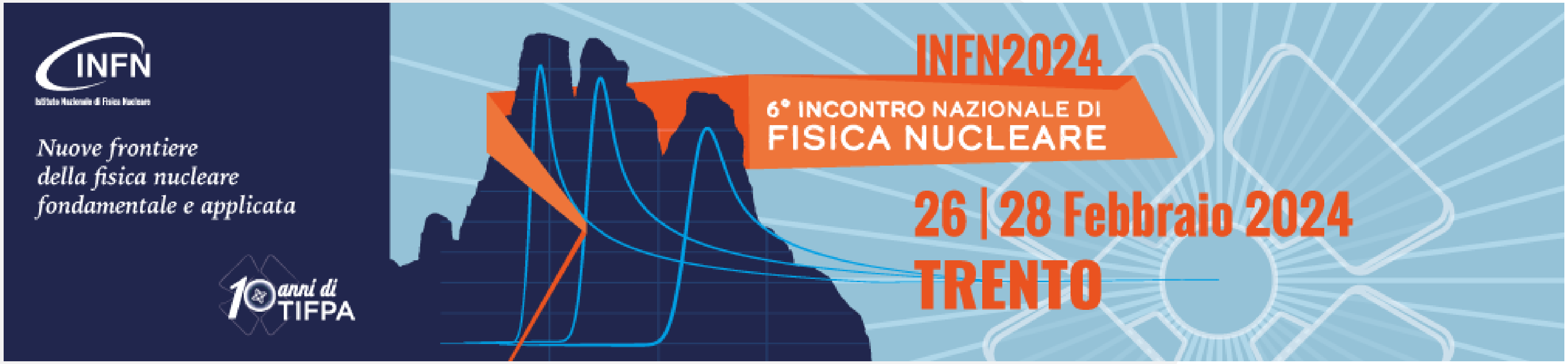

Studies on MAPS devices for medical applications.

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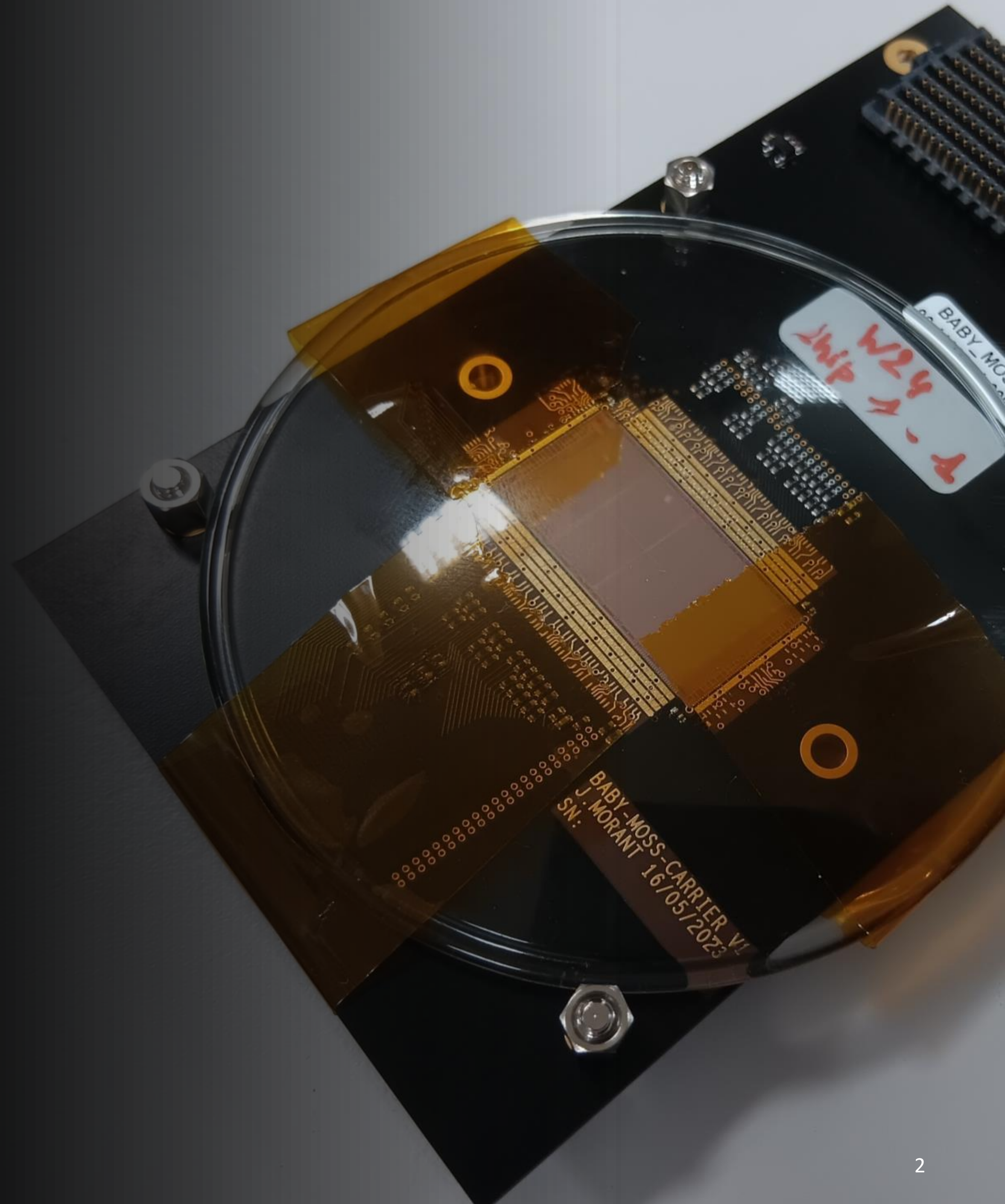
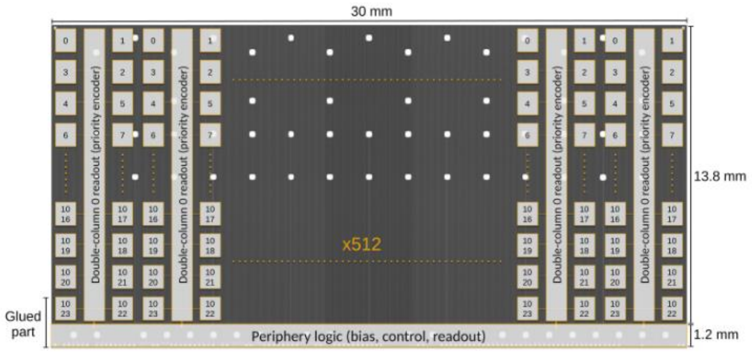
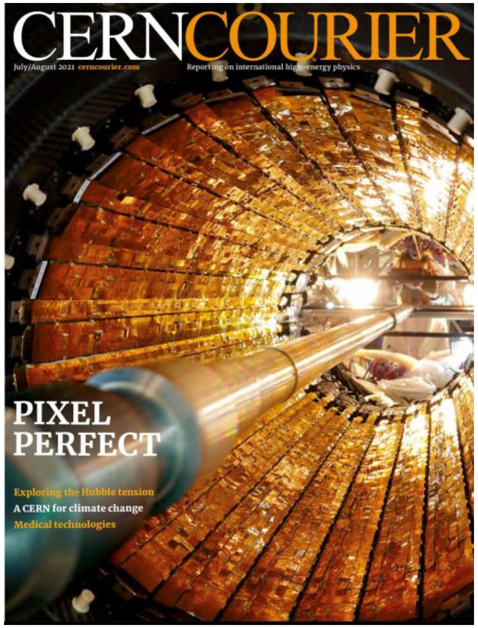
The ALice PIxel DEtector.



The **AL**ice **PI**xel **DE**tector

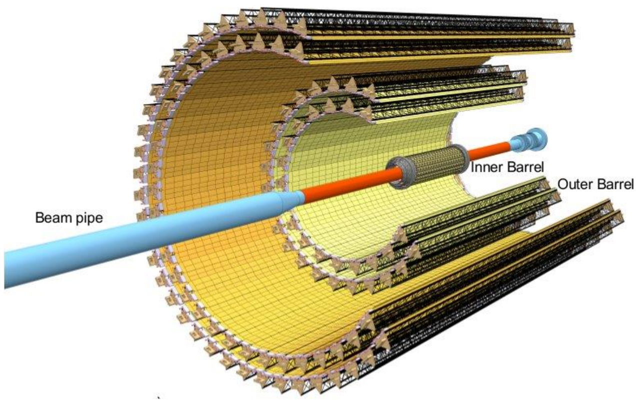


- Developed for the particle tracking of ALICE experiment at CERN (detection unity of the current ITS2).
- High performing MAPS, based on CMOS technology.
- 5 x10^5 pixels (512 rows x 1024 columns).
- Pixel size = 29.24 x 26.88 μm^2.
- Total area = 15 x 30 mm^2.



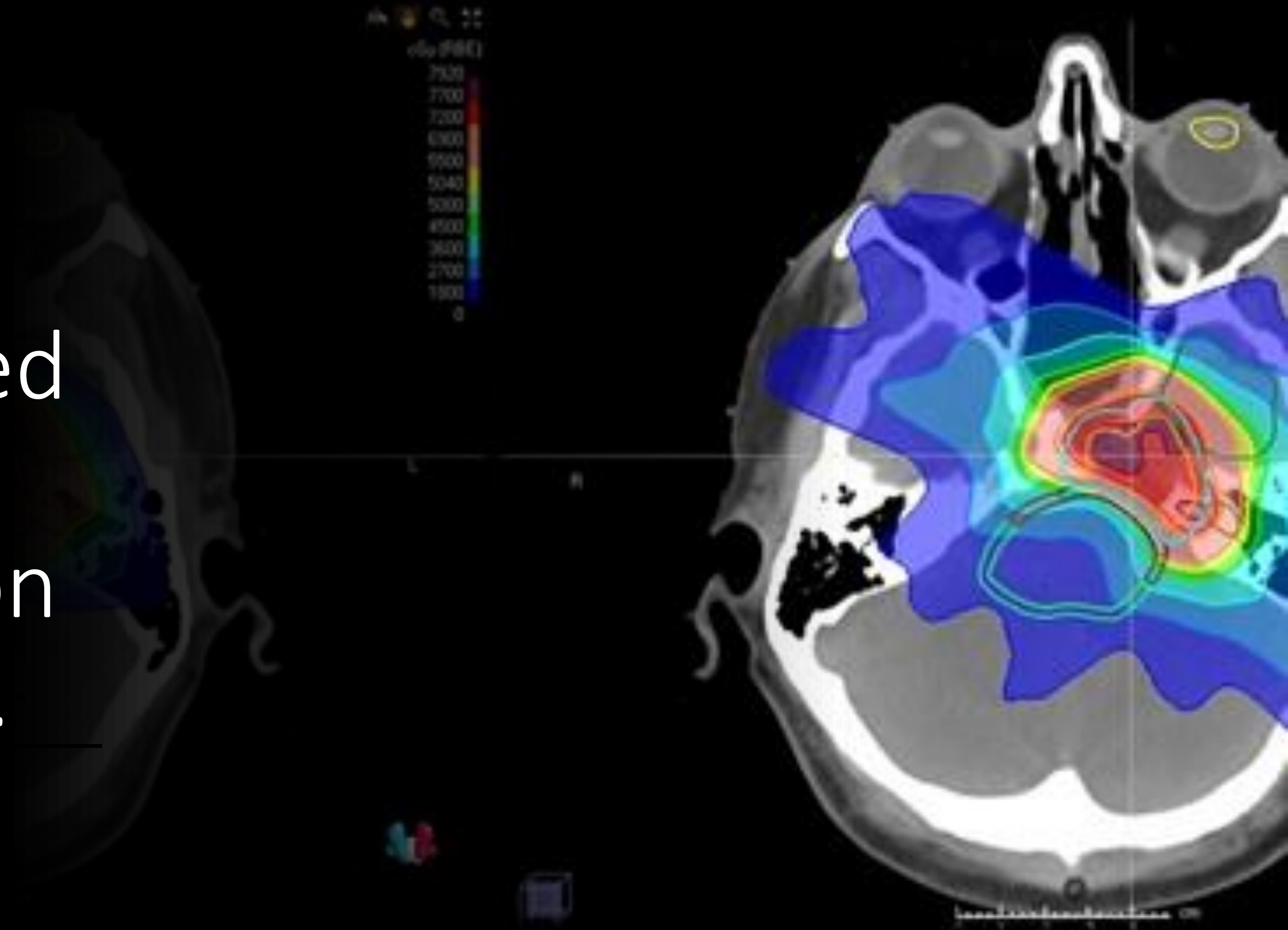
Performance in HEP:

- Detection efficiency > 99%
- Fake hit probability << 10^{-6}
- Spatial resolution ≈ 5 µm
- Designed for operating at high rates and particle density environments.

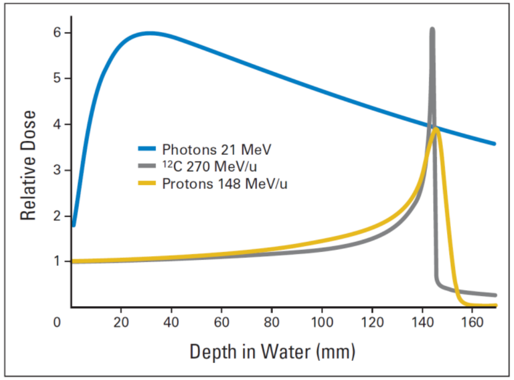


A varied range of medical applications can benefit of the technological evolution of MAPS as commercial devices.

System for computerized tomography with a proton beam [ref1].



System for computerized tomography with a proton beam.

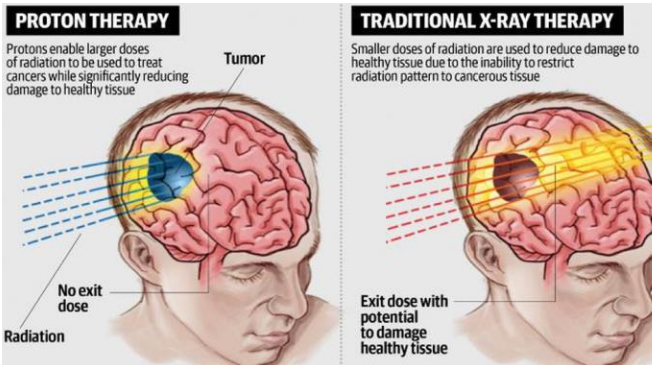


- Protons experience a continuous slow down as they cross matter, until they stop and release a large fraction of their initial energy, originating the Bragg pick at the end of their path.

- From measuring the energy loss of the protons in the tissues, a pCT can be performed.

- Dose delivered to the patient with a pCT (few mGy).

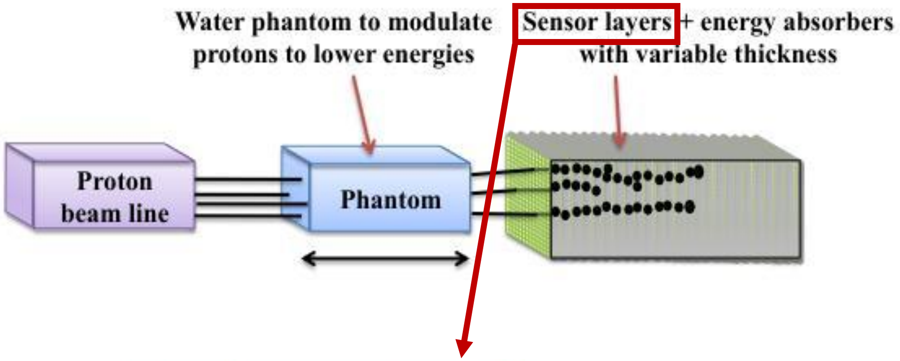
At least an order of magnitude lower than traditional X-ray CT (10–100 mGy).

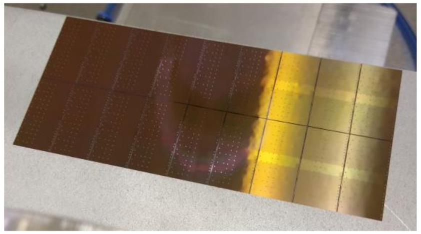


Hybrid calorimeter with layers of pixelated silicon sensors.

- Single technology for both tracking and residual energy measurement would simplify the system assembly and guarantee stable operation in a clinical environment.

- Needs to fulfill the requirements to handle pencil beams with therapeutic characteristics:
  - High particle rate and localized dose depositions.
  - Readout speed fast enough to handle many tracks at the same time.
  - Accurate determination of the ranges of individual protons.



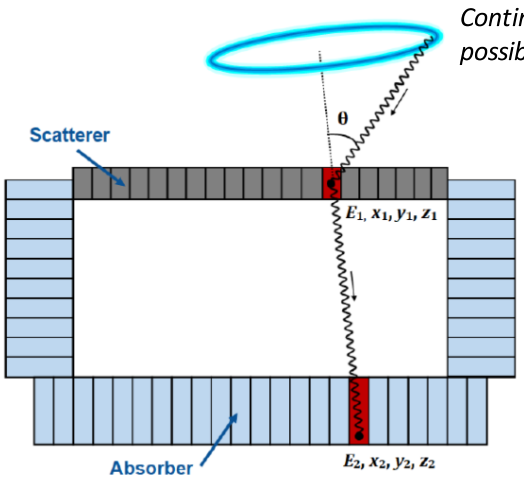


Prototype of a silicon pixel detector with area of 138 × 60.1 mm^2 and thickness of 40 μm.

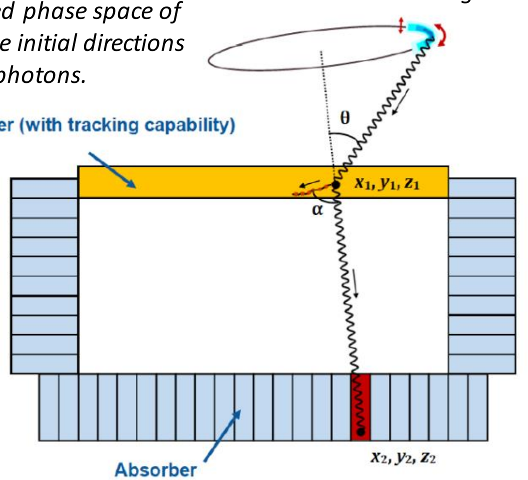
Compton Camera for hadron-therapy with a 3D silicon Pixel Chamber [ref2, 3].

Compton Camera for hadron-therapy with a 3D silicon Pixel Chamber.

- Compton Cameras can perform in vivo beam monitoring during hadrontherapy treatments.
- High-resolution imaging of direct gamma sources is required to perform a precise monitoring over a time of a few seconds.
- Several gammas from the same source point are needed to reconstruct the source position (The direction of a single incident gamma cannot be determined univocally).

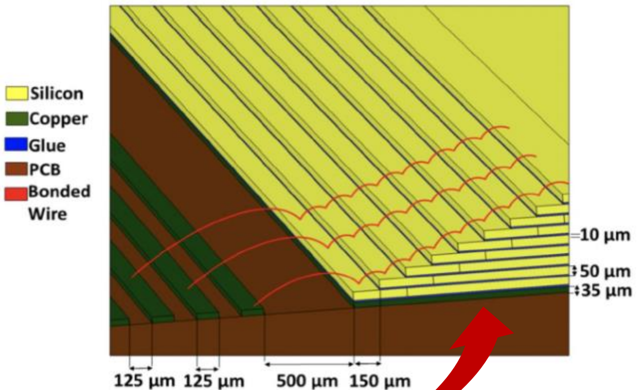


New concept of Compton Camera with a Pixel Chamber as the scatterer



- Reconstruction of the trajectory of the recoil electron.
- More constraint on the reaction plane of the Compton interaction.
- Reduction by order(s) of magnitude the numbers of gammas required for a precise source imaging.
- The acquisition time would match the needs for in vivo monitoring during hadrontherapy

Stack of ultra-thin ALPIDE on top of each other to provide a continuous three-dimensional tracking.



The high granularity, low thickness and high spatial resolution makes ALPIDE an excellent candidate for the Pixel Chamber.

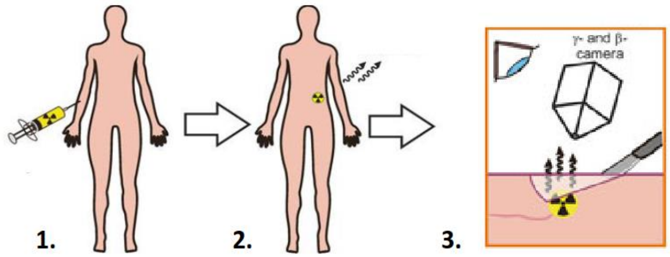
https://www.sciencedirect.com/science/article/pii/S0168900222010166?dgcid=rss_sd_all

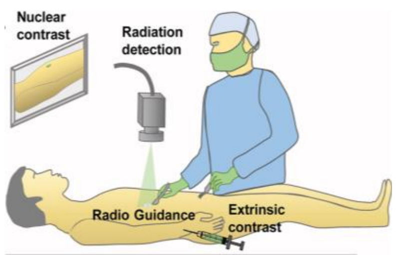
Radio-Guided Surgery with β-emitting radio-tracers [ref4].

Radio-Guided Surgery with β-emitting radio-tracers

- The goal is to allow the surgeon to localize tumoral masses in real time.
- Before the intervention, a dose of a radiotracer, preferentially absorbed by tumoral cells, is administered to the patient.
- By detecting the emissions of the radiotracer with a dedicated probe, it is possible to identify the primary tumor.

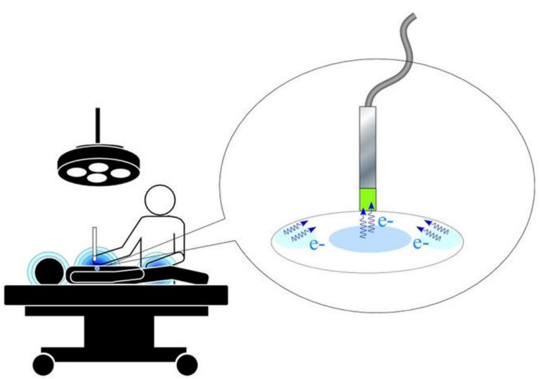
The usage of a probe with imaging capabilities may allow the surgeon to identify the borders of the tumoral masses with great precision.





β-emitting radio-tracers:

- Limited background because their short range in human tissue (few mm at E ≈ 200 KeV.) compared to γ-emitting radio-tracers (≈10 cm at E ≈ 200 KeV).
- Higher spatial resolution ensures precise delineation of radioactive tissue.



β^+
The annihilation of positrons produce a background of 511 KeV γ with larger penetrating power.

β^-
Limited availability of the radiotracer and of suited detecting probes.

MAPS as intraoperative probes for RGS can satisfy the requirements:

- High e- detection efficiency.
- Low fake-hit rate.
- Readout electronics inside the pixel.
- Low power consumption (not need of a sophisticated cooling system).

Possibility of realizing compact, handheld probes .

↓

Excellent performance with β^--emitting radio-tracers.

- Low sensitivity to photons ➡ Suited to be used with β^+-emitting radiotracers).
- Excellent spatial resolution ➡ Optimal for a usage as imaging probes.

https://ieeexplore.ieee.org/document/8791306

Thank you

List of projects:
[1] RIPARTI, "Feasibility study of a system for computerized tomography with a proton beam"
[2] PRIN 2022, "A pioneering Compton Camera for hadrontherapy with a 3D silicon Pixel Chamber"
[3] Dipartimento di Eccellenza "Quantum Sensing and Modeling for One-Health (*QuaSiModO)*" W.P.1.2, "Quantum and Innovative Particle Detectors for Health"
[4] PRIN 2022 "Development of an innovative silicon pixel detector for imaging applications in radioguided surgery"