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Fast plastic scintillator and SiPM based devices for FLASH beams monitoring

Victor Buridon

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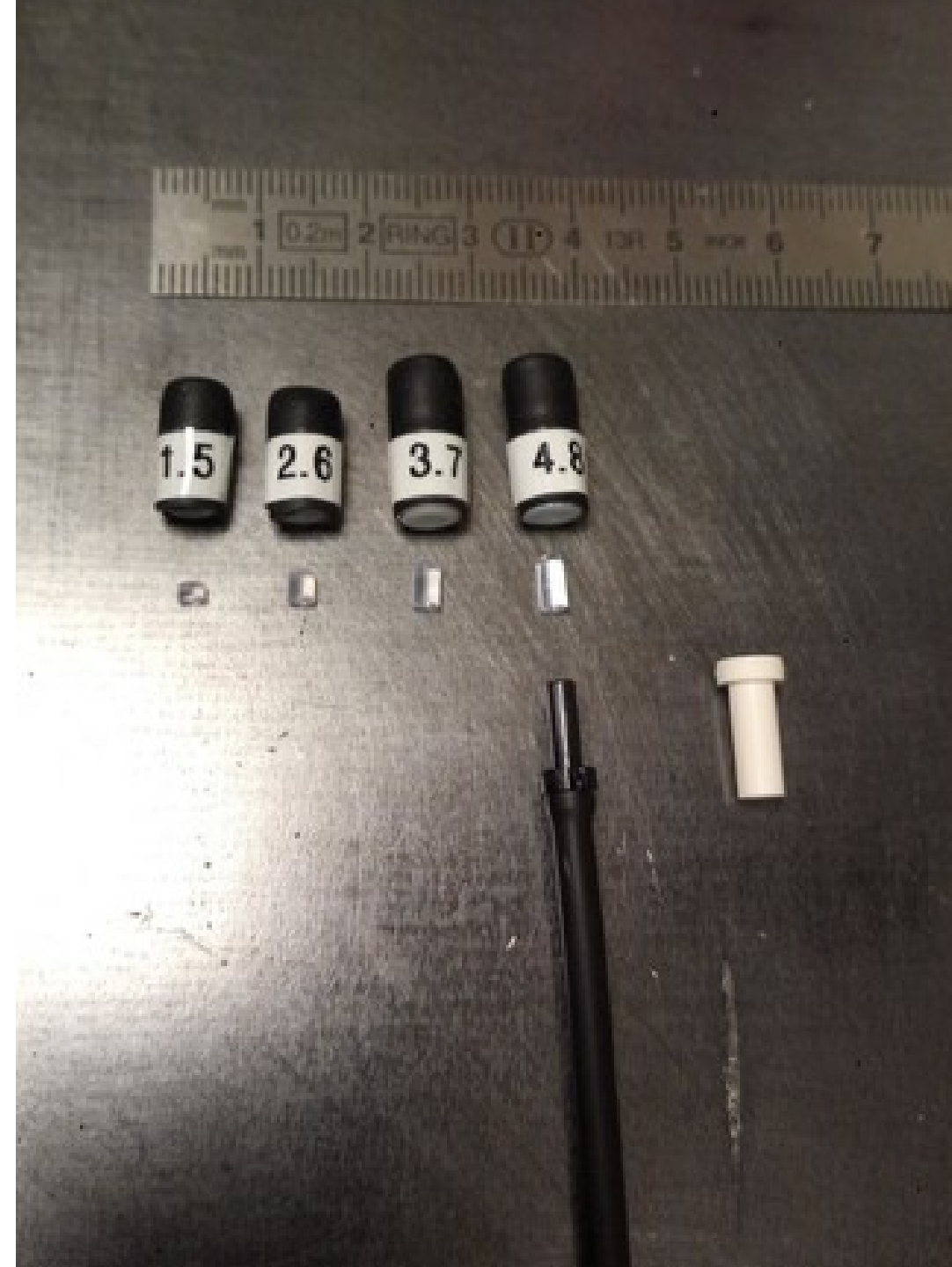
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Fast plastic scintillator and SiPM based devices for FLASH beams monitoring

V. Buridon



Summary

1.Context

2.Motivations and contents

3.Results

4.Conclusions and future developments

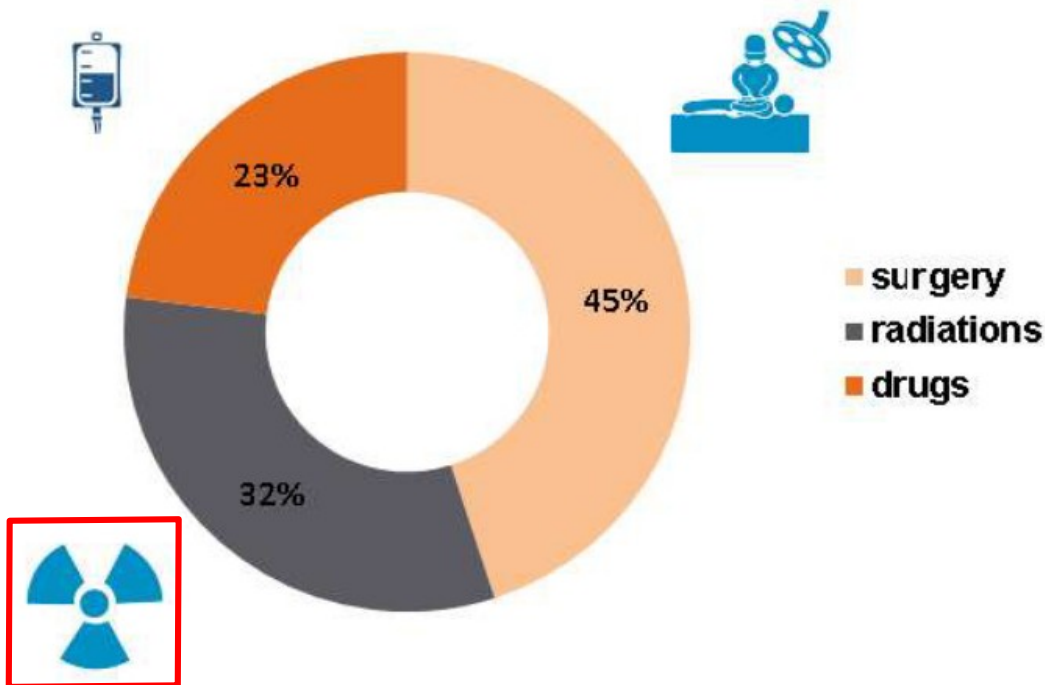




1 ■ Context

General context

Treatments techniques against solid tumors



Techniques used in conformal radiotherapy

- LINACS with low energy e^- beams.
- LINACS with intra-operative e^- RT.
- Carbon ions (high LET particles).
- Protons beams (cyclotrons ...).
- Very High Energy e^- beams (VHEE).
- X rays (synchrotron or X ray tubes).

→ **Conventional and FLASH Beams**

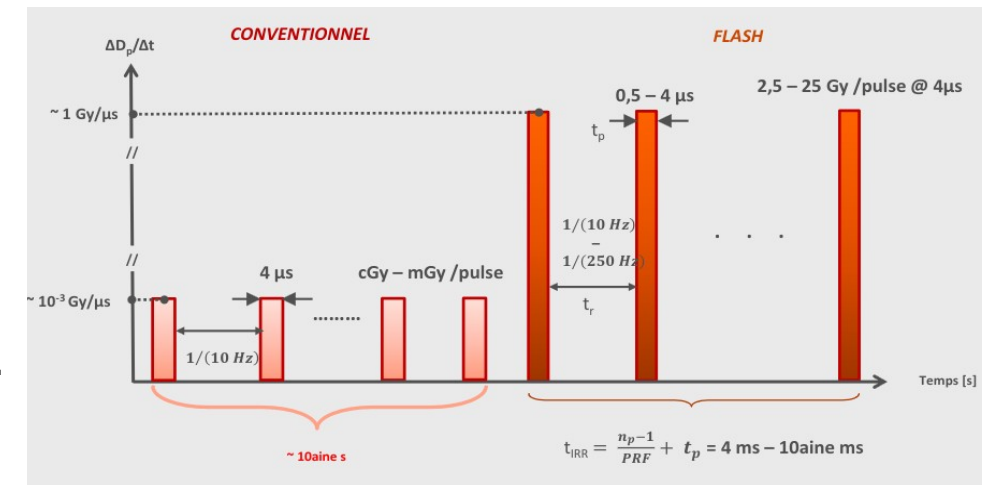
Conventional and FLASH Beams



- Install in September 2020 in Centre de Recherche – Orsay



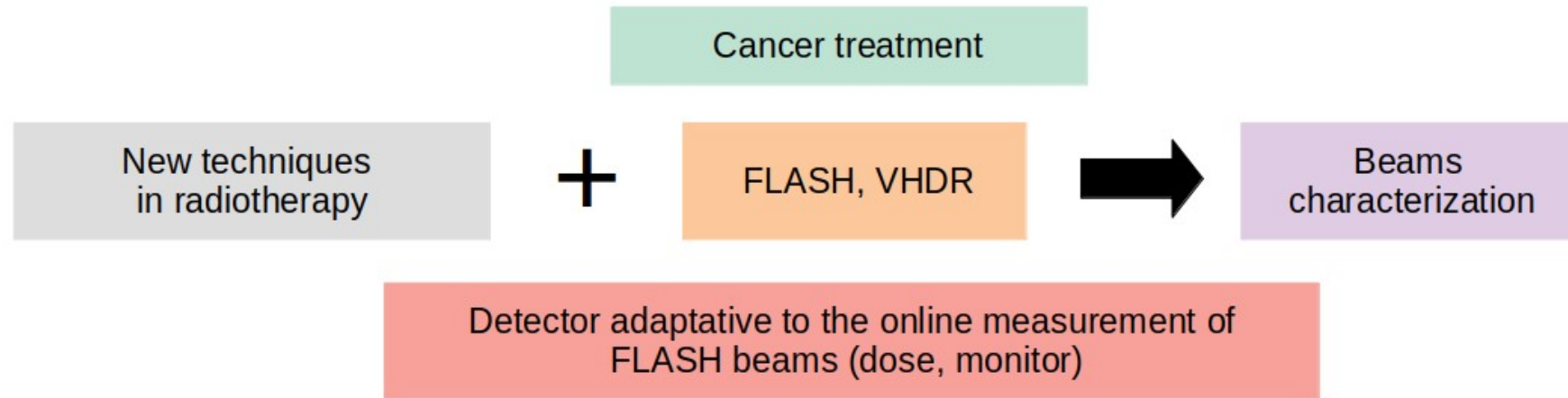
- Only electrons 5MeV or 7MeV.
- 2 modes : conventional and FLASH.
- Specific monitor system for each mode.
- Field size between 12cm and 1cm of diameter (applicators).
- Dose flowrate between 0.1-1000Gy/s on the field of diameter 10cm.
- Dose/pulse : [1,25] Gy/pulse.





2 ■ Motivations and contents

Problematic



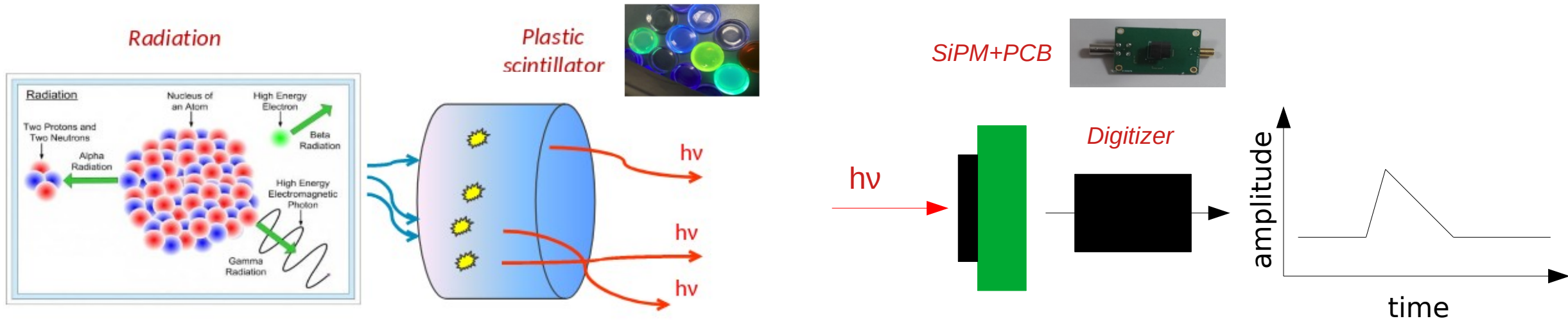
Difficulties in FLASH beams :

- Saturation of existing dosimeters :
 - Ionisation chambers
 - diodes
- EBT (passive dosimeters) not adapted for clinical uses.

Alternative technology :

- Coupling chemically modified scintillator with a SiPM.
- Requirements :
 - Twin-device without scintillator to estimate the Cerenkov contribution.
 - Wave guide to export the electronics out of beam.

Dosimeters properties and specifications



ASTROLABE project : **f**ast **S**cin**T**illato**R** based device for **O**n line **FLASH** **B**Eam dosimetry.

Scintillator characteristics

- High scintillation yield.
- Linearity between light yield and radiation energy.
- High transparency to the scintillation light.
- Fast response
- Good spectral matching
- High stability in harsh environment.

Point dosimeter specifications

- Temporal resolution : 5-10ns (1% of precision for a pulse of 1 μ s).
- $\lambda_{\text{emission}}$: [420-600]nm.

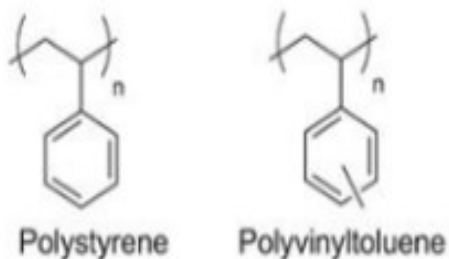


3 ■ Results

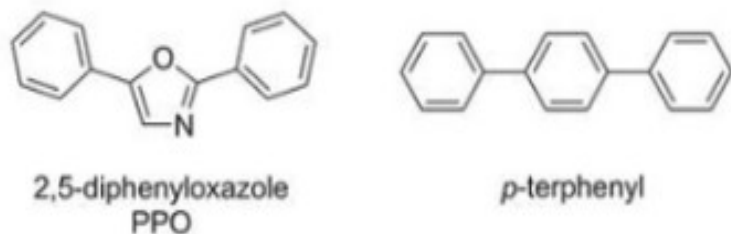
Fast plastic scintillators synthesis



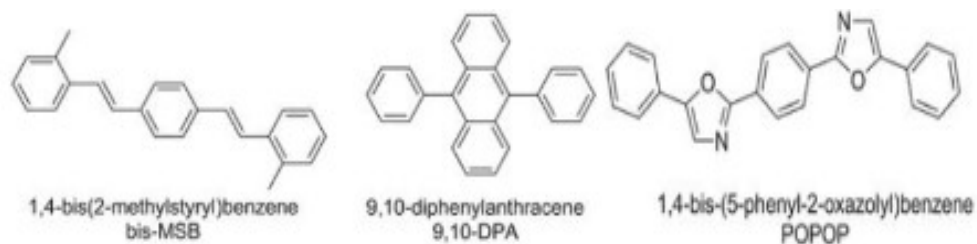
Polymer matrice



Primary fluorophore

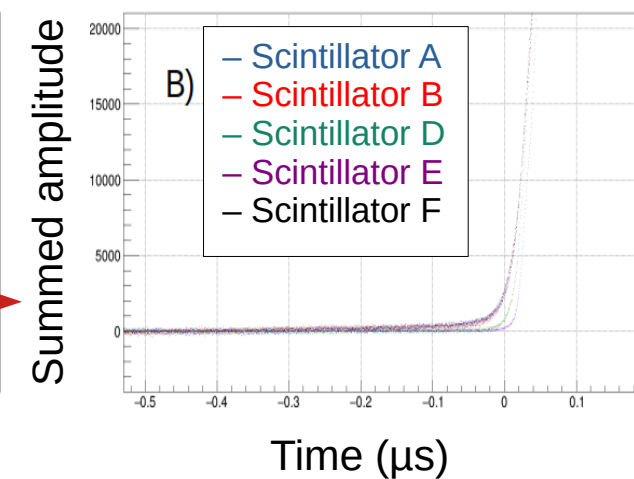
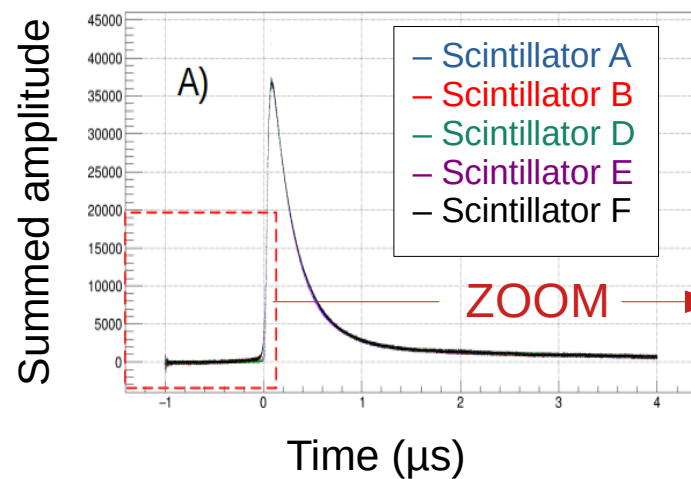
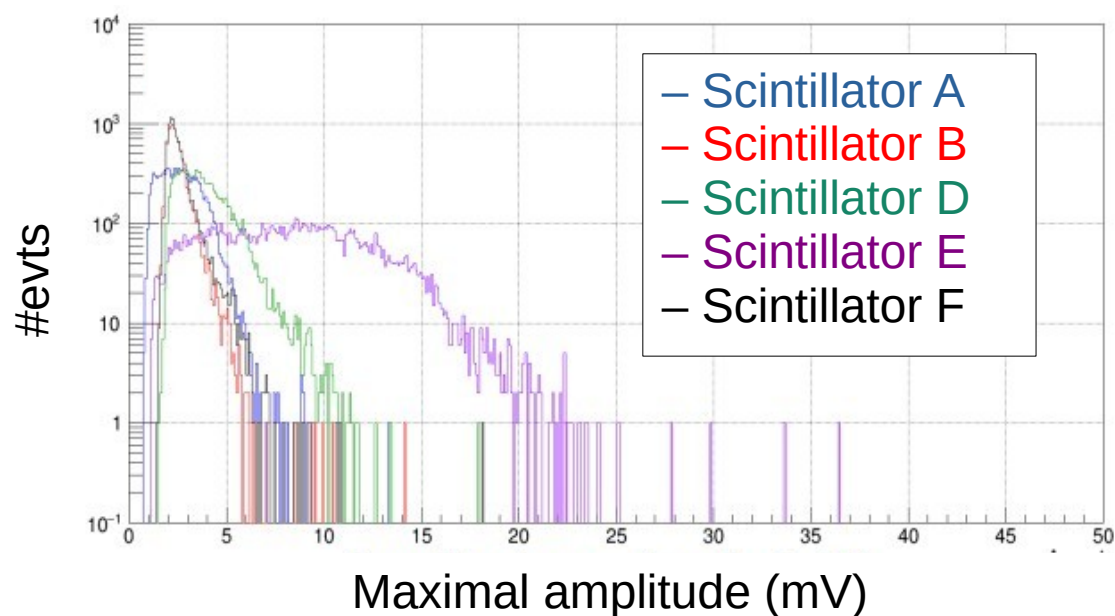
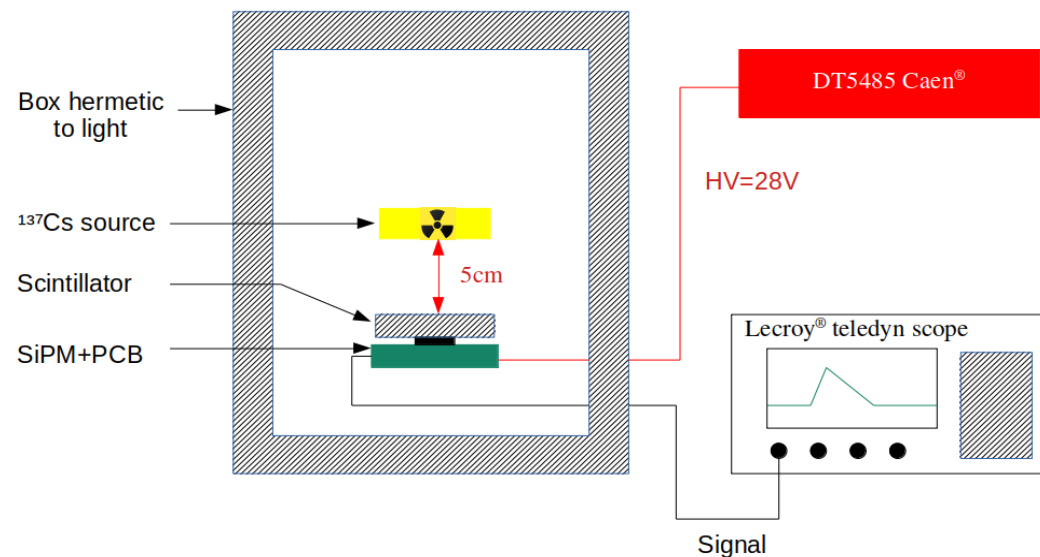
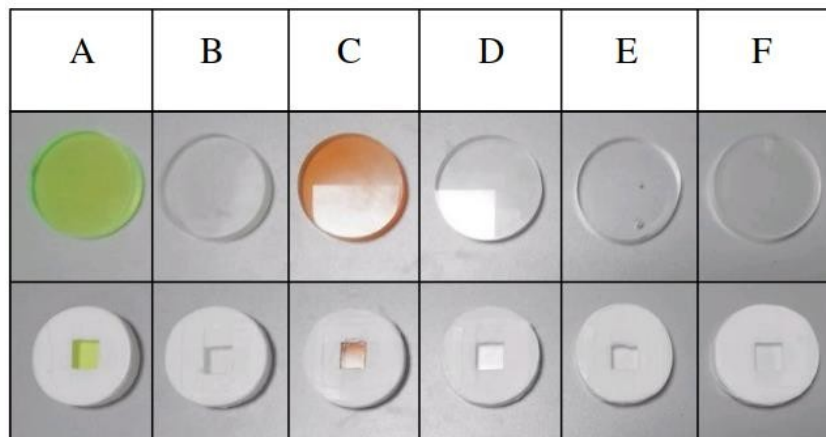


Secondary fluorophore



Scintillators	Chemical composition (%)	λ_{\max} emission (nm)
A	99.9% Styrene 0.1% CM30	474
B	99.9% Styrene 0.1% BBQ	389
C	99.9% Styrene 0.1% DCM	551
D	99.9% Styrene 0.1% PBD	382
E	96.9% Styrene 3% PPO 0.1% MSB	445
F	99.9% Styrene 0.1% Pterphenyl	383

Scintillators characterization and selection



Set-up assembly (point dosimeters)



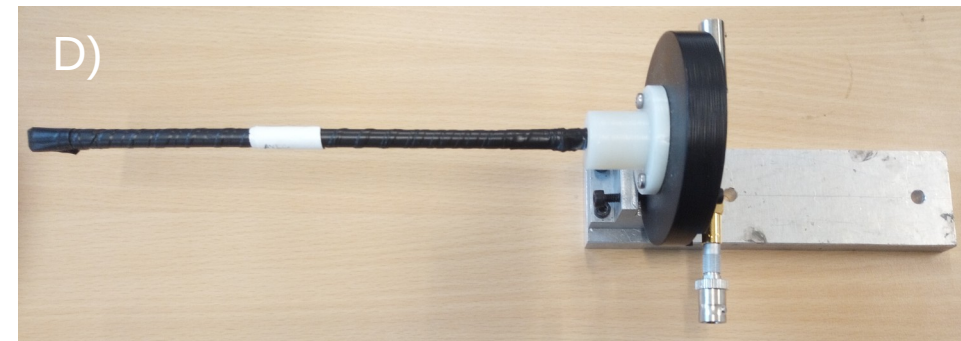
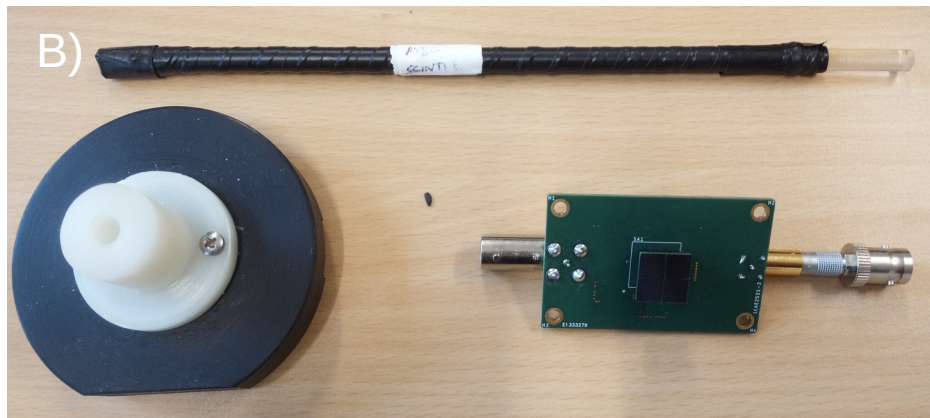
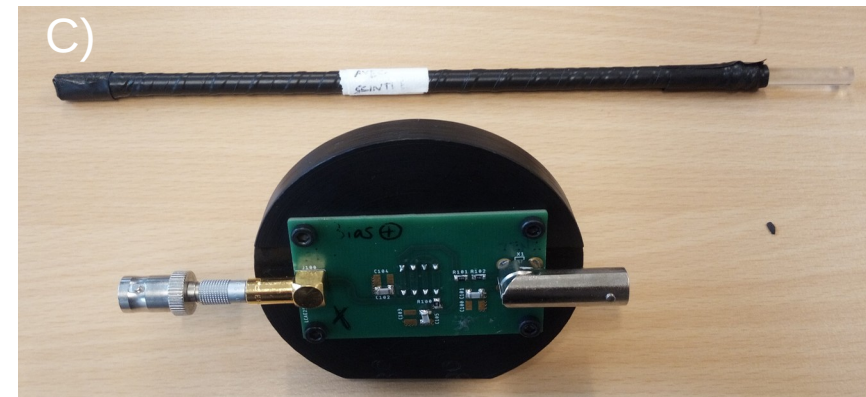
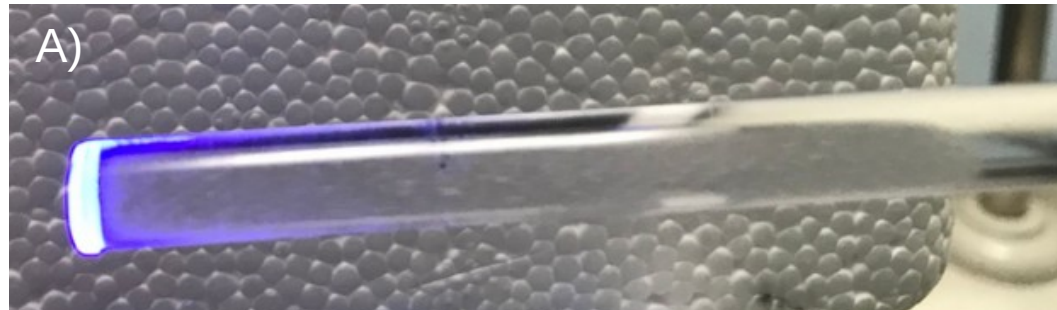
Scintillator E
(Length : 0.6mm, Diam. : 6mm)

PMMA wave guide
(Length : 23cm, Diam. : 6mm)

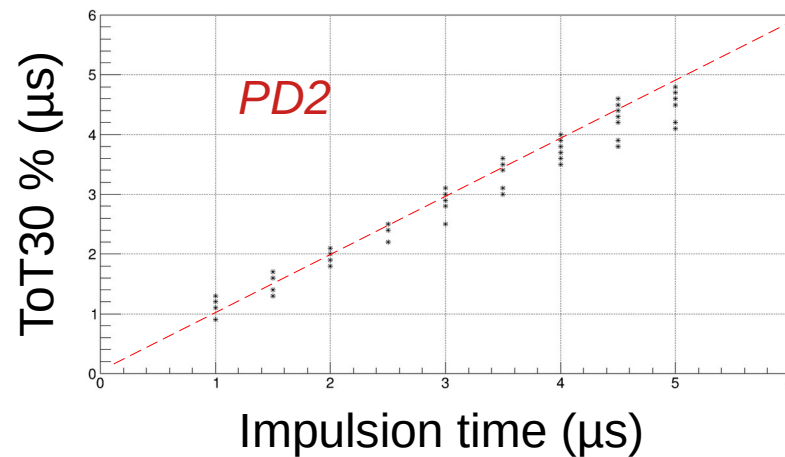
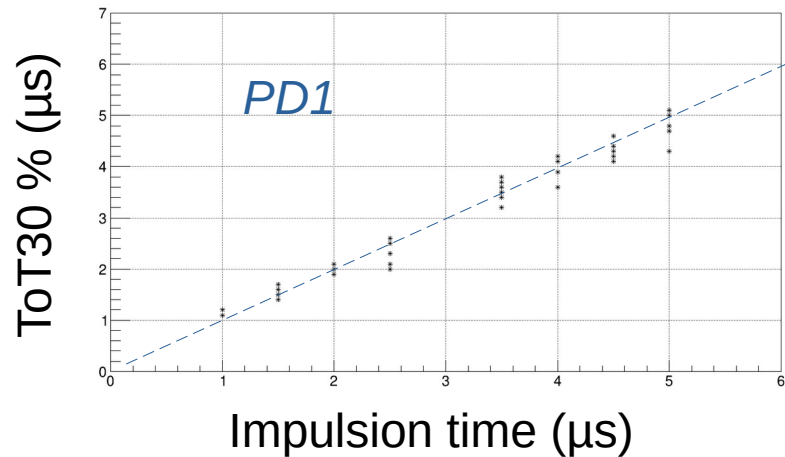
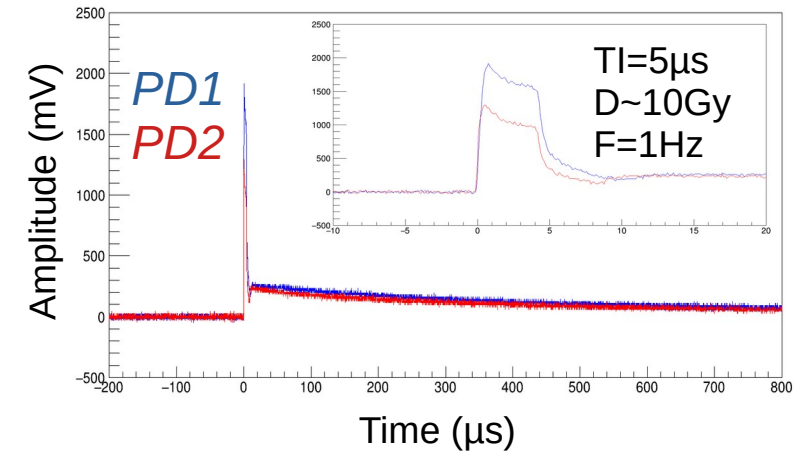
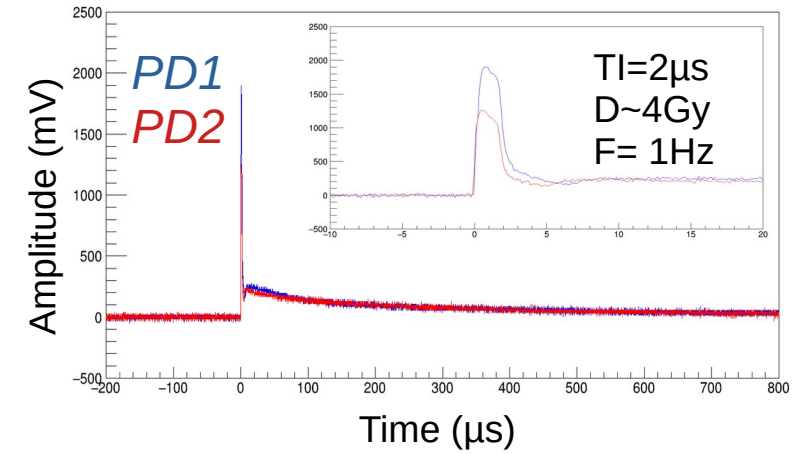
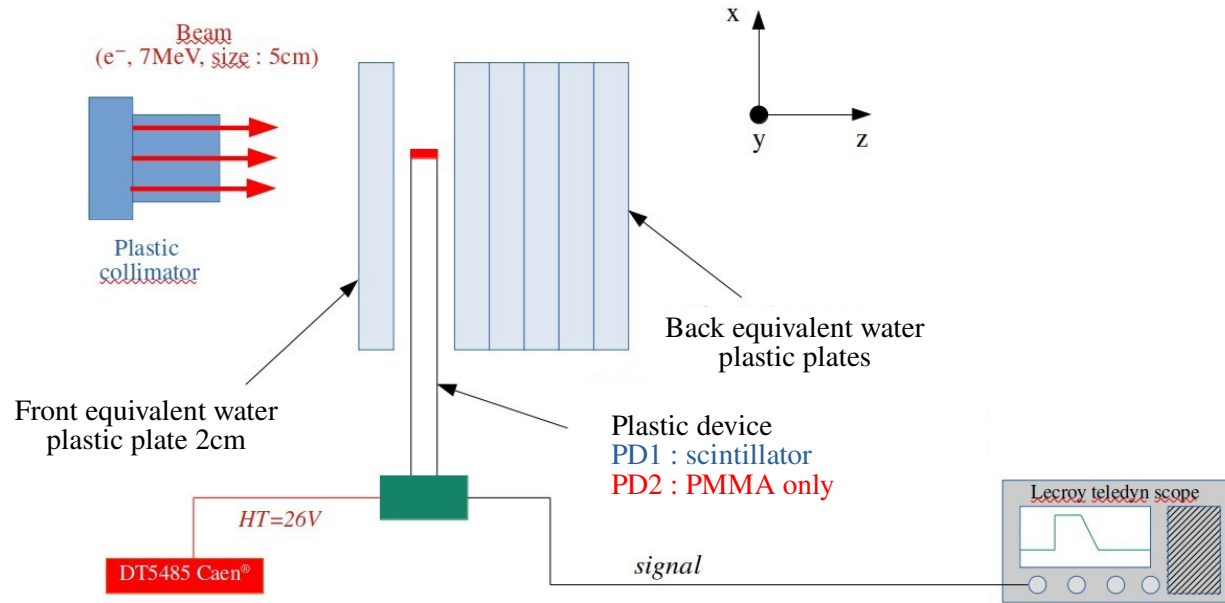
SiPM

Digitizer or
scope

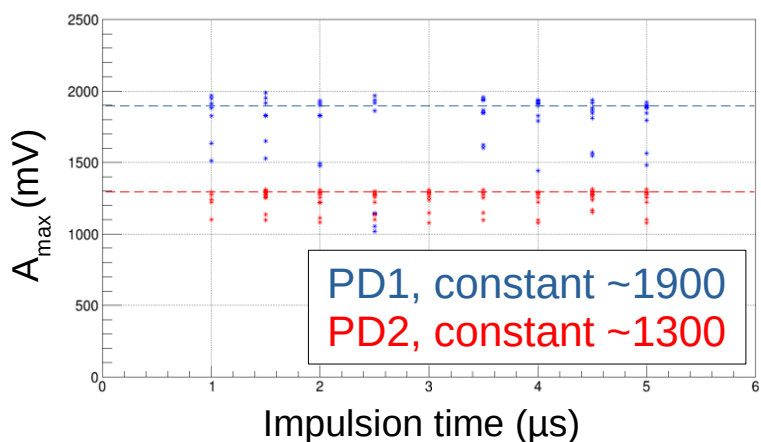
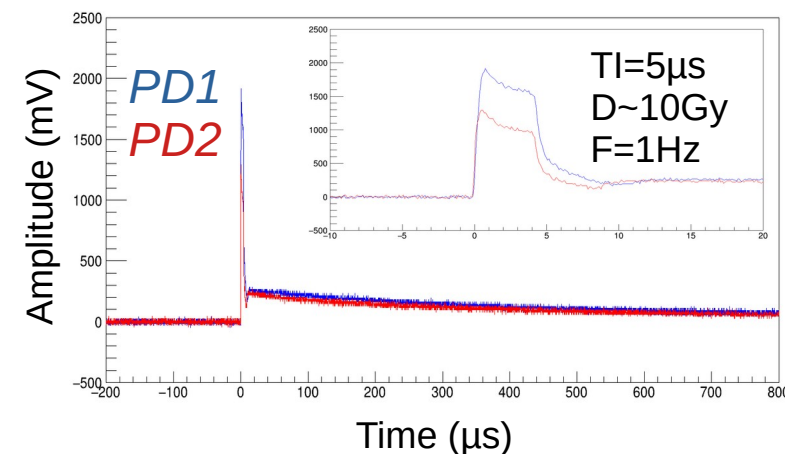
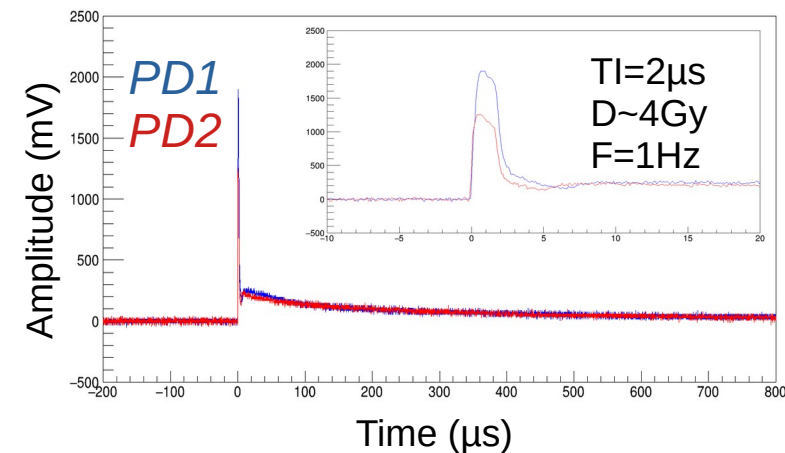
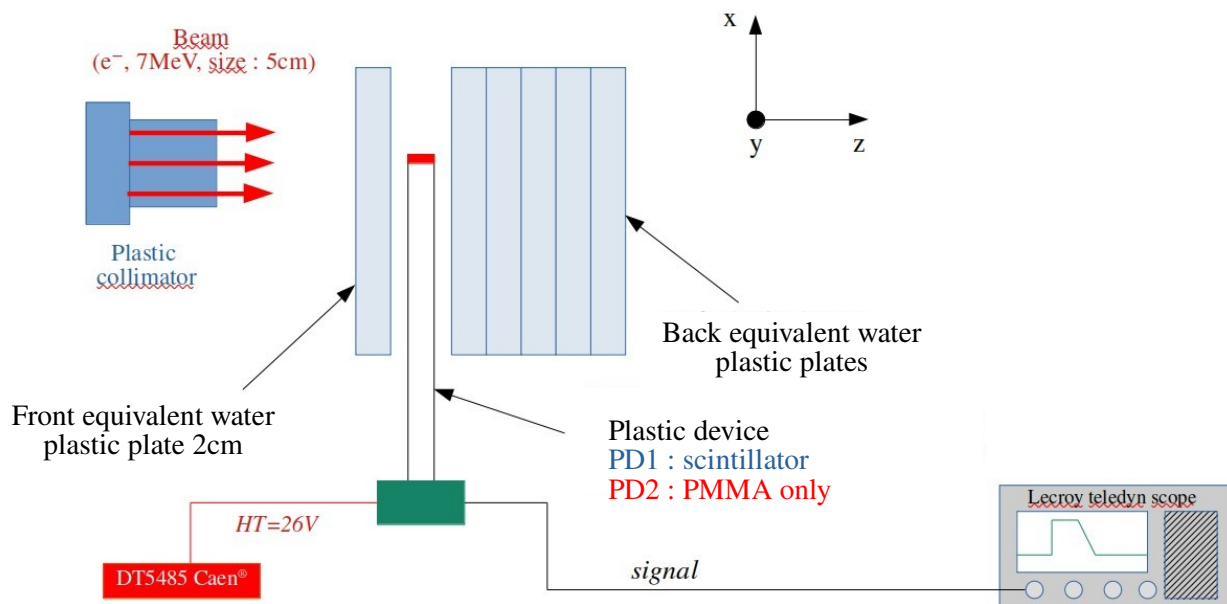
Computer



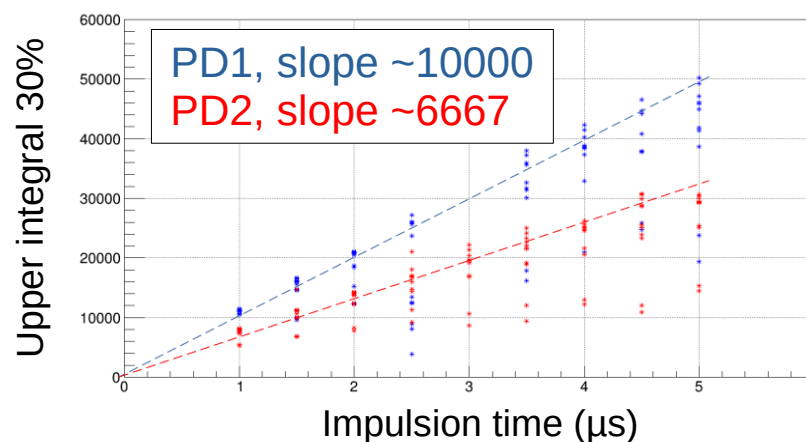
Measurements on FLASH Beam



Measurements on FLASH Beam

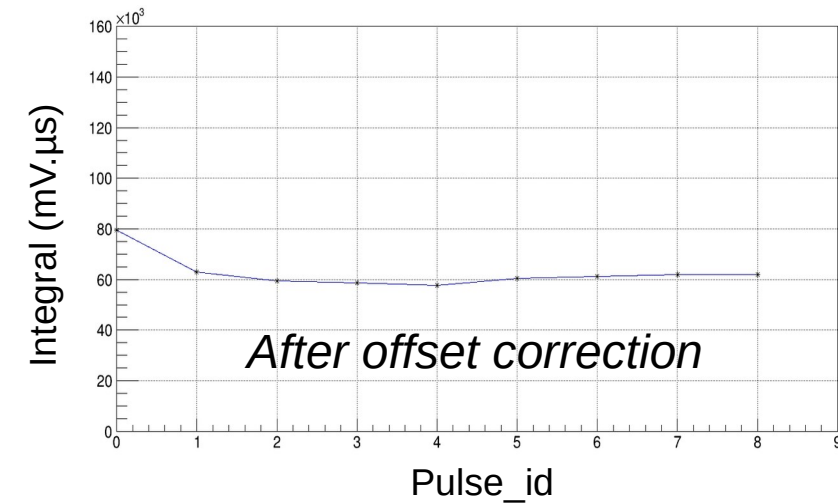
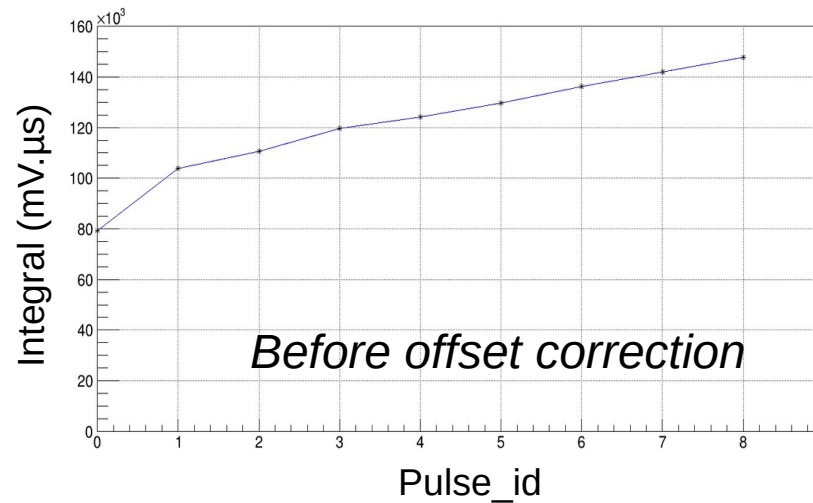
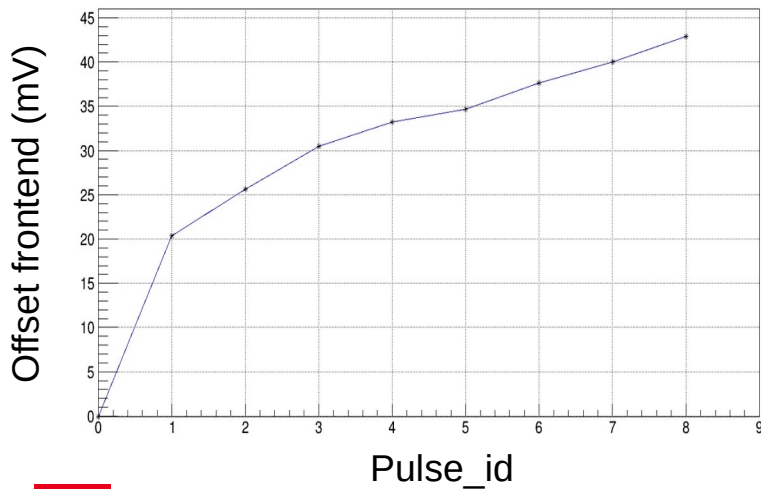
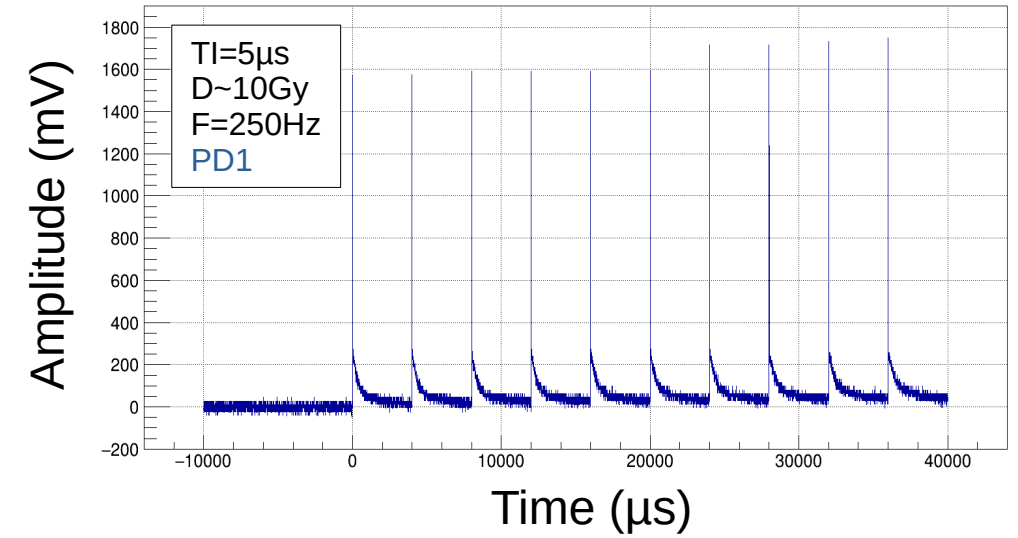
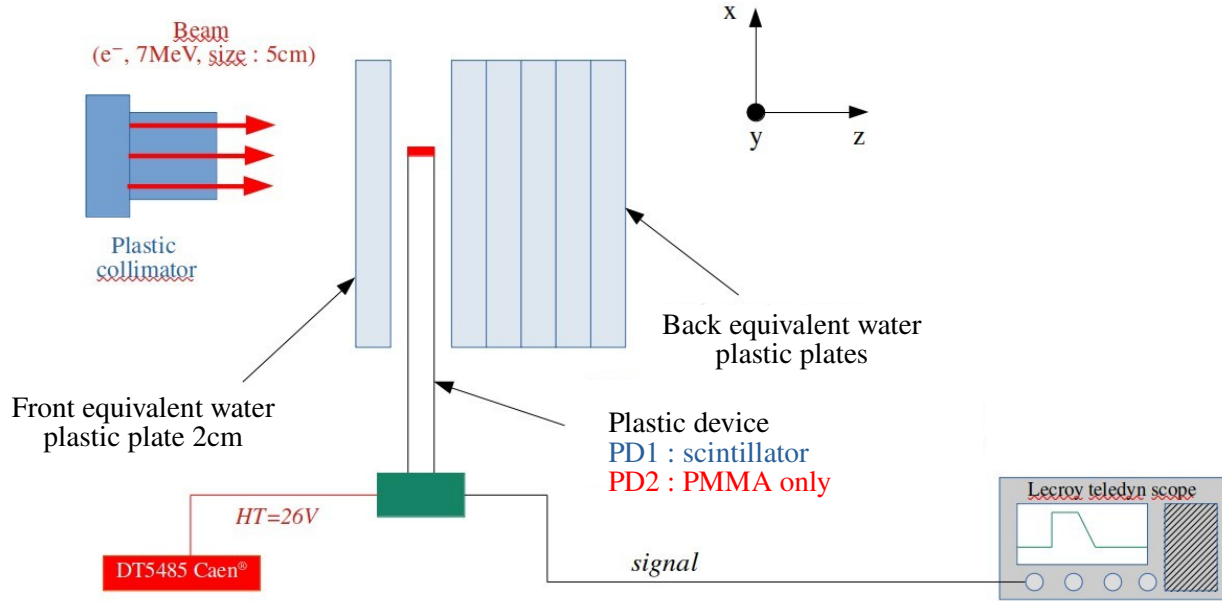


Cerenkov = 68.42%



Cerenkov = 66.67%

Measurements on FLASH Beam





4 ■ Conclusions and future developments

Conclusion and future developments

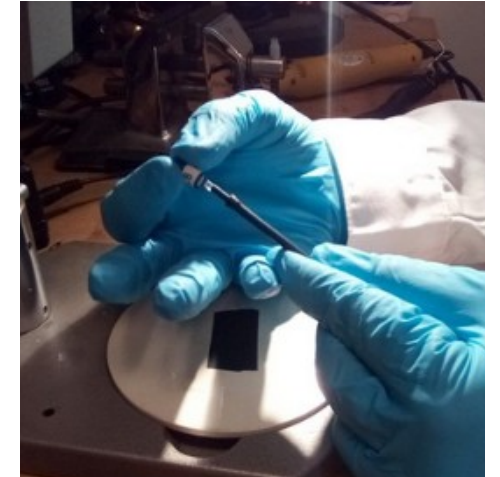
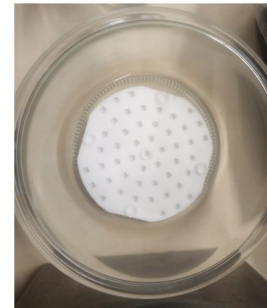


list



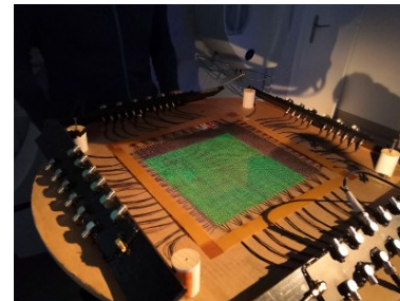
Point dosimeter

- Setup modification
 - scintillator **molding**
- Modification of **chemical formulation**
- Improvement of signal readout
 - using “**fast**” output of SiPMs
 - set-up **shielding**
- Mounting set-up using **PMMA fiber** as wave guide
 - Measurements carried out on **FLASH beams**.



FLASH Beam monitor

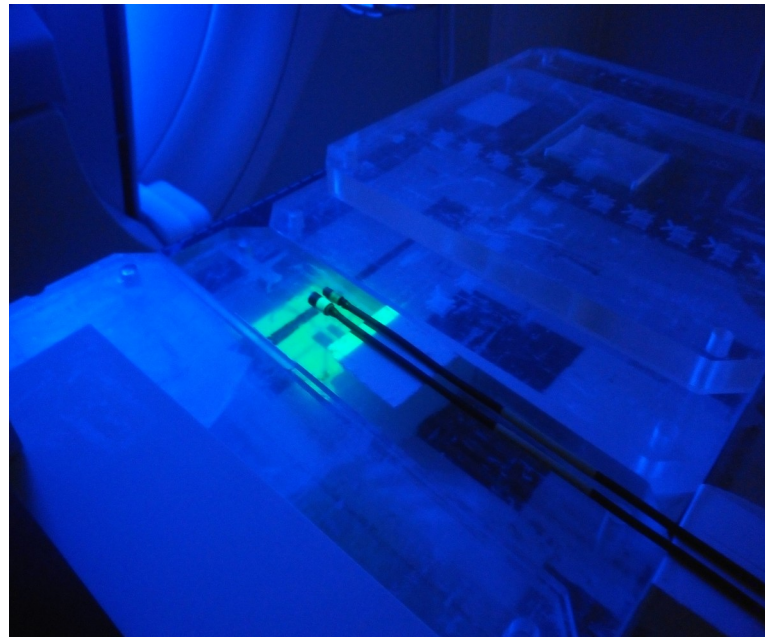
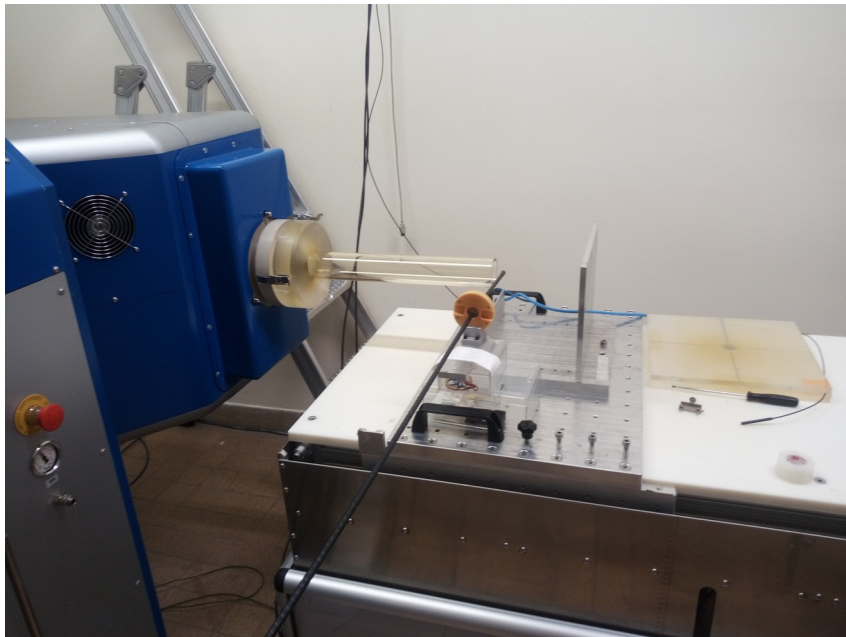
- Setup based on fibers “carpet”.



Aknowledgement



*M. Agelou, G. H. V. Bertrand, G. Boissonnat, V. Buridon, C. Lynde, J. J. Nahimana, J. Plagnard, D. Tromson
A. Bonfrate, S. Heinrich, S. Kaur, A. L. Patriarca, L. De Marzi*





Thank you for your attention