Study of the MIT proton therapy beam using fast detectors – Fibre Detector

Francisco Cavaco [a)]

a) francisco.cavaco@tecnico.ulisboa.pt; ist1107002

Supervisors:
Prof. Pedro Assis, Gonçalo Ribeiro, Manuel Ratola

Motivation

- The ambition of the **BoneOscopy** project is to enable treatment diagnostics without exposing patients to additional radiation [1].

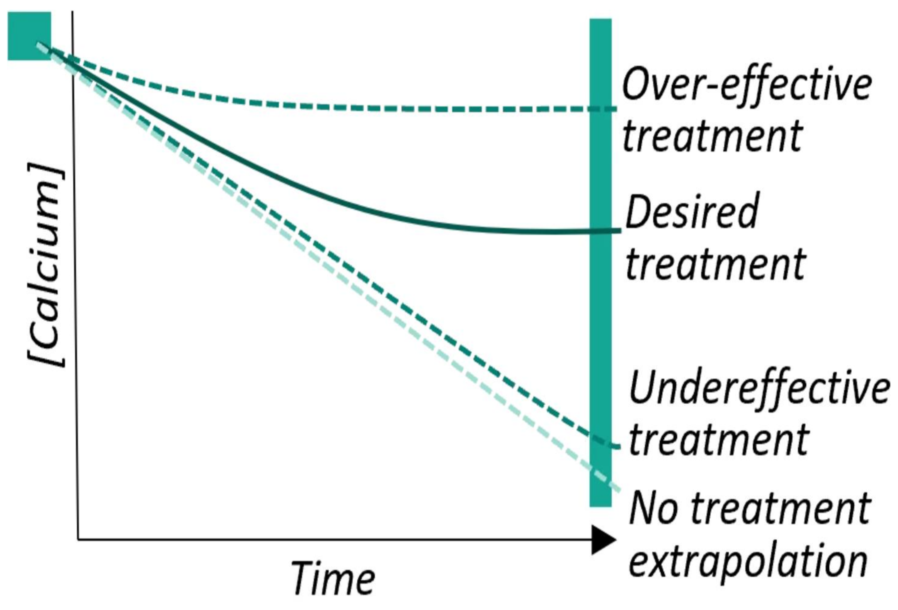
Prompt Gamma Detection

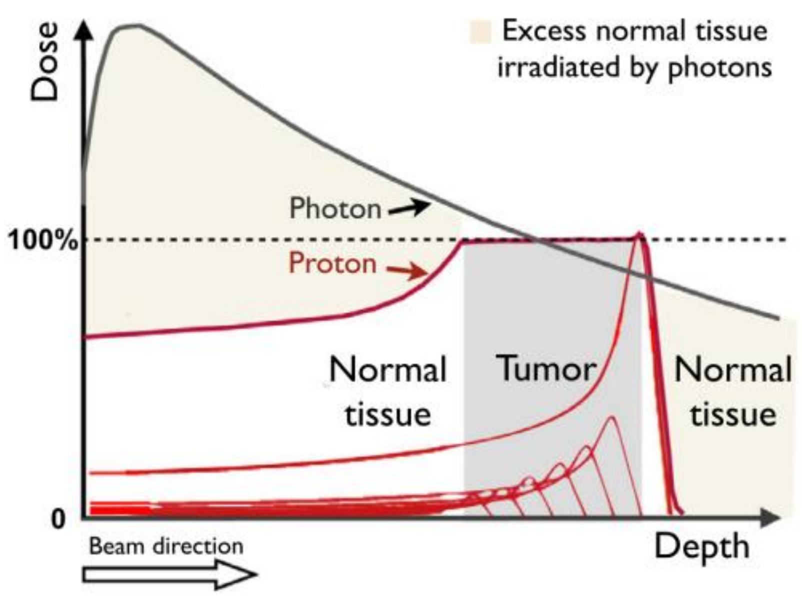
↓

Calcium Content

↓

Information on Cancer Progression and Treatment Efficiency

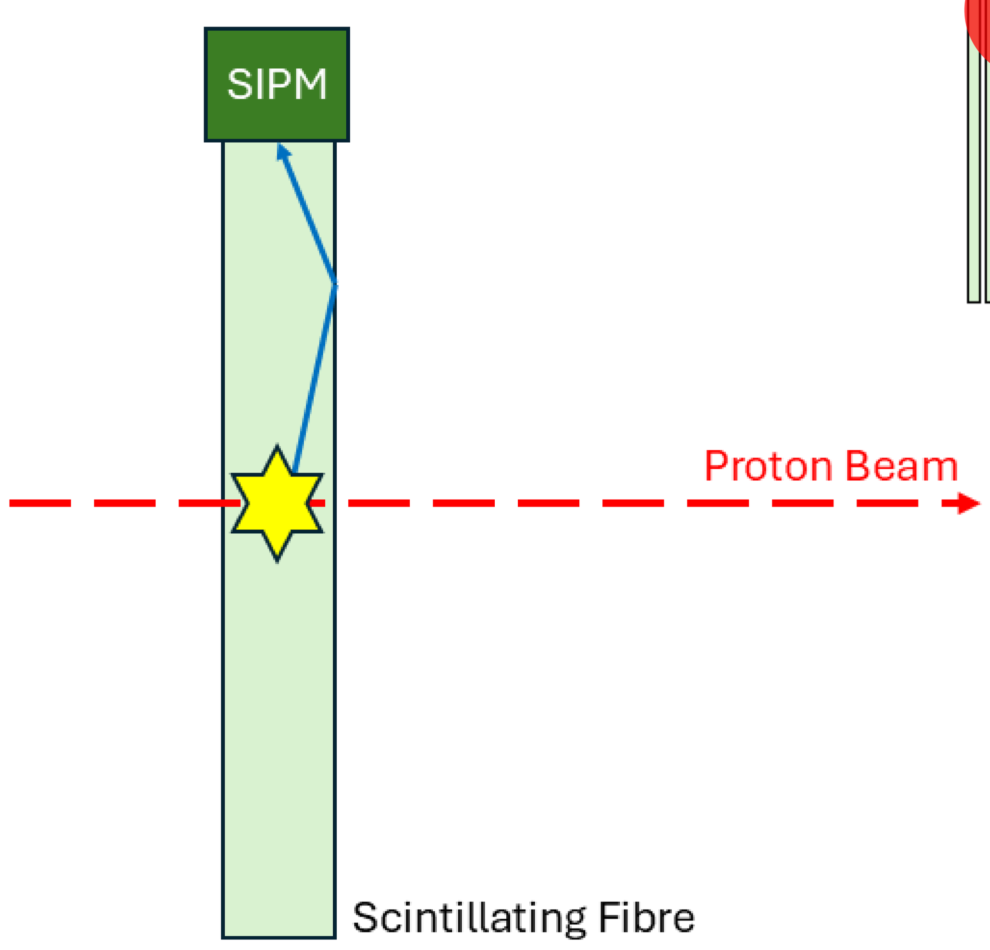


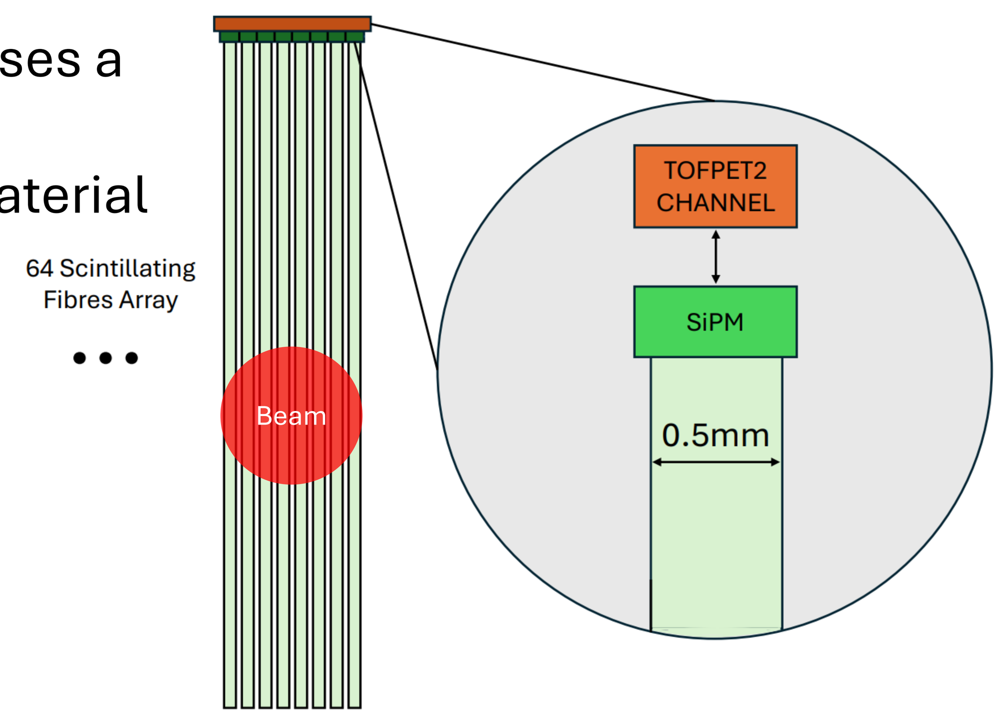


- Using **Proton therapy** enables highly conformal dose delivery, but the spectroscopy system's accuracy depends on precise and reproducible beam monitoring, where **accurate timing** is critical for improving the signal-to-noise ratio [1] [2].
- Scintillating fibres coupled to silicon photomultipliers (SIPMs) offer a **fast** solution for beam monitoring, while also providing information about the **spatial profile** of the proton beam.

Detector setup schematic

- A **charged particle** traverses a scintillating fibre
- Deposits **energy** in the material
- **Light** is emitted through scintillation





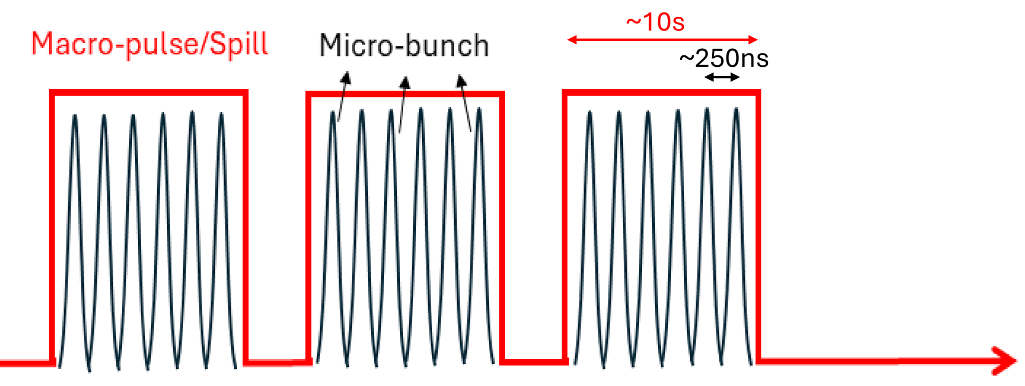
A fraction of the emitted light is **trapped** by total internal **reflection** and guided along the fibre towards its end

It is then **detected** in the **SIPM**

Illustrating figures, Not to Scale

Experimental Acquisition

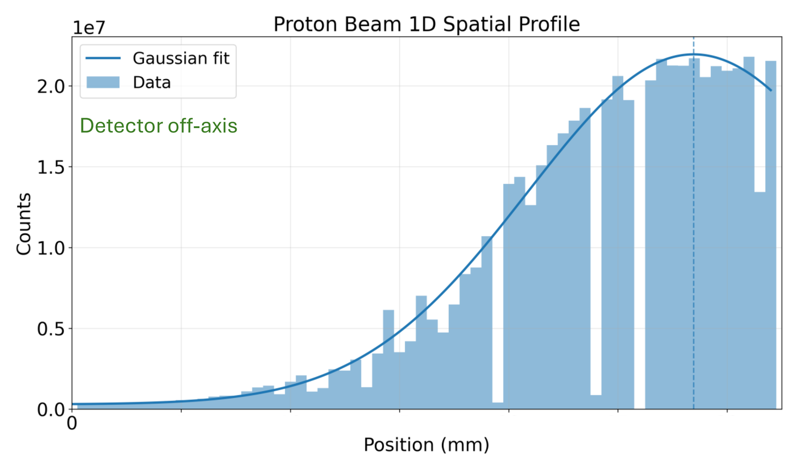
- A series of irradiations was performed using the **proton beam** at MIT (Marburger Ionenstrahl-Therapiezentrum), as of June of 2025.



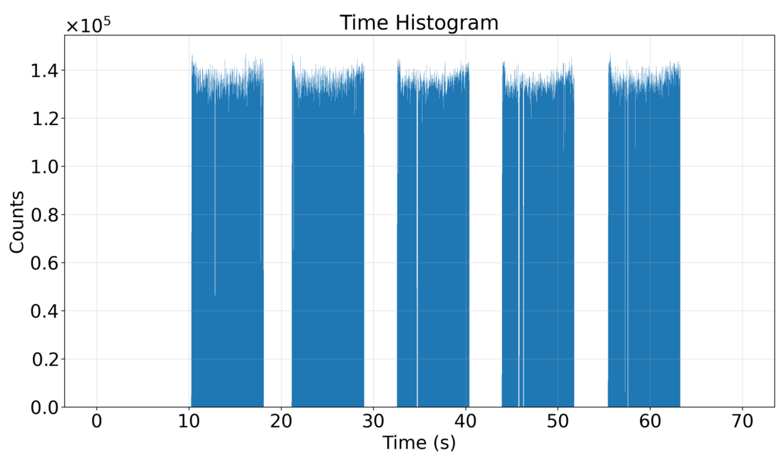
- The accelerator delivers the beam in **spills**, each **micro-bunches** whose repetition frequency is determined by the **RF cavity frequency**.
- For each event, the **charge**, detector **channel**, and precise **timestamp** (<100ps resolution) were recorded, enabling the temporal structure of the proton beam to be investigated.

Results

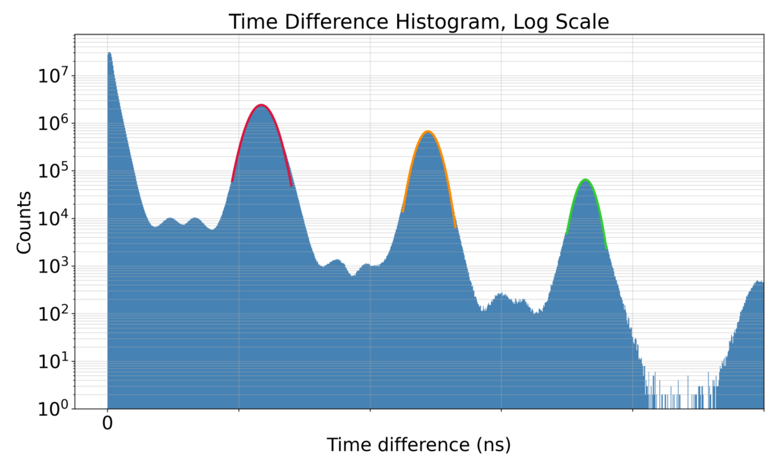
Proton beam 1-dimensional spatial profile



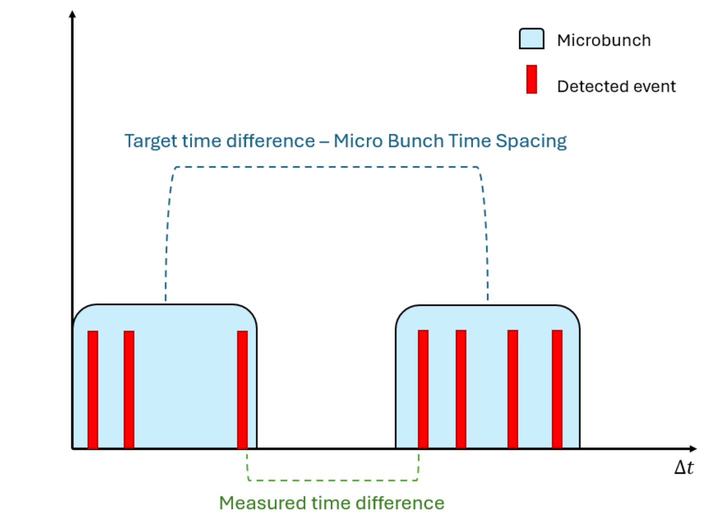
Macroscopic temporal structure



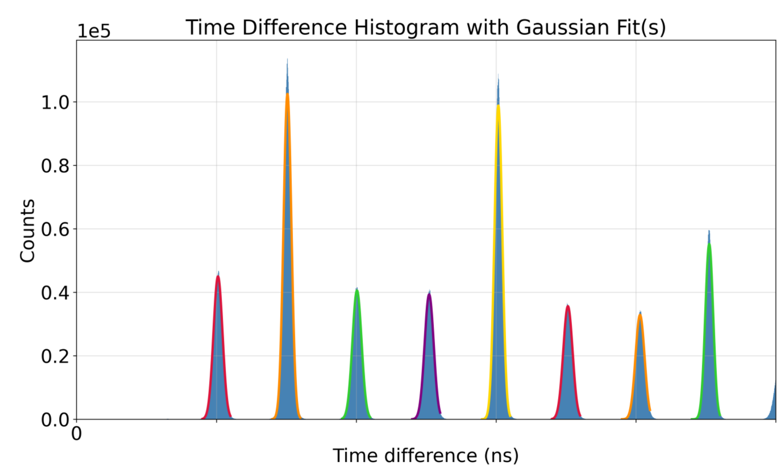
Time difference for all detected subsequent events



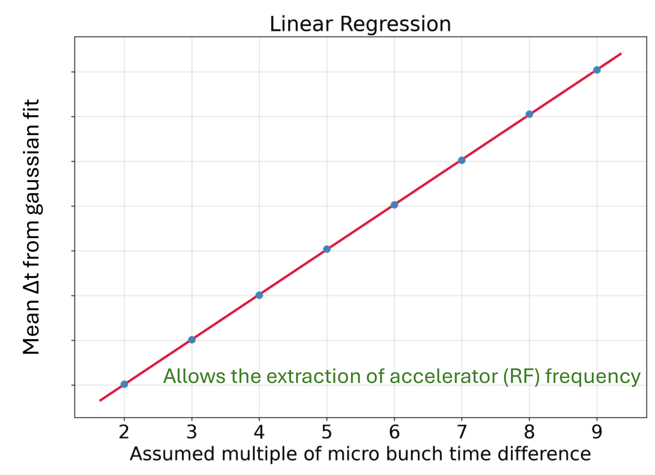
Schematic illustration of how the time difference is defined



Time difference between subsequent events for a single fibre with Gaussian fits



Linear regression of the extracted mean values (right)



Some information not shown due to confidentiality

Conclusions

- Single fibre's event time differences provide precise information on the micro-bunch repetition frequency, in agreement with the accelerator parameters, proving the accuracy of both the detector and the methods used.
- The detector presents a good enough temporal resolution (ns), providing inter and intra bunch information.
- Such information allows for the rejection of noise based on timing for spectroscopy applications.
- Future work will focus on further characterizing the beam's temporal structure in order to improve, develop and provide a trigger detector for the prompt-gamma spectroscopy system.

References

[1] BoneOscopy, "Project-boneoscopy," 2026. https: //boneoscopy.eu/project/

[2] T. J. Royce and J. A. Efstathiou, "Proton therapy for prostate cancer: A review of the rationale, evidence, and current state," Urologic Oncology: Seminars and Original Investigations, vol. 37, no. 9, pp. 628–636, 2019.

Acknowledgements

This work was supported by the BoneOscopy project, funded by the European Union's Horizon Europe programme (Grant Agreement No. 101185141) and, for the Swiss Partner, by the Swiss State Secretariat for Education, Research and Inovation (SERI).

TÉCNICO UNIVERSIDADE DE LISBOA

European Innovation Council