First Silicon Carbide characterization for relative dosimetry with flash-radiotherapy

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Outline

- A new generation of Silicon Carbide
  - Silicon Carbide as dosimeter

- First Exp Run
  - CATANA Facilty
  - Radiation damage
  - Linearity with realesed dose and dose rate

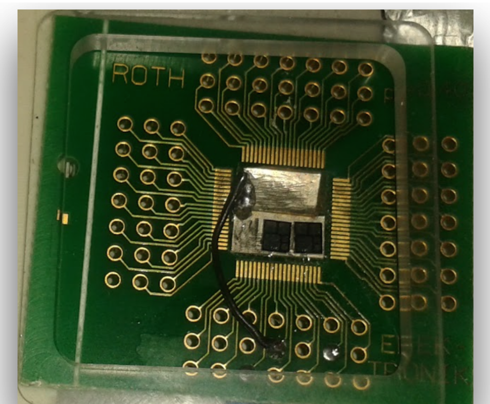
- Second Exp Run
  - Exp setup
  - Linearity with realesed dose and dose rate

- PRAGUE project

A new generation of Silicon Carbide

SiCILIA - Silicon Carbide detectors for Intense Luminosity Investigations and Applications

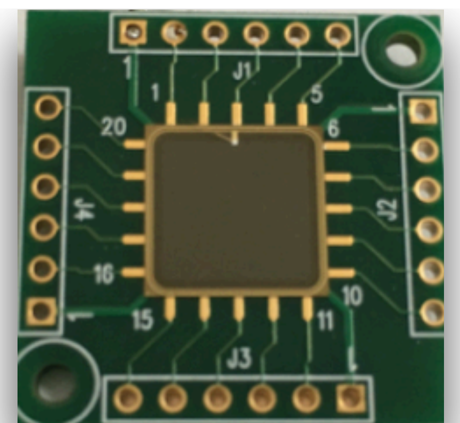
Old generation



2x2 mm^2

43.7 um

New generation



15x15 mm^2

10 um

The strategy of project was the use of material **grown epitaxially as the active layer** of detectors for the realization of *ΔE* detector(CVD process by means of gaseous precursos: Nitrogen for n-type doping and Trimethylaluminium for p-type doping), and the use of semi-insulating thick **4H-SiC** material for the *E* detector. The quality of 4H-SiC epitaxial material is nowadays very high considering the high progresses achieved in the last decades in the growth of material.

IMM

INFN Istituto Nazionale di Fisica Nucleare

STMicroelectronics

Istituto Nazionale di Fisica Nucleare Commissione Scientifica Nazionale CSN5

S. Tudisco et al. "Sicilia-silicon carbide detectors for intense luminosity investigations and applications", Sensors, 18:2289, 2018.

Silicon Carbide as Dosimeter

Properties	Diamond	Silicon	4H-Silicon Carbide
Energy Gap [eV]	5.45	1.12	3.26
Hole lifetime τ_p	10^{-9}	$2.5*10^{-3}$	$6*10^{-7}$
Relative dielectric constant ε_r	5.7	11.9	9.7
e-h pair energy (eV)	13	3.62	7.78
Density (gr/cm^3)	3.52	2.33	3.21
Thermal conductivity (W/cm °C)	20	1.5	3-5
Electron mobility [cm^2/Vs]	1800-2200	1400-1500	800-1000
Hole mobility [cm^2/Vs]	1200-1600	450-600	100-115
Breakdown electric field (MV/cm)	10	0.2-0.3	2.2-4.0
Max working temperature (°C)	1100	300	1240
Displacement [eV]	43	13-20	25

Wide bandgap lower leakage current than silicon

High signal Diamond 16 e/um SiC 51 e/um Si 89 e/um

=> more charge than diamond

Fast responce time

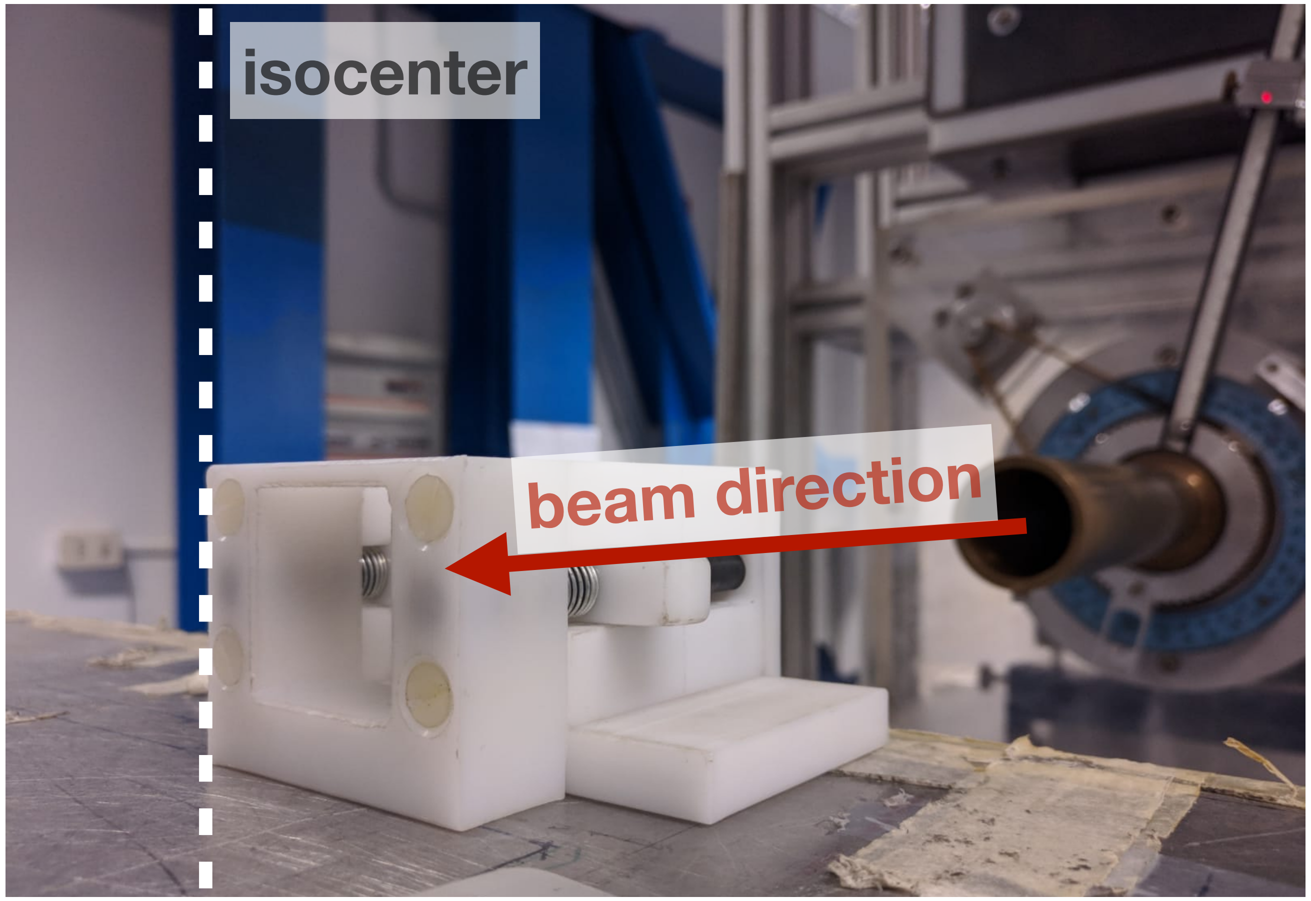
High Radiation hardness

The ideal device to perform the daily QA programs should have:

- good linearity against the released dose;
- high radiation hardness;
- dose rate and LET independent;
- tissue- equivalent;
- time-savings for PDD distribution measurements;

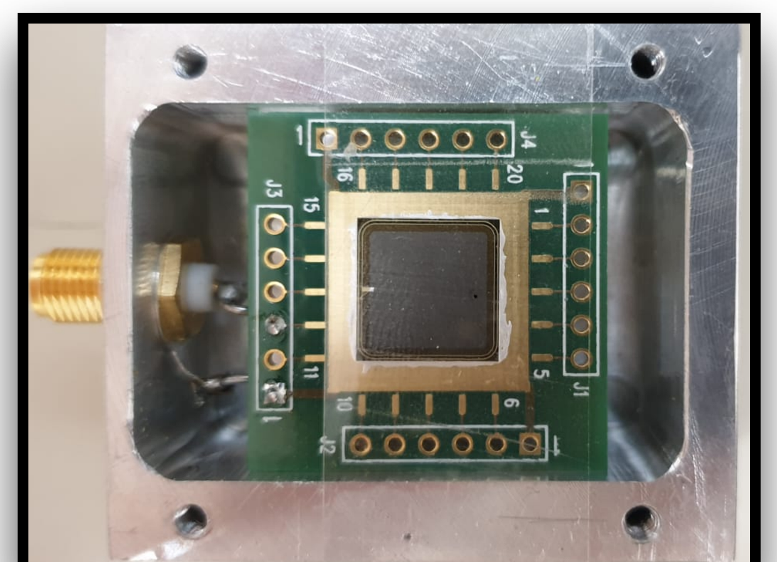
National patent N. Rif. 102018000007139 - G.A.P. Cirrone,S.Tudisco,G. Petringa and S.M.R Puglia

Experimental run @LNS-INFN



CATANA

Centro di AdroTerapia ed Applicazioni Nucleari Avanzate



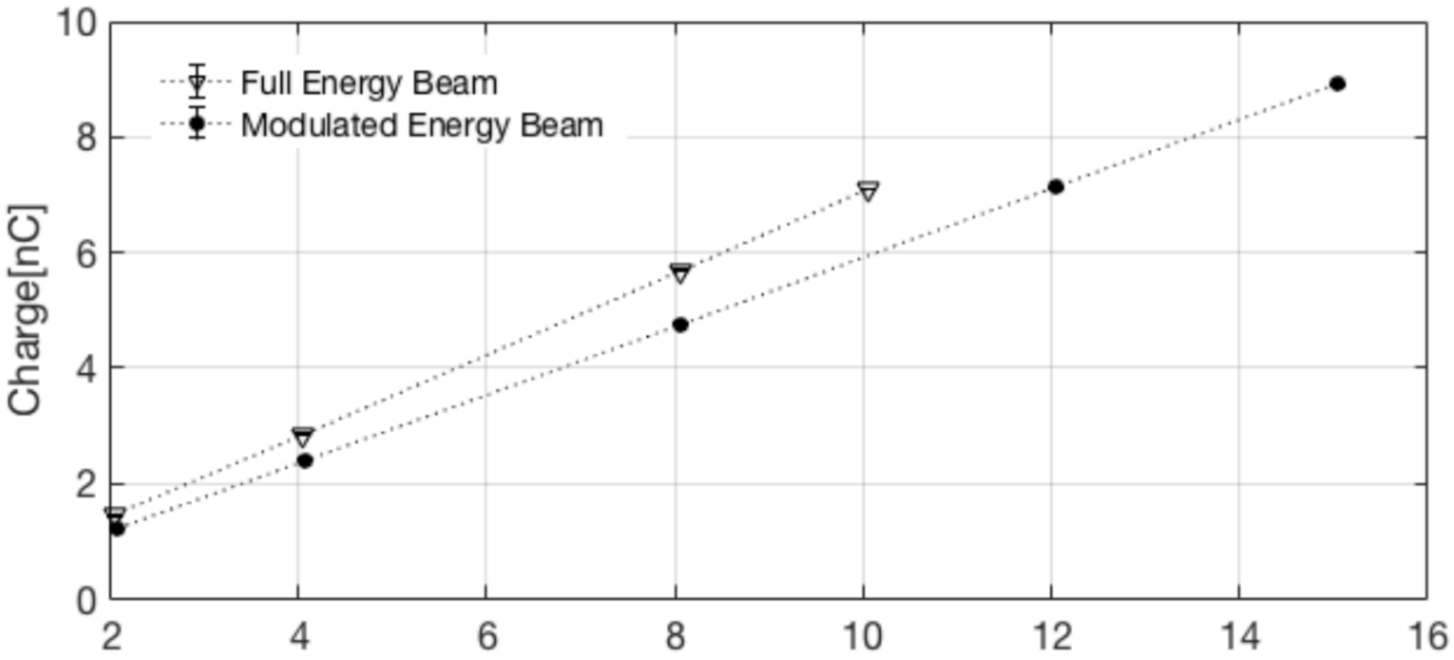
Irradiation field: 5mm in diameter

Energy: 62 MeV proton beam
Modulated and Pristine beam

Beam Current: 10^6-10^8 p/cm^2

Radiation Damage: after 3kGy

Linearity with released dose and dose-rate



Good linear behavior was observed in both cases

Normalized charge collected by the SiC as a function of the proton incidente dose-rate fixed at a released total dose of 5Gy

Dependence on particle LET

Exp. Run - Flash Condition

proton 62 MeV - Full Energy

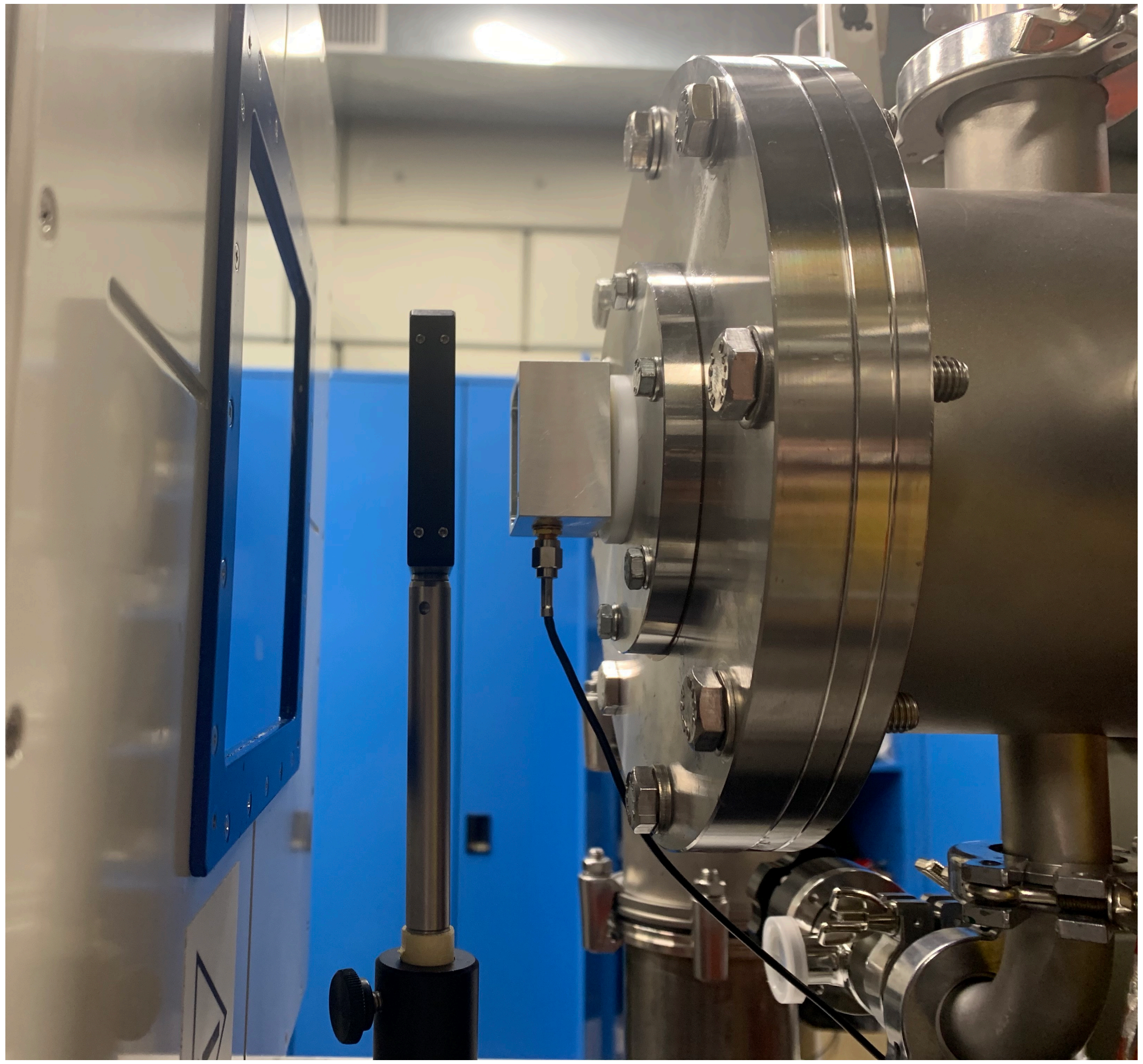
Beam current: 1 - 50 nA

Shot time: 10ms - 200ms

Beam Collimator: $1x1cm^2$

Detector Collimator: $5x5\ mm^2$

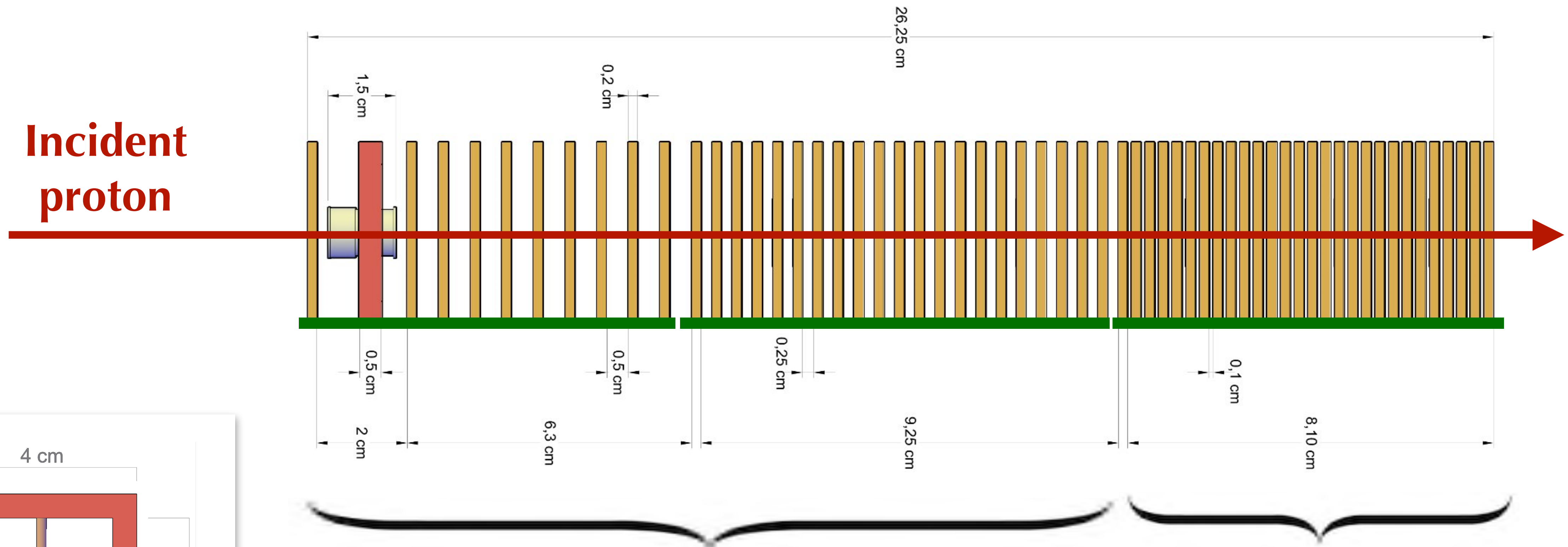
Detector (ST): 10um - $1x1cm^2$



Linearity with released dose and dose-rate

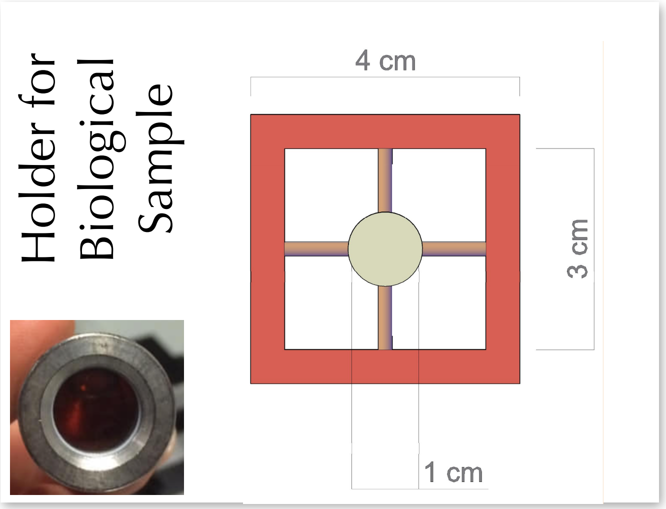
PRAGUE detector

PRAGUE
Proton RAnGe measure Using silicon Carbide



30 SiC with 10um of active layer and 100 um of passive substrate

30 SiC w/o passive layer



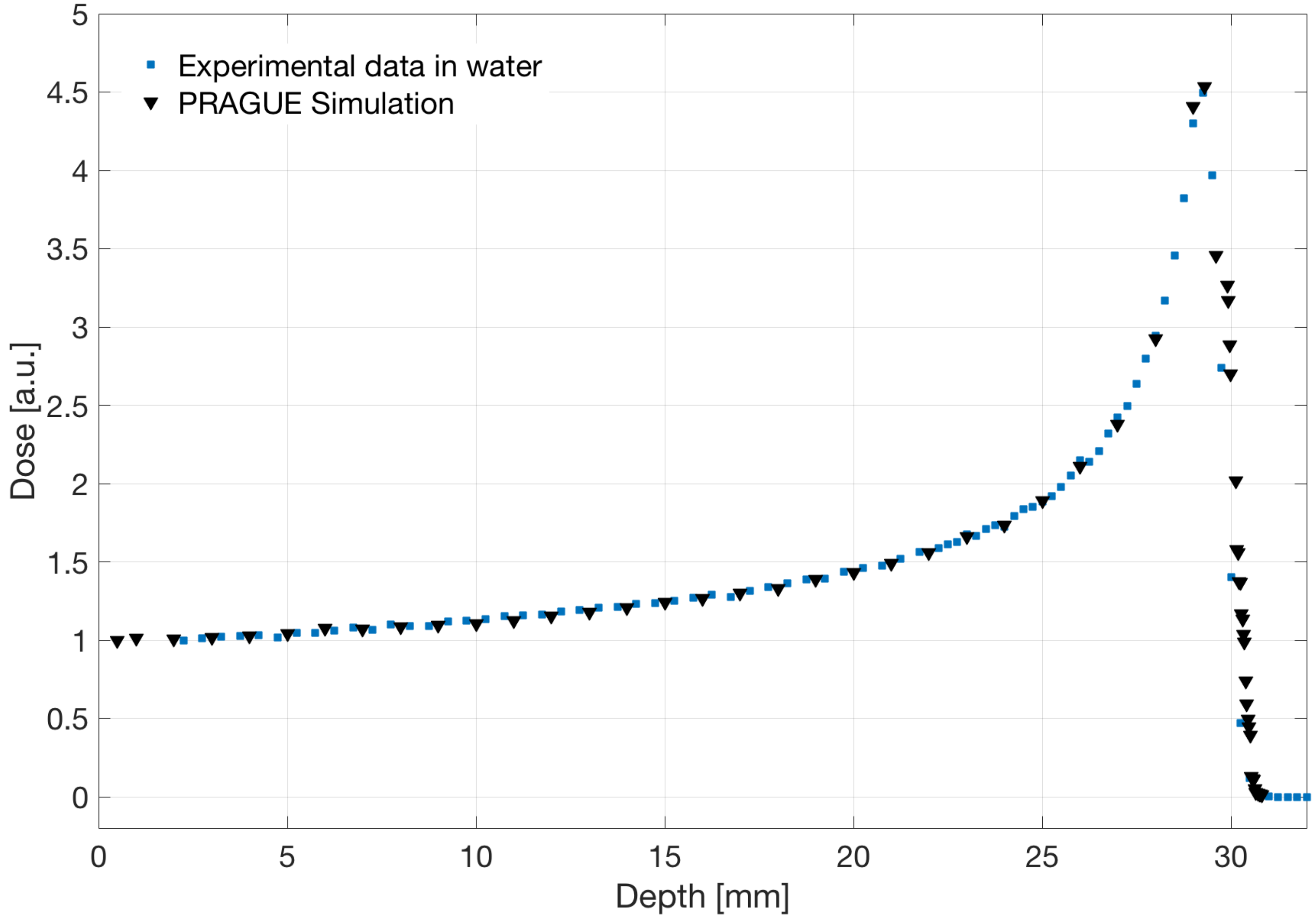
Feasibility Study

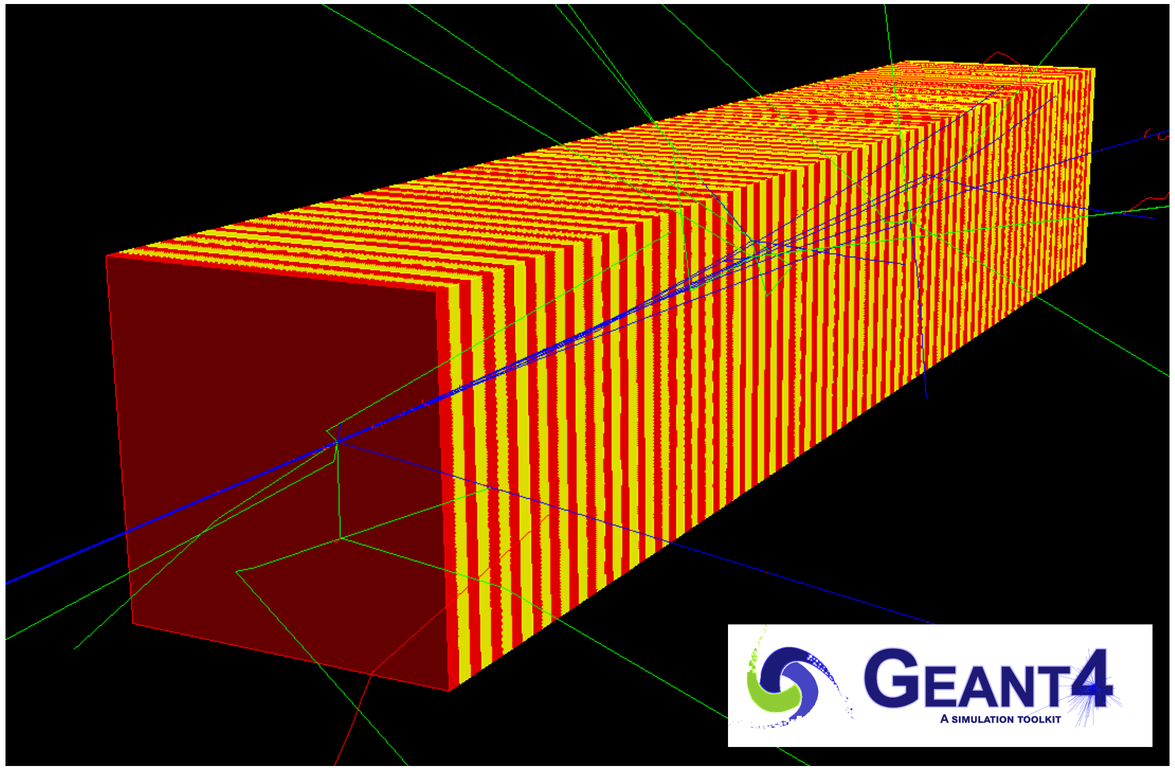
<u>Geant4 Simulations</u>

62 MeV of incident protons

Experimental room: CATANA facility

550um PMMA layers





circular beam spot

gaussian distribution (**σ**=5 mm)

FWHM variation: 30%

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Thanks for listening