Beam and treatment monitoring in FLASH and CONV regimes for PT applications

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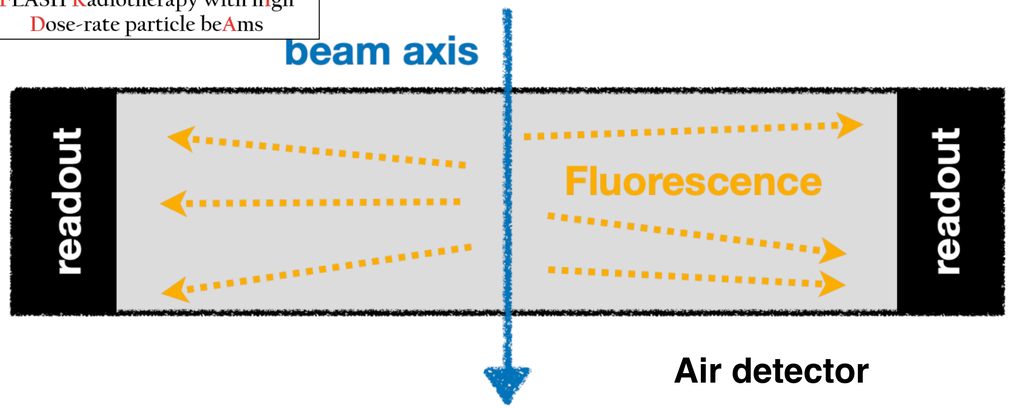
INFN - Roma

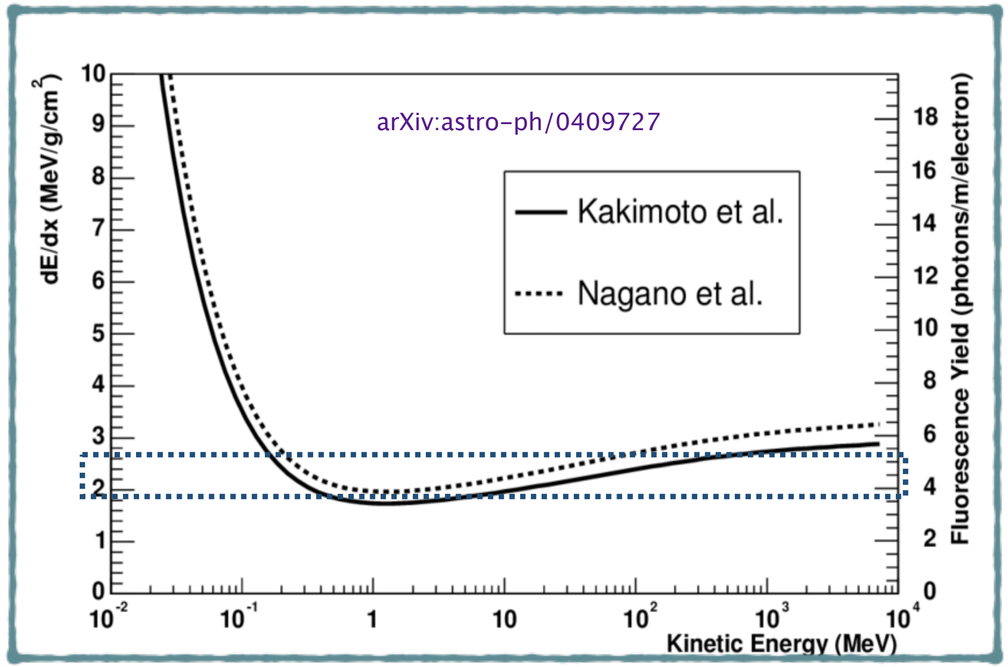
FLASH Radiotherapy with hIgh Dose-rate particle beAms

Monitor with fluorescence light from air for FLASH



- Low impact of the detector on the beam line, preserving the best irradiation conditions for the patient
- Device **simple and cheap to produce**, with a simple light collection system (photons emitted isotropically) and **minimal dependence from the electron energy**

Photon emission	Isotropic (3D)
Excited state lifetime	10 ns
Wavelength spectrum	290-430 nm
Fluorescence yield	$\propto dE/dx$ (~ 4 ph./m)
Signal-to-#e⁻ relation	**LINEAR**
Transparency wrt ref. cond.	100%
Radiation hardness	Optimal



FLASH Radiotherapy with hIgh Dose-rate particle beAms

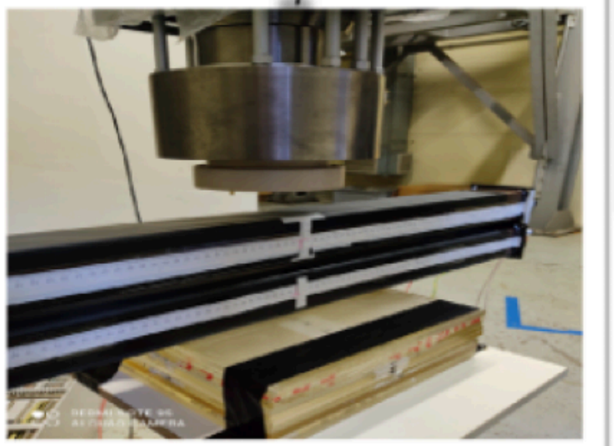
Device history

First round: LIAC-HWL
November 2020-June 2021

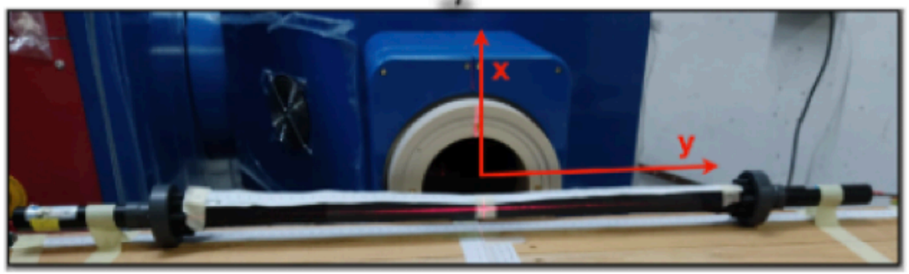
Second round: EF Antwerp
July 2021-June 2022

Third round: EF Pisa
July 2022-June 2023

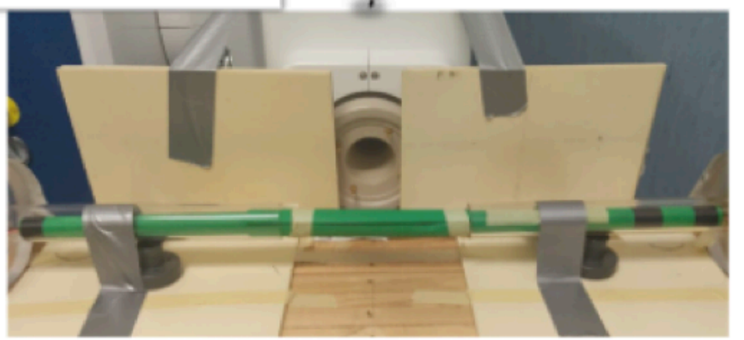
2021



2022



2023



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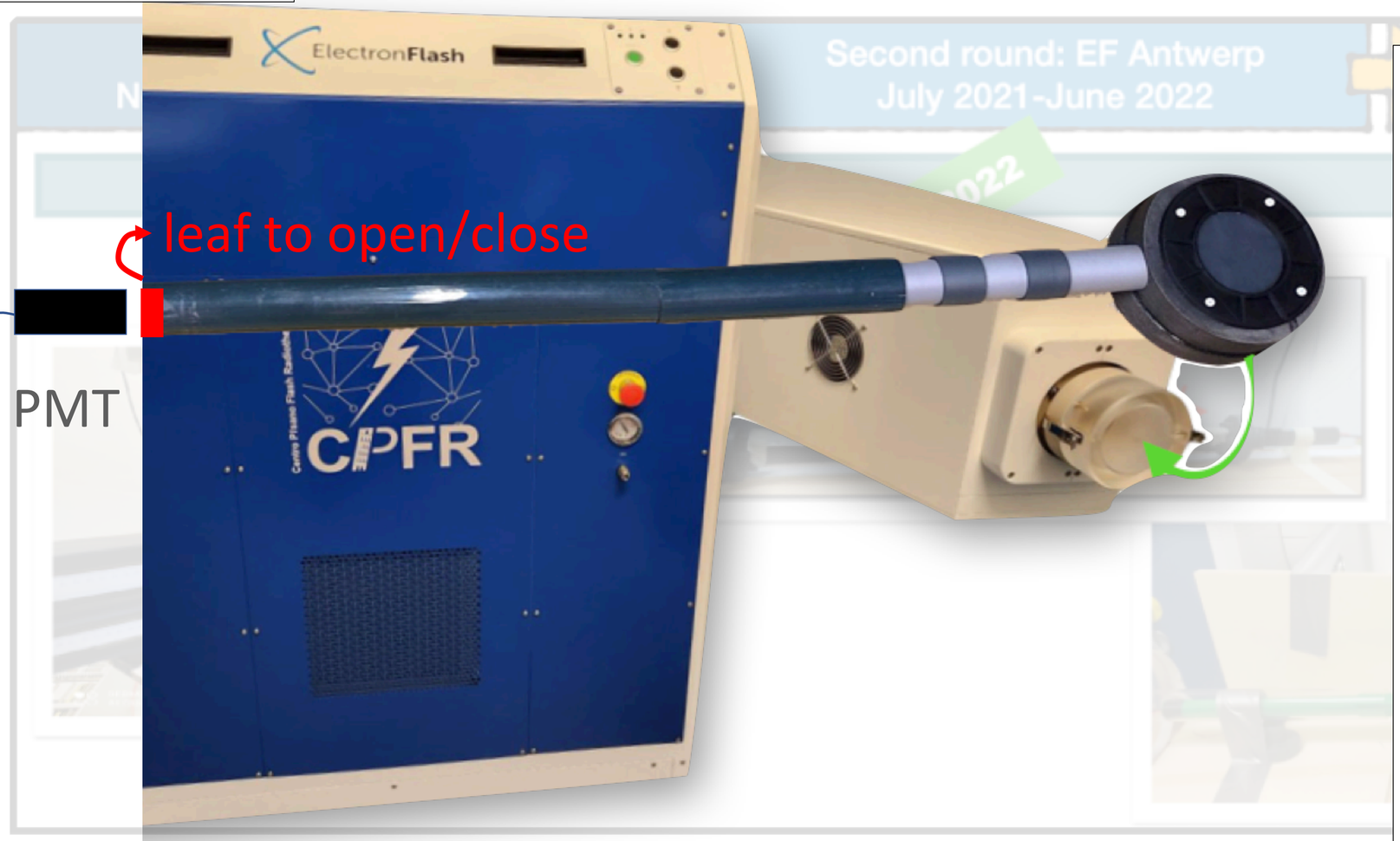


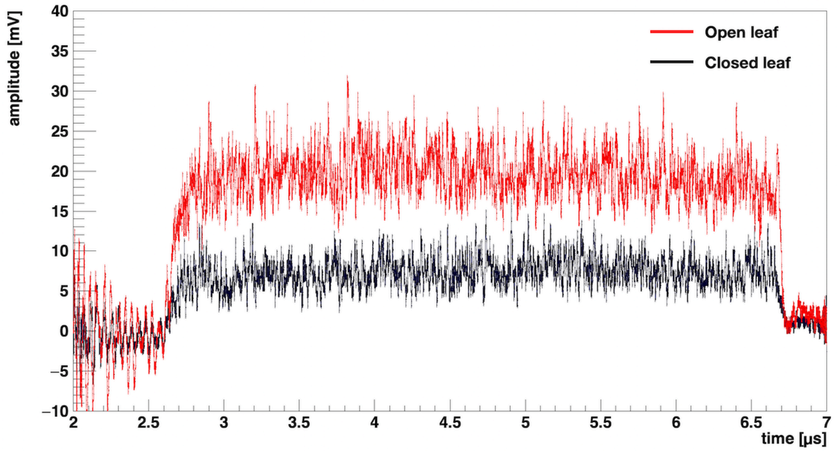
- Device locked to the beam exit window
- Light is produced in the air between the linac exit window and the detector exit window
- A long pipe has been used to transport light while keeping the PMT as far as possible from the beam

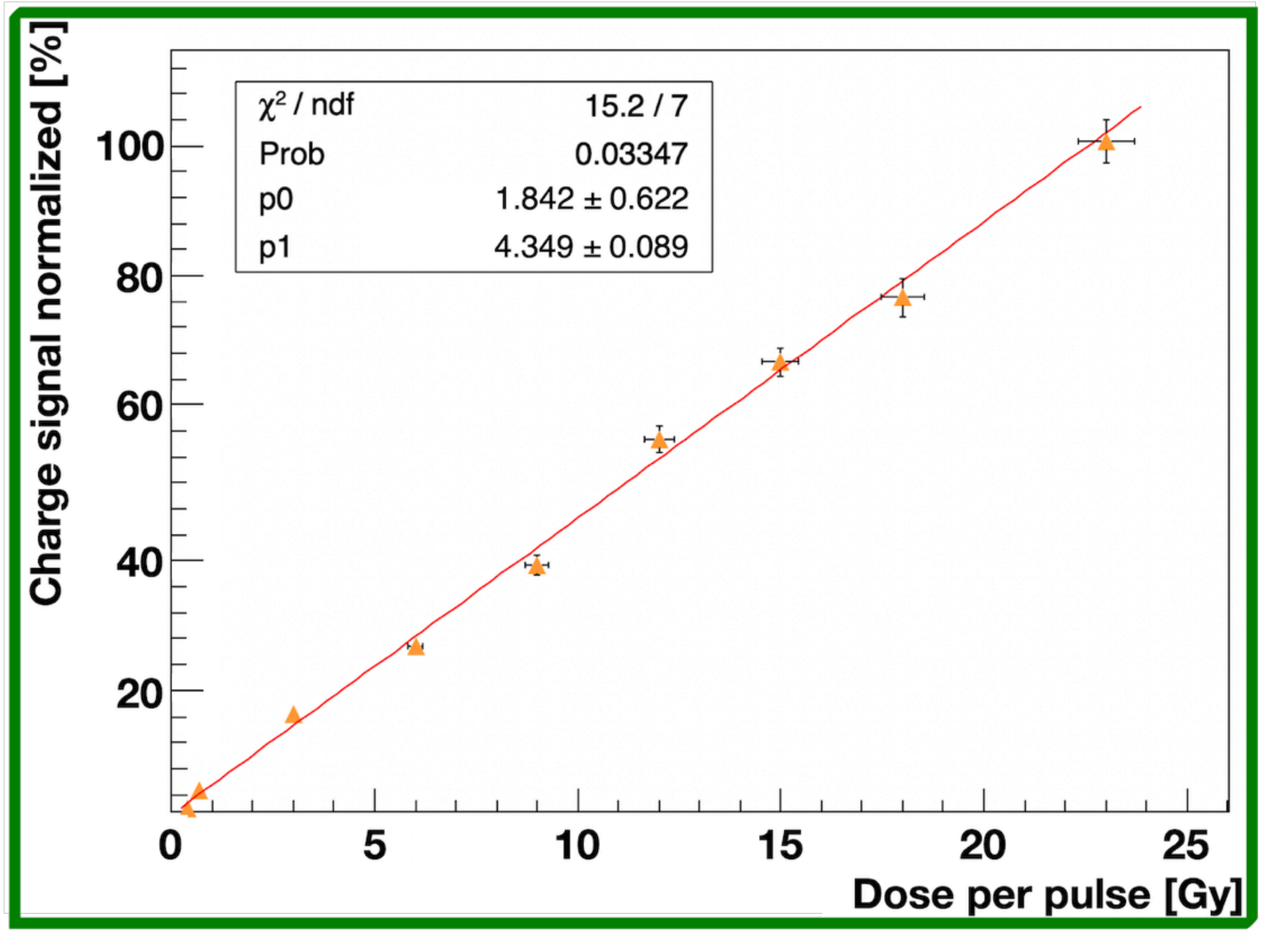
FLASH Radiotherapy with hIgh Dose-rate particle beAms

Test @ CPFR with 9 MeV e- beam

- Linear response with the beam intensity (values ranging from 70 to 120 mA). Noise can be successfully subtracted from the signal.

- **Background** (beam halo, secondaries…) is a sizable portion (~35%) of the total signal. Moreover, the gain of the PMT is still non-optimal for the fluctuations of the signal amplitude.





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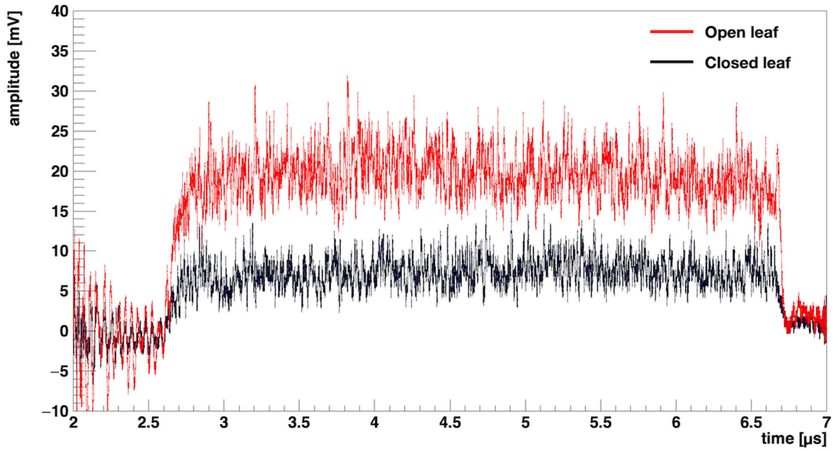
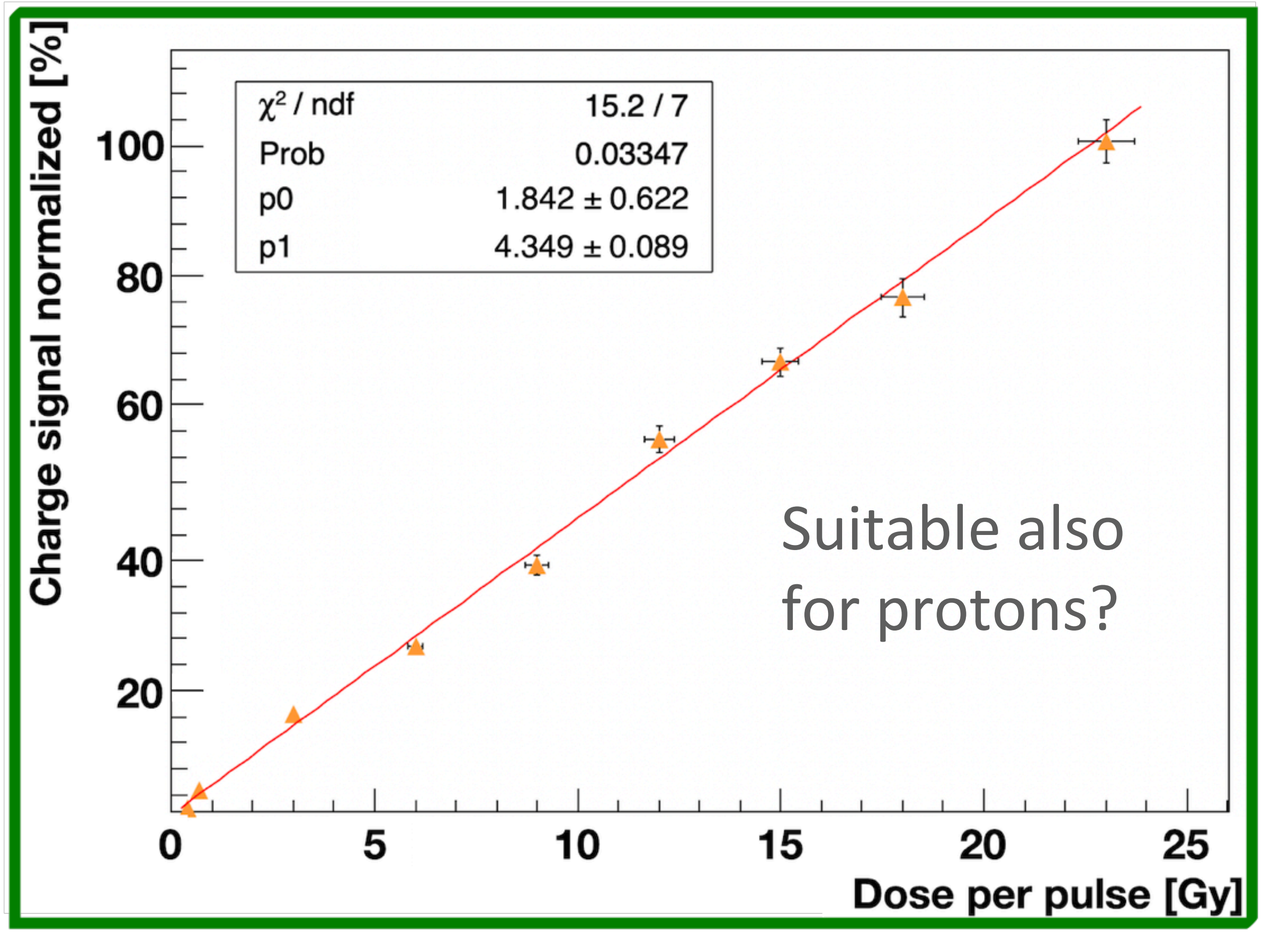
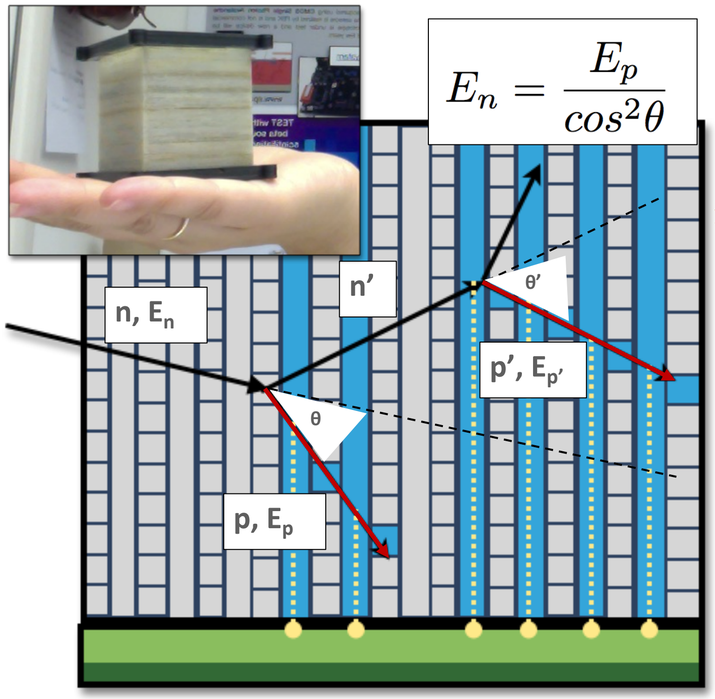


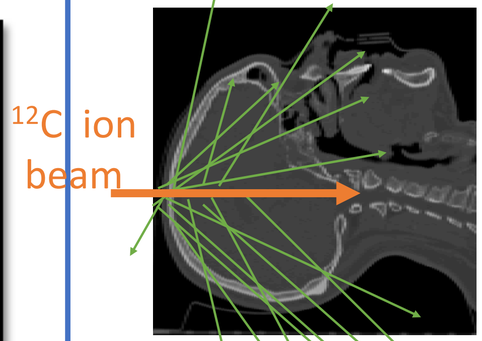


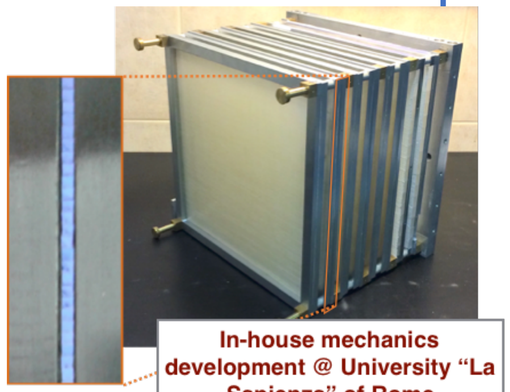
Detection of secondary particles in PT: a quick story

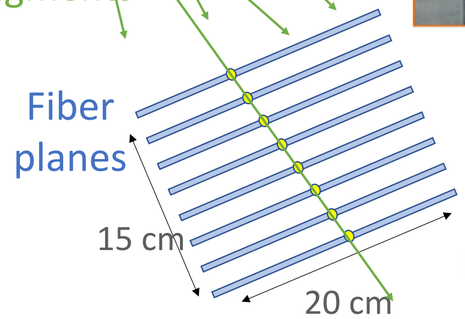


Neutrons characterization (E,θ) in particle therapy

Charged-fragments detection



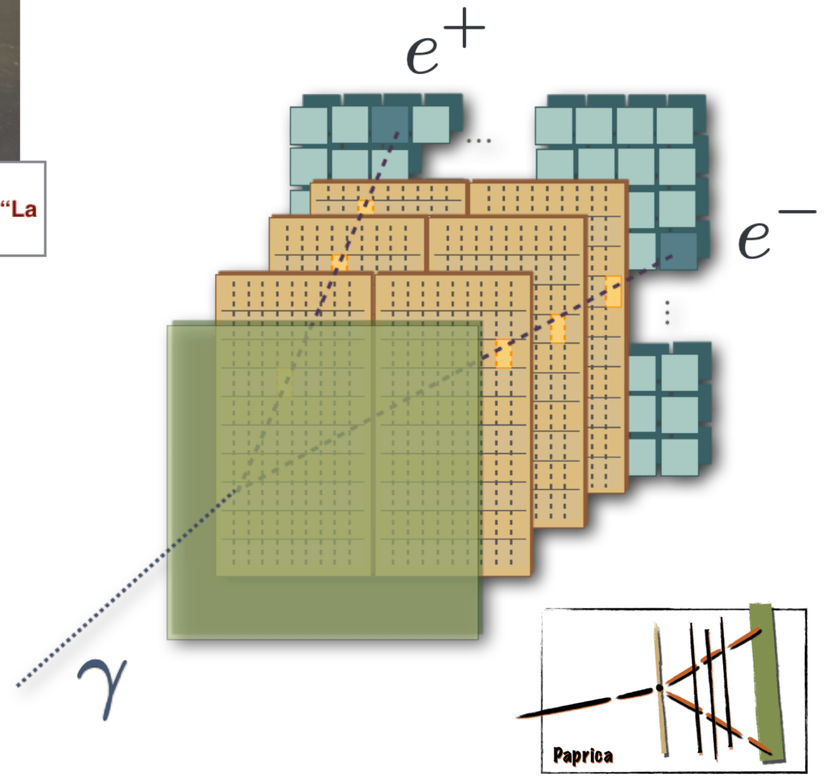




InSIDE

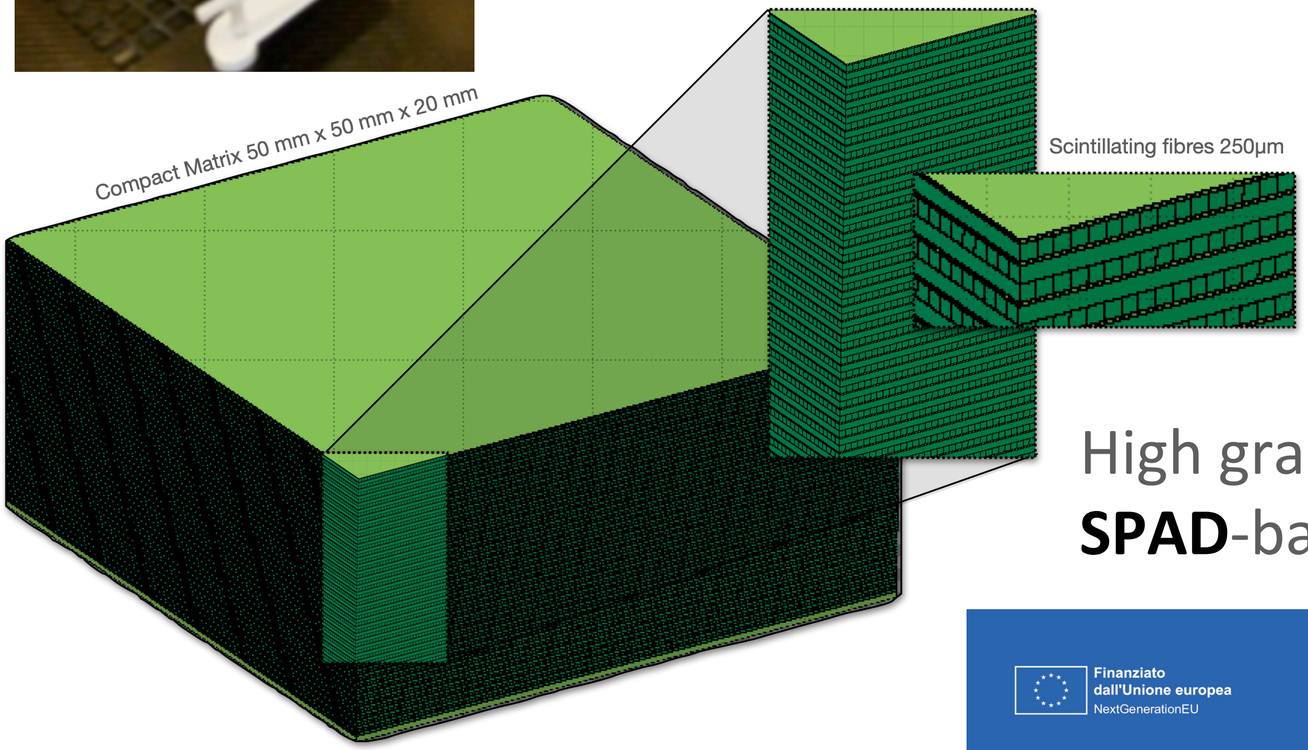
Inter-fractional monitoring, clinical trial @ CNAO ongoing

Prompt-γ detection exploiting pair production



The MULTIPASS project

Plastic scintillating fibers 250 µm thick



- Integrated, compact device that exploits simultaneously the detection of charged fragments, prompt-γ, neutrons
- Multipass will address and overcome the limitation of Dose Profiler (rate capability, limited angular acceptance) and PAPRICA ((limited spatial resolution due to multiple scattering) while providing

High granularity
SPAD-based readout

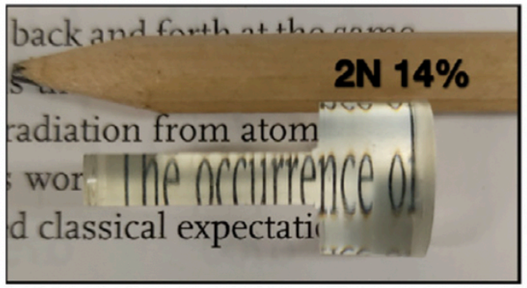
FONDAZIONE BRUNO KESSLER

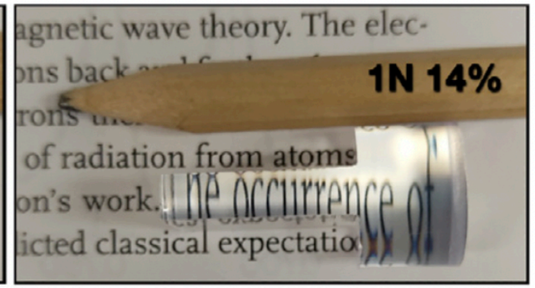
Finanziato dall'Unione europea NextGenerationEU | Ministero dell'Università e della Ricerca | Italiadomani PIANO NAZIONALE DI RIPRESA E RESILIENZA | INFN

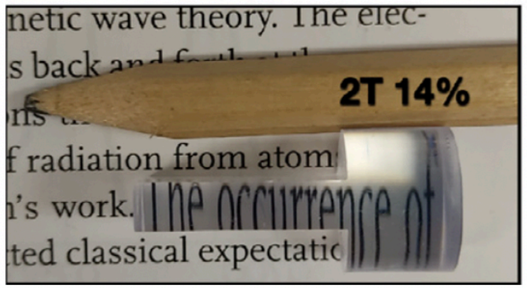
New fast plastic scintillator: the TOPS project

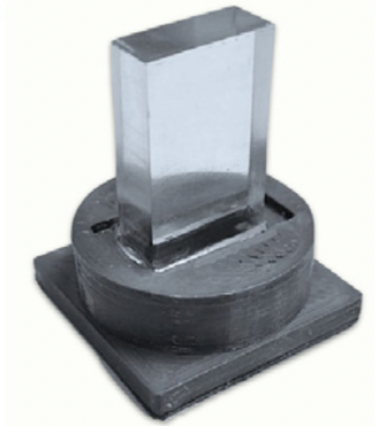
- Plastic scintillators consist principally of a **fluorophore**, responsible for the absorption and conversion of the kinetic energy of the particles into lower-energy light radiation and, sometimes, a wavelength shifter dissolved in a plastic polymer matrix. Obtaining homogeneous, light, machinable, transparent and high-performance plastic objects is one of the main challenges of **TOPS (*Time Of flight Plastic Scintillator)*** *research line*

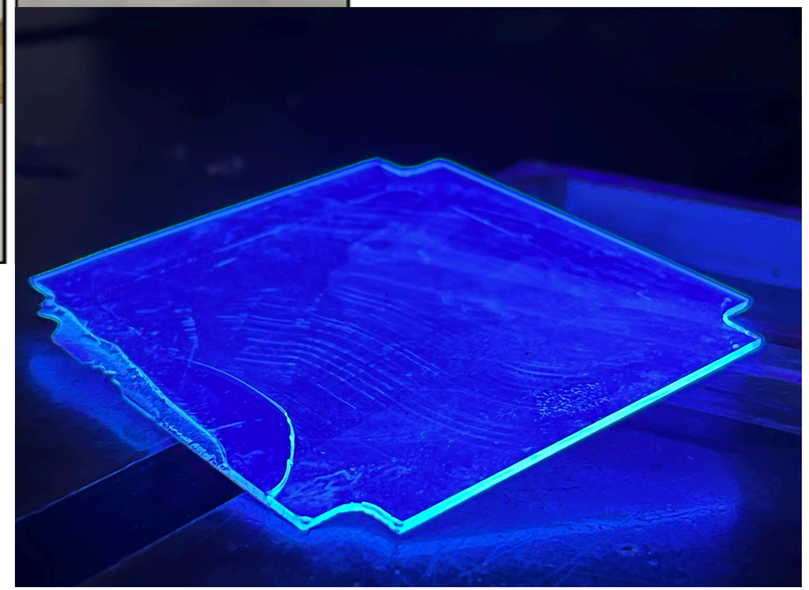
- Different scintillators have been realised in samples of a shape suitable for systematic timing measurements



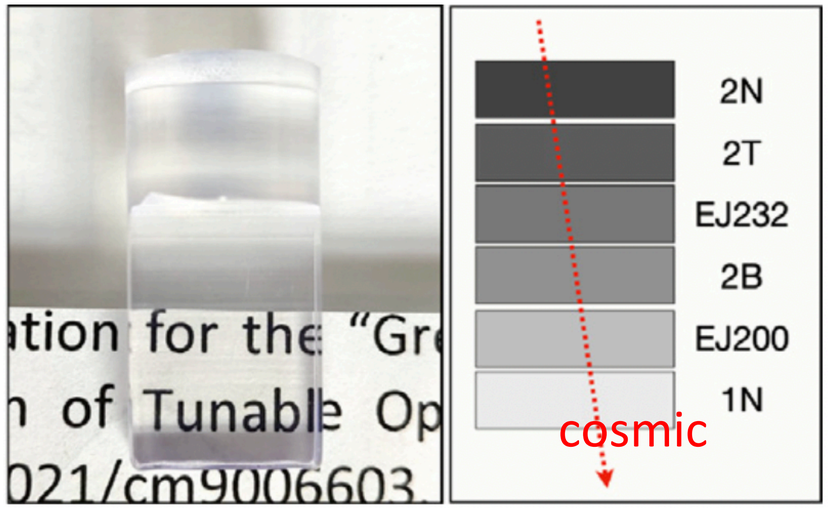




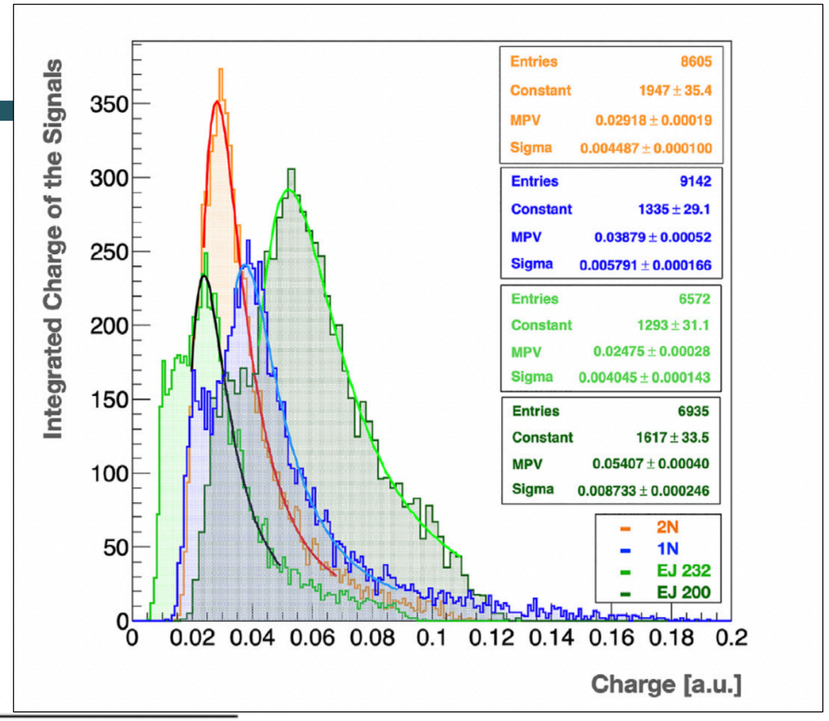




Test with cosmic rays



Readout
PMTs -
Hamamatsu
H10721-20



Samples	Primary dopant %	Wavelength Max emission [nm]	Light output % EJ232	Time resolution [ps]
EJ-232	–	370	100	123
EJ-204	–	408	220	211
2N	14	405	118	81
2T	14	–	245	97
1N	14	414	157	102
2B	14	420	160	110

Great interest in testing with ion beams for time of flight applications (FOOT?)

Rocco et al., https://doi.org/10.1016/j.nima.2023.168277

Conclusions

Several activities concerning different applications carrying on in the context of several INFN, CREF and Sapienza projects have been profited and could profit from the collaboration with the Trento facility in the next future.

Thanks for your attention!