WP3- FLASH beam monitoring & dosimetry

Characterization of silicon carbide and alanine detectors with UHDR electron beams

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Deliverables

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Deliver.	Short name	Description	When (M)
D3.1.1	air fluorescence	Design, realization and test of air monitoring based detector for electrons	16
D3.1.2	ICB	Design, realization and test of an ICT specifically tailored for intense and short proton/ion beams	16
D.3.1.3	Silicon and Diamond	Tests of silicon/diamond prototypes with proton and electron beams	16
D.3.1.4	SiC	"Free standing Membrane" SiC detectors tests with electrons/protons for beam monitoring	16
M3.1	BM R&D end	Production and test of the first BM prototypes	16
D.3.2.1	Calorimeter	Portable calorimeter prototype development and characterization with electrons/protons	16
D.3.2.2	Scintillators	Development and test of scintillator-based dosimeters with RO electronics	16
D.3.2.3	SiC Dosimeters	SiC detectors optimization and test for relative dosimetry with proton/electron beams	16
M3.2	Dosimeters R&D end	Production and test of the first dosimeter prototypes	16
D3.3.1	Beam characterization	Dosimetric characterization of the beams with available BM systems (dual gap chamber, SEM, FC) and reference dosimeters (Faraday cup, alanine, RCF, IC)	24
D.3.3.2	Intercomparisons	Intercomparisons and calibrations of the developed BMs and dosimeters	32
D3.3.3	Guidelines	Guidelines and recommendations for the monitoring and dosimetry of FLASH beams (what we learnt so far…)	36
M3.3	Prototypes commissioning	BM and Dosimetric systems prototypes commissioning	36

WP3. Dosimetry

Activity of INFN Catania

D.3.3.1

*Dosimetric characterization of the beams with reference dosimeters: **alanine** dosimeters (M24)*

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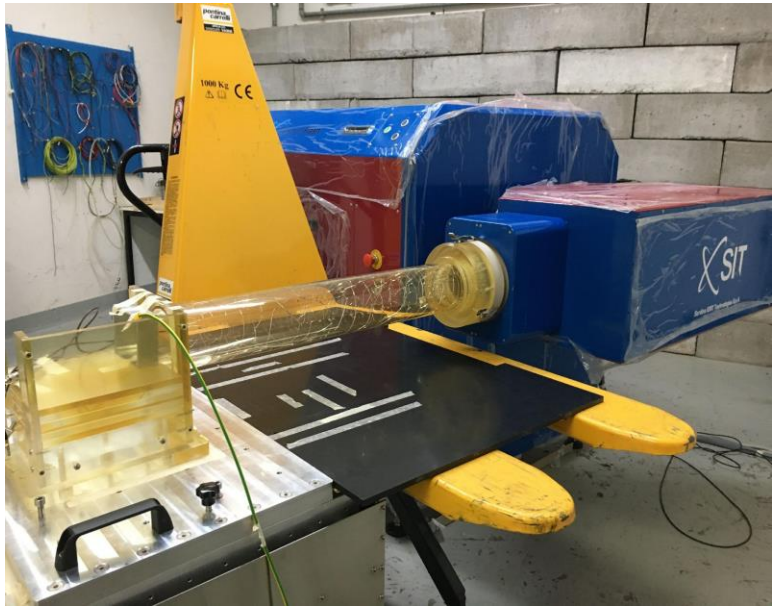
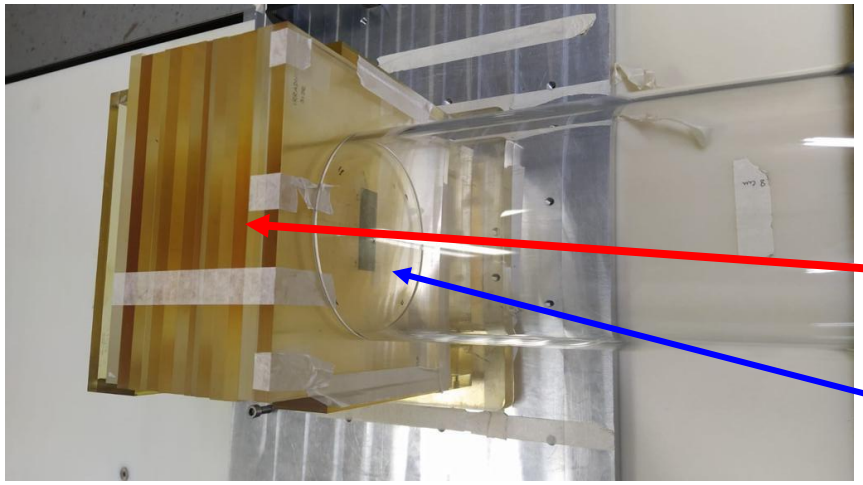
Sezione di Catania

First experiment performed at SIT-Sordina (Aprilia, Italy)

This work aims at investigating the response of alanine pellets exposed to UHDR electron beams and, in particular, a possible dependence of alanine response on the dose rate for these UHDR beams (dose-rate up to 10^3 kGy/s).

- **Electron FLASH at 7 and 9 MeV**
- **Pulse duration: 2-4 us**
- **Dose per pulse: from 0.01-12 Gy**
- **Dose rate during pulse: up to ≅2.6 10^3 kGy/s**





Alanine pellets stacked inside PMMA phantom

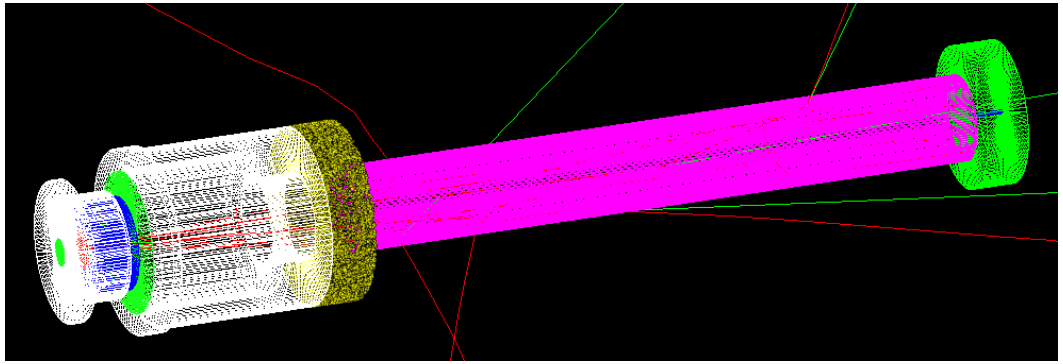
Gafchromic film to measure entrance dose

Monte Carlo Simulations

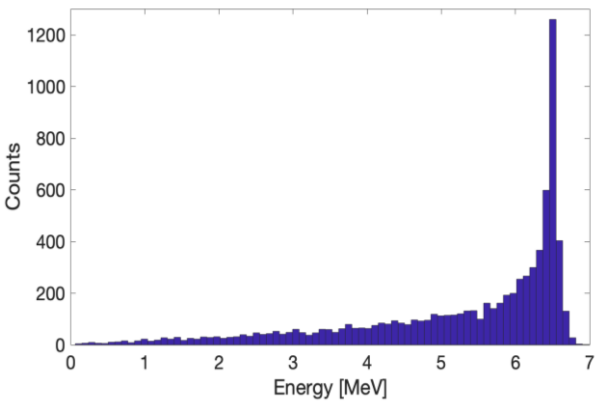
By J. Pensavalle UNIPi

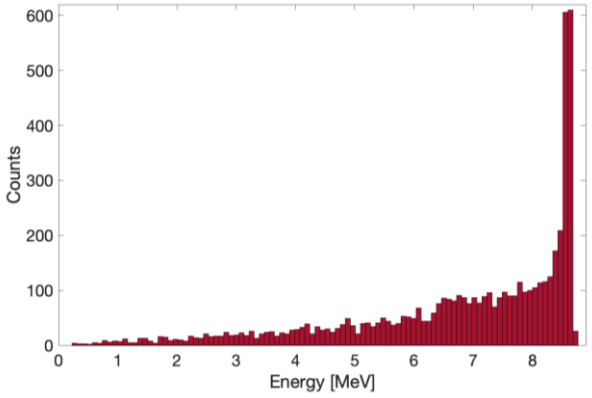
Percentage Depth Dose (PDD) distributions inside the water phantom were calculated through Geant4 - Monte Carlo (MC) simulations.

The entire experimental accelerator and setup were simulated by using constructive details provided by the producer (SIT Sordina).
The beam path was simulated, starting from the accelerator exit window, passing through the applicator-collimator system, and ending into the PMMA phantom (sky-blue box) wherein alanine pellets are placed.



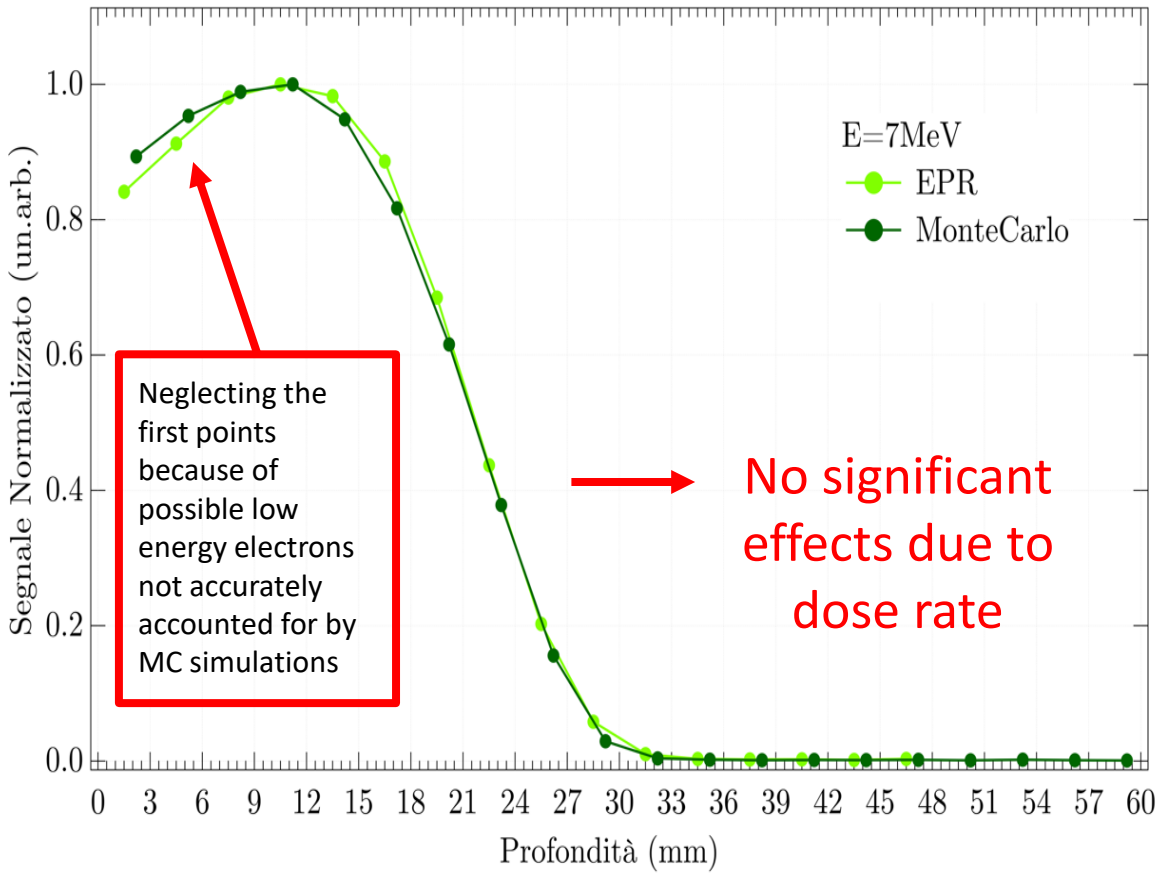
Energy spectra at the phantom entrance (7,9 MeV)



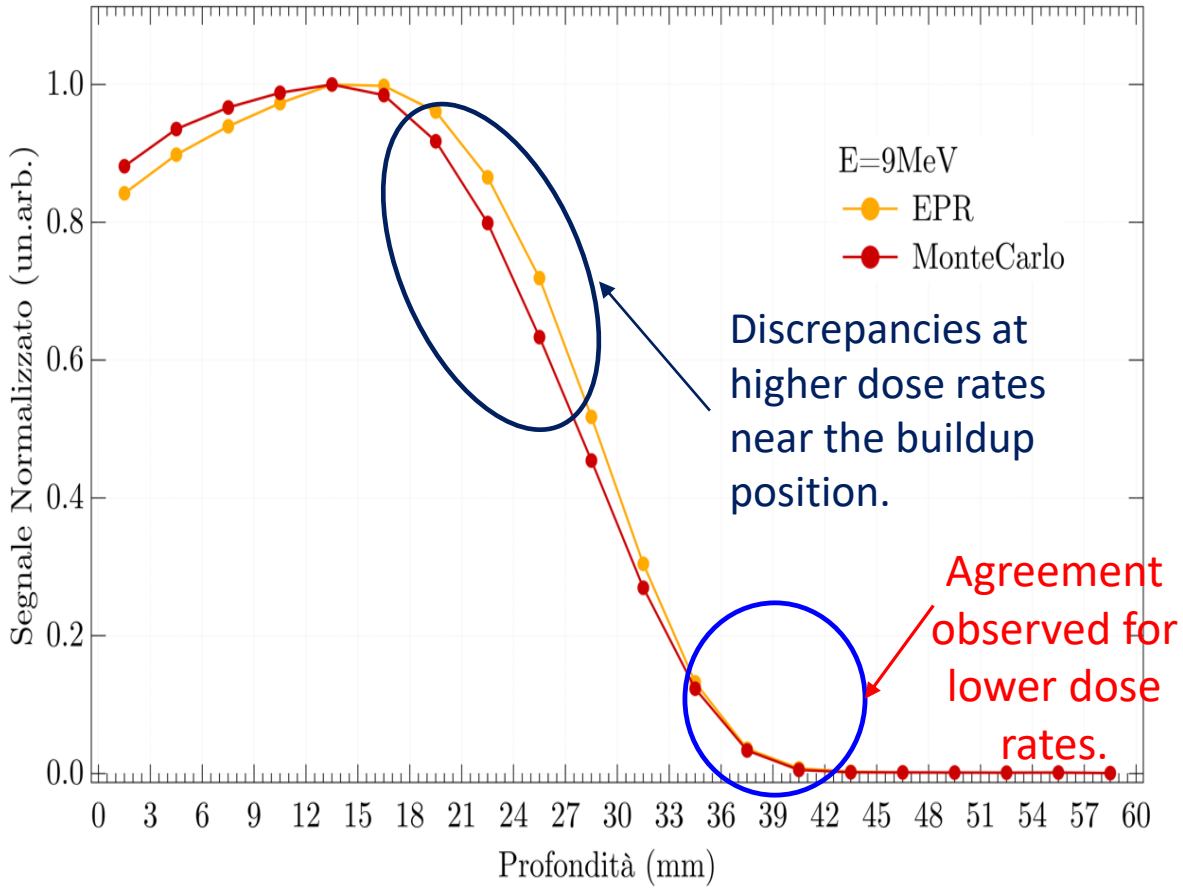


Comparison with experimental data

Electron average energy: 7 MeV
Collimator diameter: 120 mm
Collimator length: 91 cm
Dose rate during pulse: ≅ 350 kGy/s



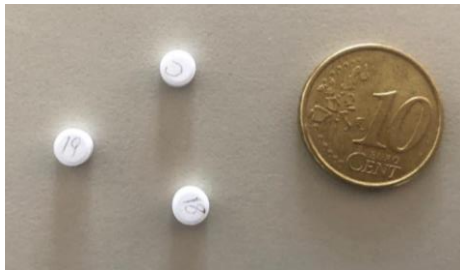
Electron average energy: 9 MeV
Collimator diameter: 35 mm
Collimator length: 35.6 cm
Dose rate during pulse: ≅ 2.6 10^3 kGy/s



Experiment with Electron FLASH linac accelerator @ CPFR

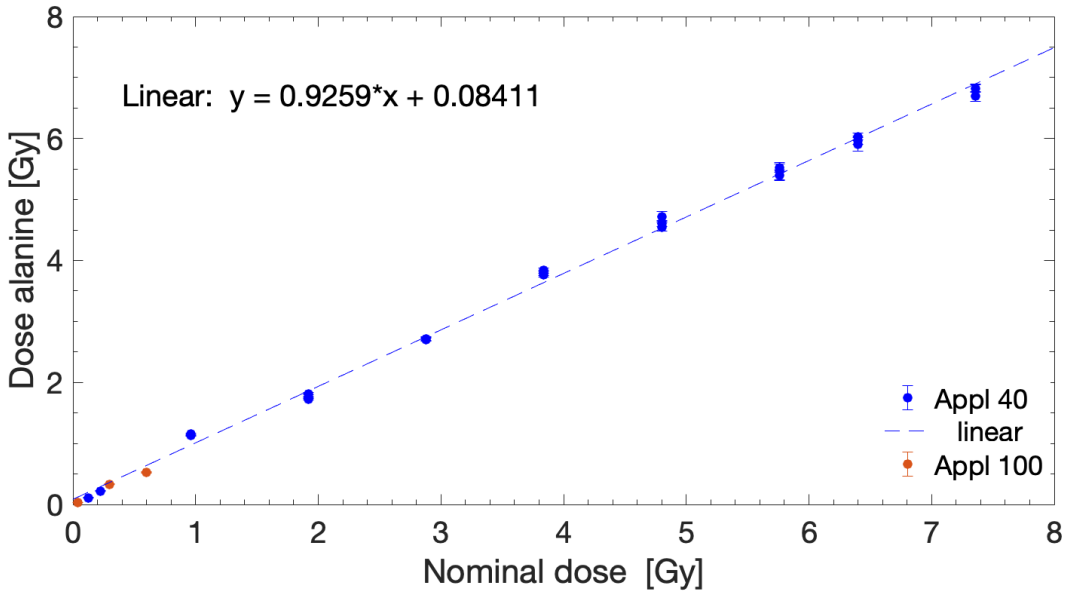
Experimental conditions

- E = 9 MeV
- Pulse duration: 4 us
- Dose per pulse: from 0.1-7 Gy
- Istantaneous dose rates up to MGy/s
- Single alanine detector
  placed in a phantom at the build-up
- 40-100 mm Applicator



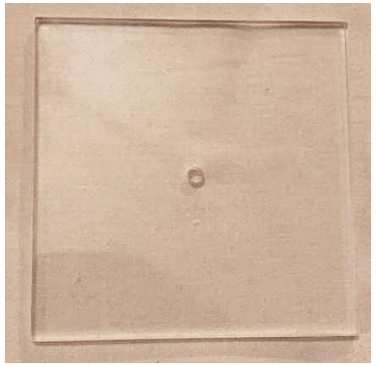
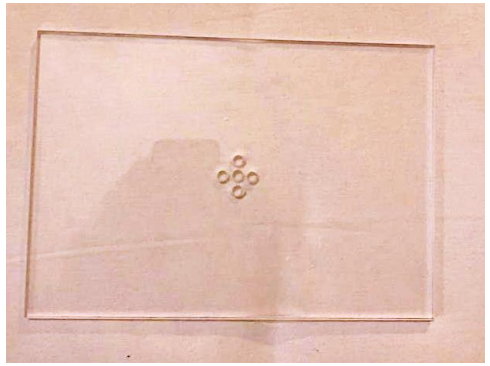
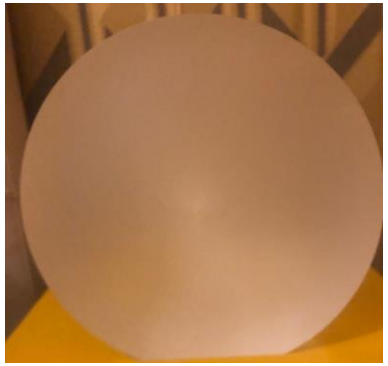
Measurements

- Comparison of alanine dose response with the reference dosimeter (Flash diamond) varying the DPP (working points)



Status and plan of the activities

- Established calibration and dose extraction procedure with UHDR beams
- PMMA phantoms realized@ INFN-CT for single and multiple alanine irradiation and for PDD reconstruction


- Intercomparison of alanine response with the metrology service of Belgian institute and with NPL

WP3. Beam monitoring

Activity of INFN Catania

D.3.1.4

***SiC** detectors tests with UHDR electron/protons for beam monitoring (M16)*

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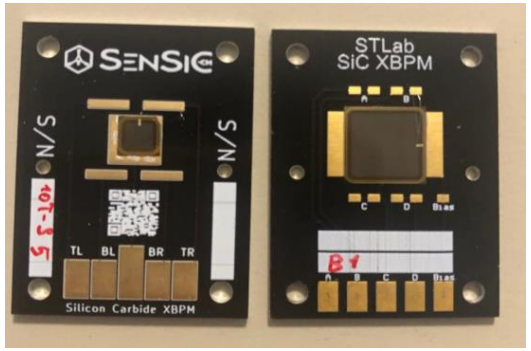
Silicon carbide detectors for beam monitoring and dosimetry

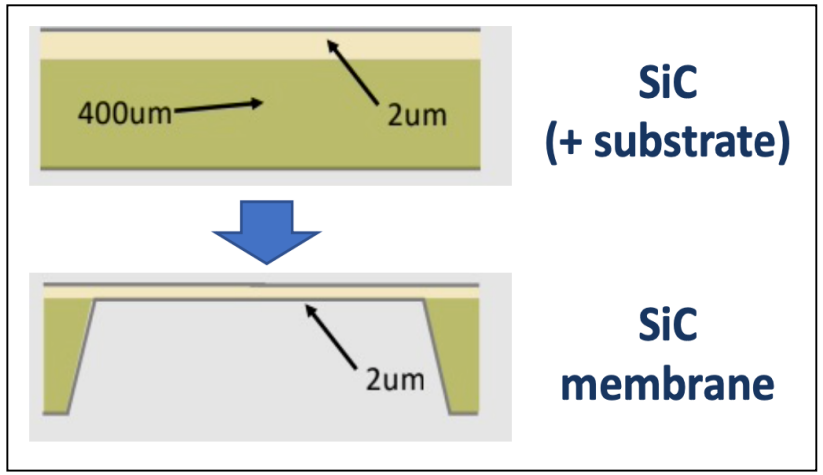
Silicon carbide (SiC) detectors have been realized at the STLab company. The devices are semiconductor PIN junctions: a thin p+, highly doped layer and a n- low doped layer on top of a n+ thick substrate. In case of the free-standing membranes the substrate n+ is removed by electrochemical etching

SiC with bulk

5x5 mm² **1x1 cm²**

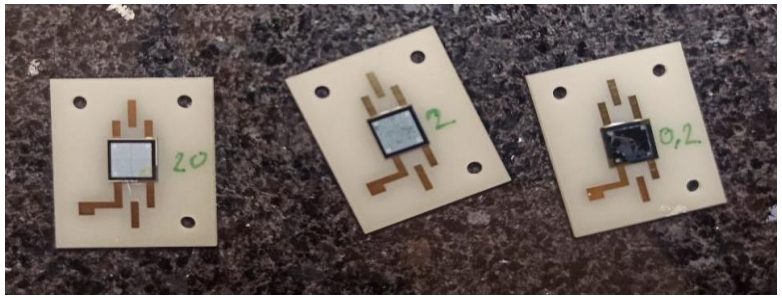


Characterization with UHDR electron beams @CPFR



Freestanding membranes

20um **2um** **0.2um**

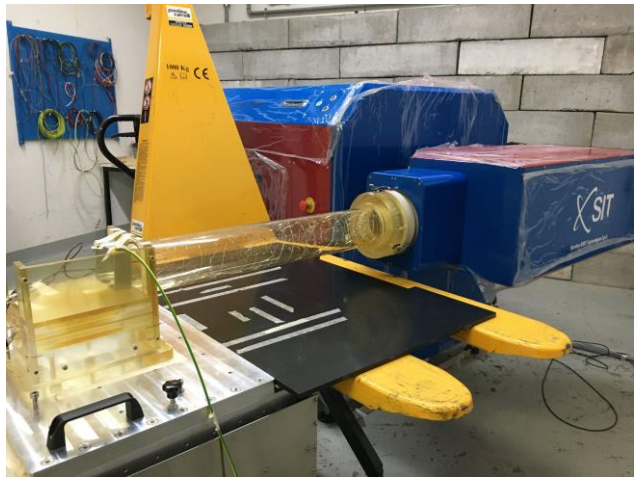


Test with proton micro-beam with IBIC technique
See E. Medina talk

Preliminary test of SiC detectors with UHDR electrons @SiT Sordina Electron FLASH facility

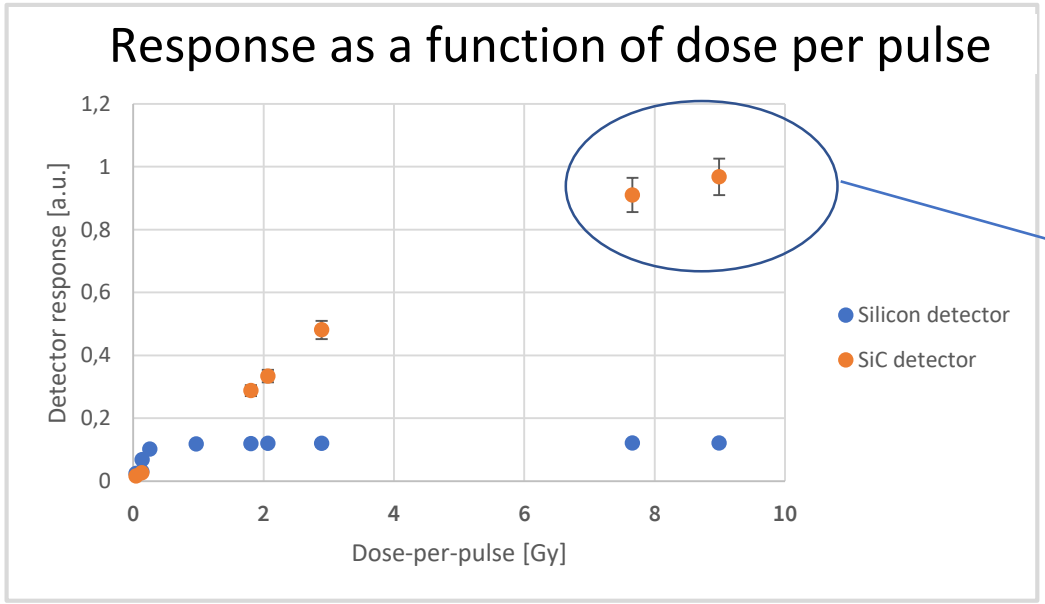
Accelerator parameters

- SiT-Sordina Electron FLASH
- E = 7, 9 MeV
- Pulse duration: 1-4 us
- Dose per pulse: from 0.01-10 Gy
- Average dose rates up to few kGy/s



Measurements

- E = 9 MeV
- Pulse t = 2 us
- 10 um thick SiC
- V = 480 V
- D/p = 0.01 – 10 Gy
- 35 mm collimator
- Comparison with PTW diode
- Electrometer issues at larger doses per pulse

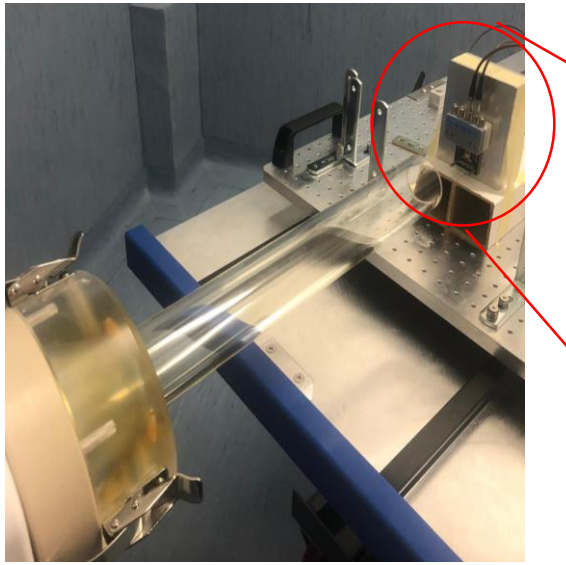


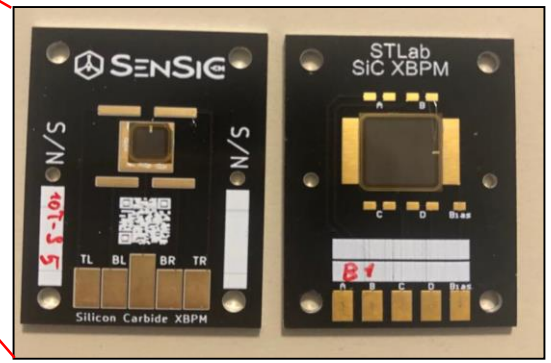
Due to saturation issues of the electrometer?

Experiment with Electron FLASH linac accelerator @ CPFR

Experimental conditions

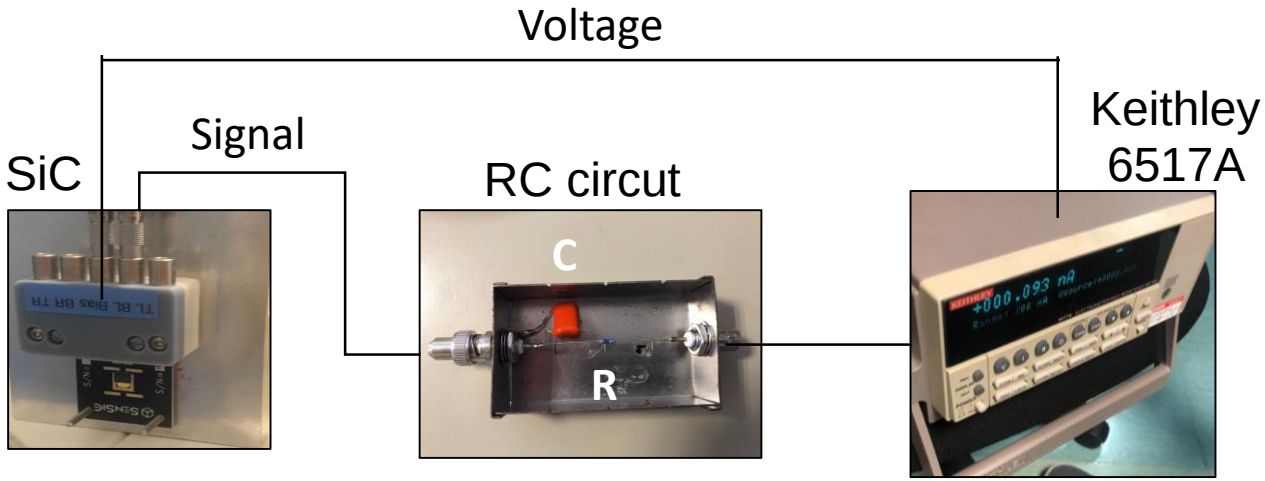
- E = 9 MeV
- Pulse duration: 4 us
- Dose per pulse: from 0.1-7 Gy
- Istantaneous dose rates up to MGy/s
- 10x10, 5x5, 1x1 mm^2 10 um thick SiC placed at the build-up connected to a Keithley electrometer
- Alanine dosimeters at the build-up
- 40 mm Applicator
- RC circuit connected to the detector to slow down the current acquisition in the electrometer





Measurements

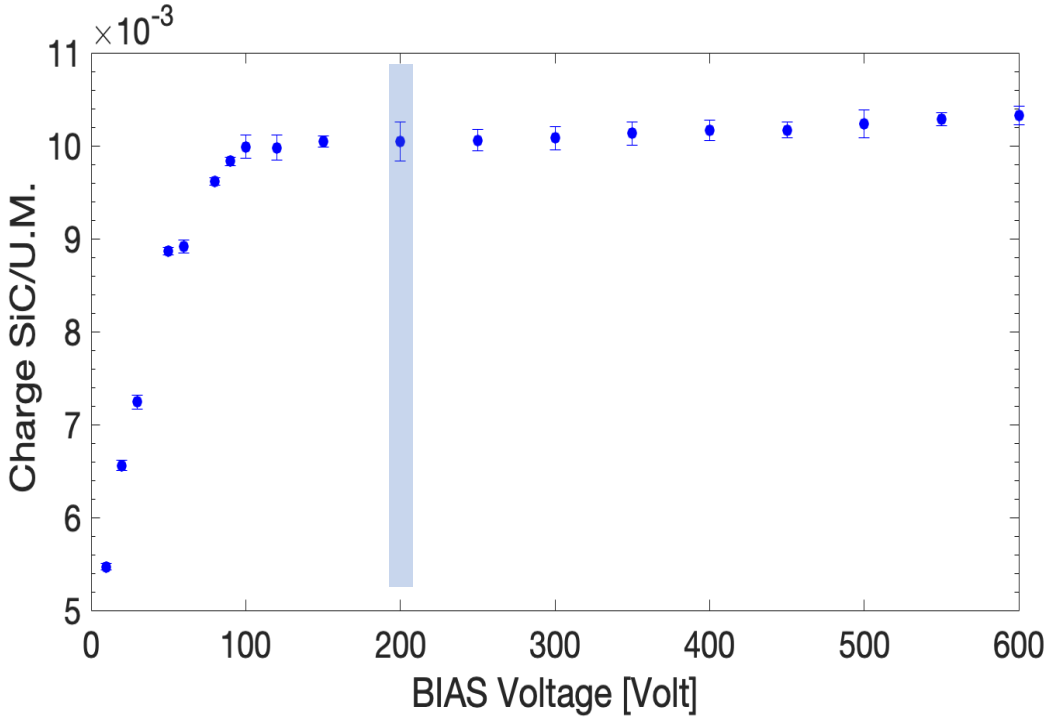
- SiC response as a function of the BIAS voltage at the maximum dose per pulse and dose rate (8 Gy/pulse)
- SiC response as a function of the dose per pulse to verify linearity in single pulse
- Comparison with alanine detectors

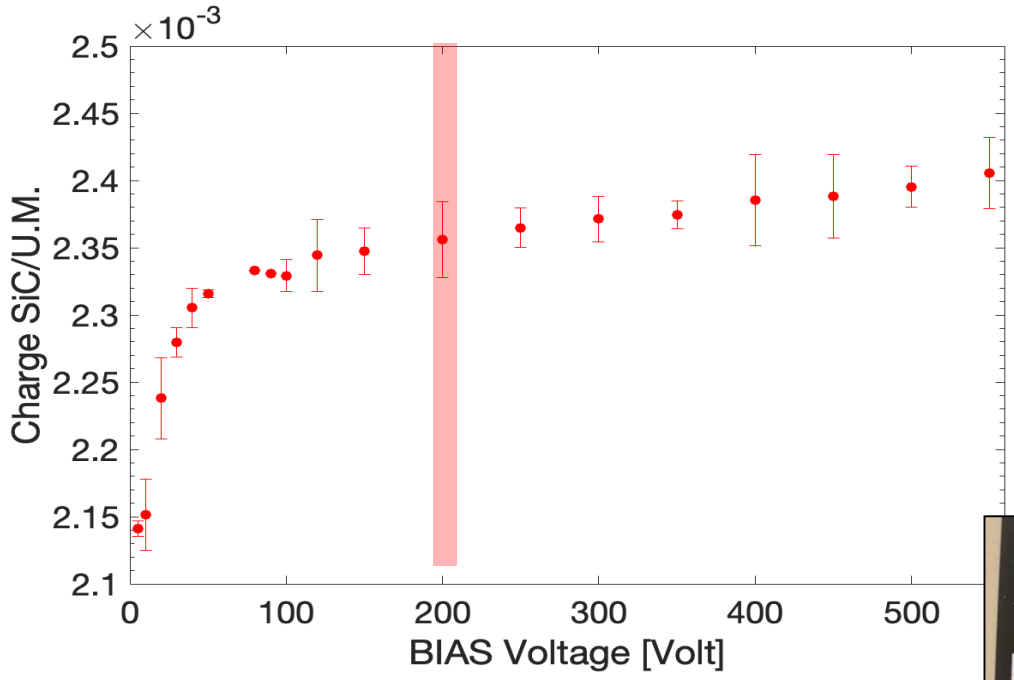


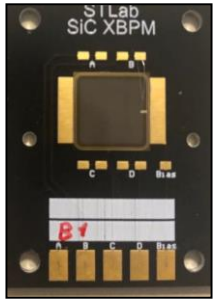
Results with Electron FLASH accelerator @ CPFR

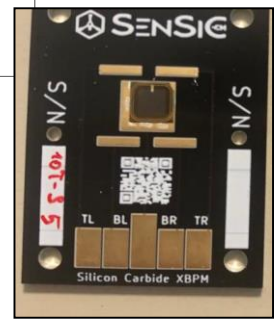
SiC Charge as a function of the BIAS voltage @ maximum DPP

DPP=8 Gy/pulse



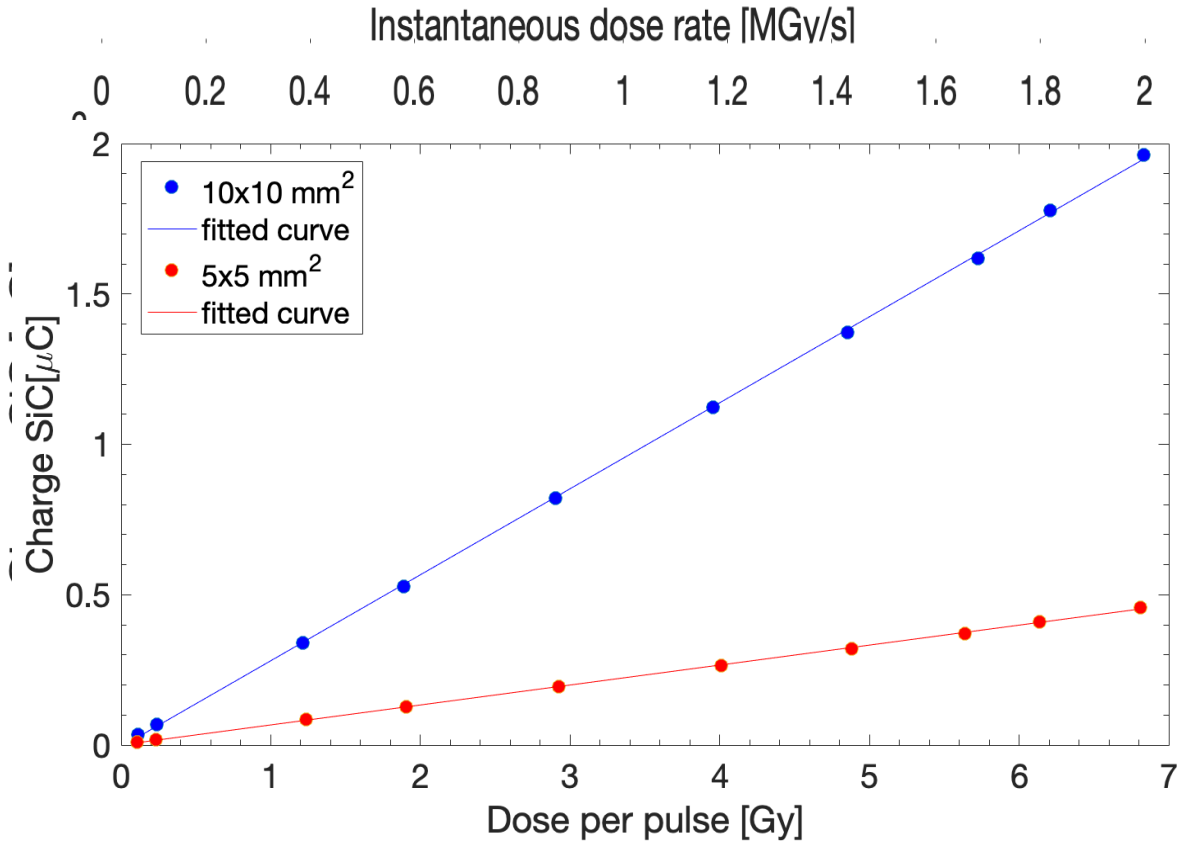




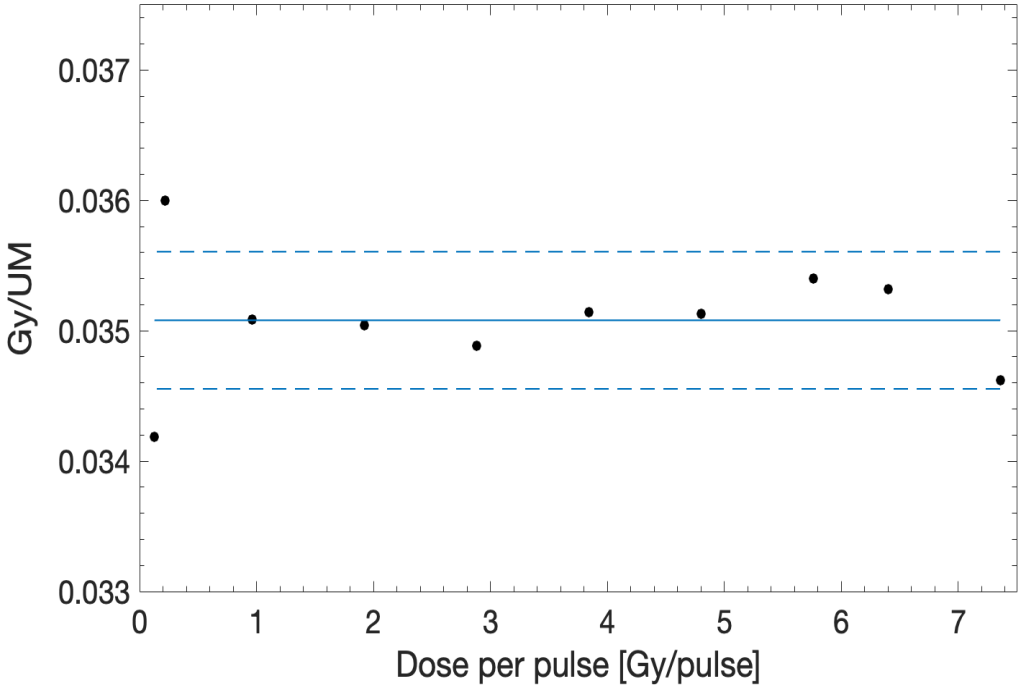


Dose calibration with alanine detectors

SiC response as a function of the dose per pulse



Gy/UM calibration factor as function of the dose per pulse



1.5%

Planned activity for Silicon carbide detectors

- Measurement of the pulse temporal structure and measurement of instanteneous dose rate @ CPFR
- Intercomparison with silicon detectors @ CPFR
- Study and design of 2D configuration
- Test with UHDR proton beams