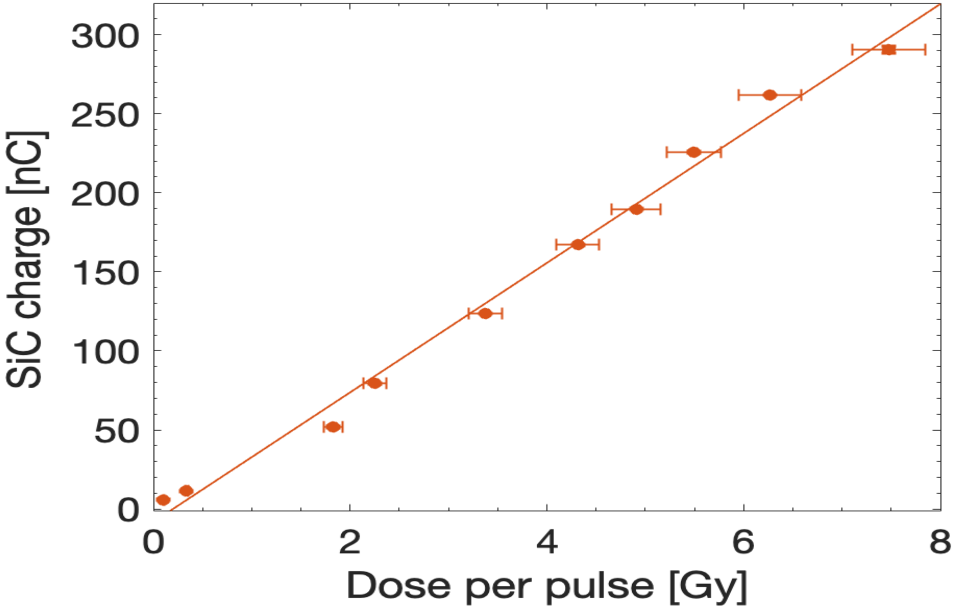
Second version

Larger area membrane









Real time monitoring of the instantaneous dose rate

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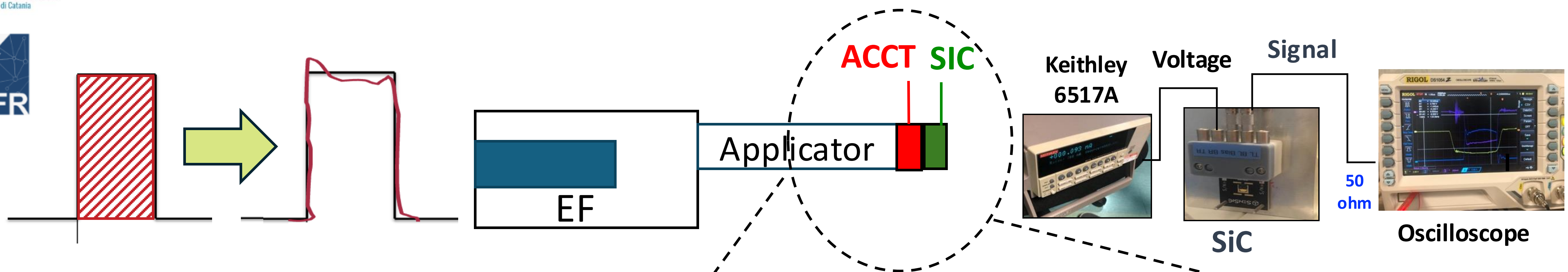
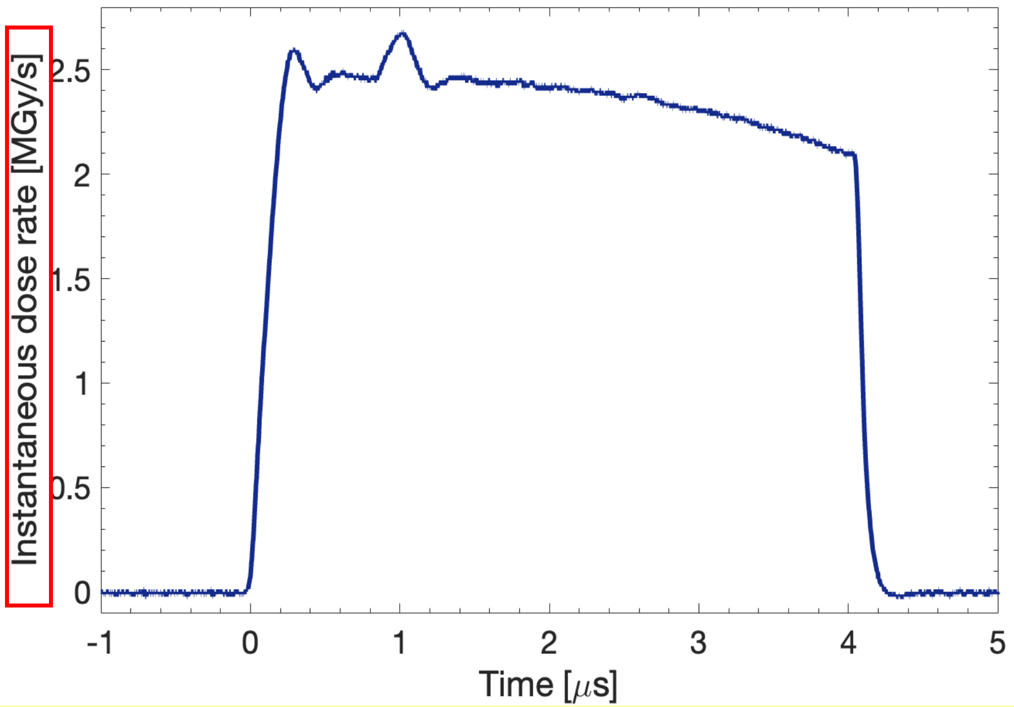
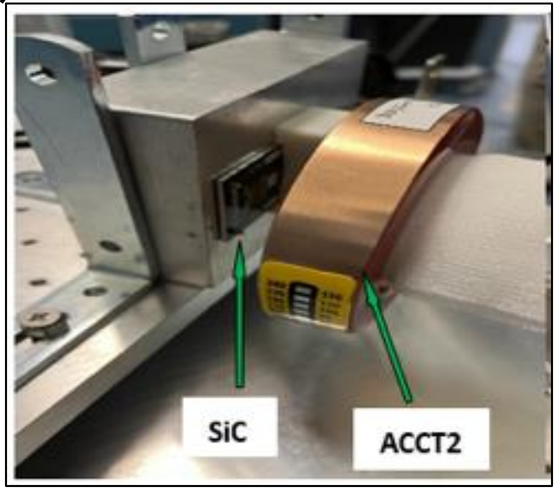
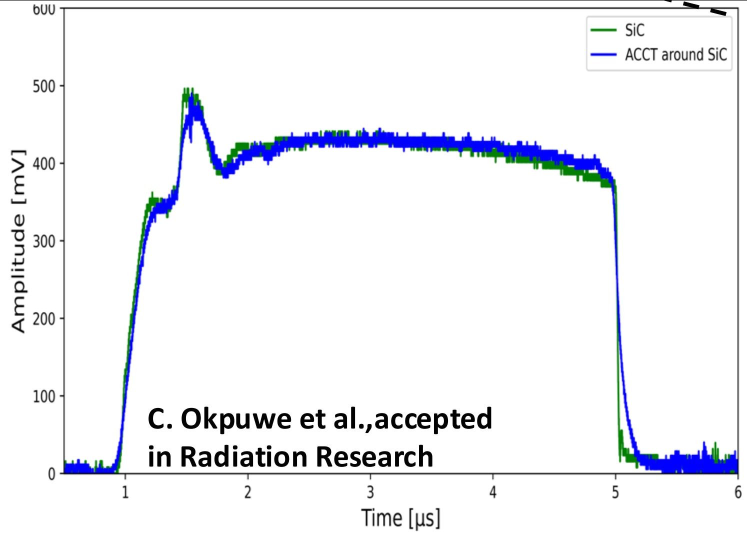


Waveforms → instantaneous dose rate



COMPARISON OF SIC-ACCT WAVEFORMS AT THE SAME POSITION





Contributi e conclusioni

- Sviluppo nuove tecnologie per alte intensità e risoluzioni spaziali spinte
- Test preliminari nuove tecnologie
- Calcolo: machine learning, AI, …
- Sviluppo acceleratori