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# Fast plastic scintillator and SiPM based devices for FLASH beams monitoring

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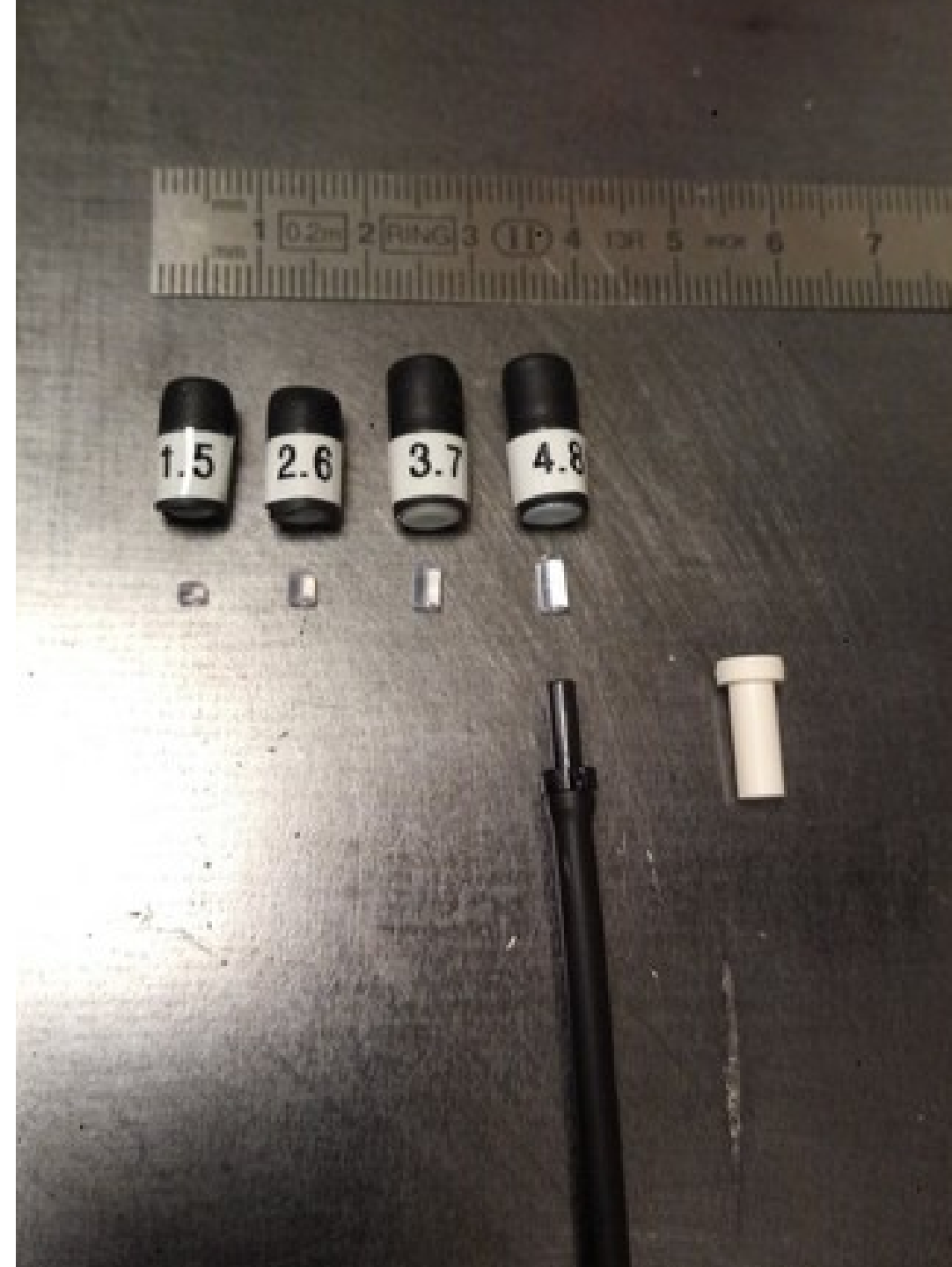
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Fast plastic scintillator and SiPM based devices for FLASH beams monitoring

V. Buridon



# Summary

1.Context

2.Motivations and contents

3.Results

4.Conclusions and future developments

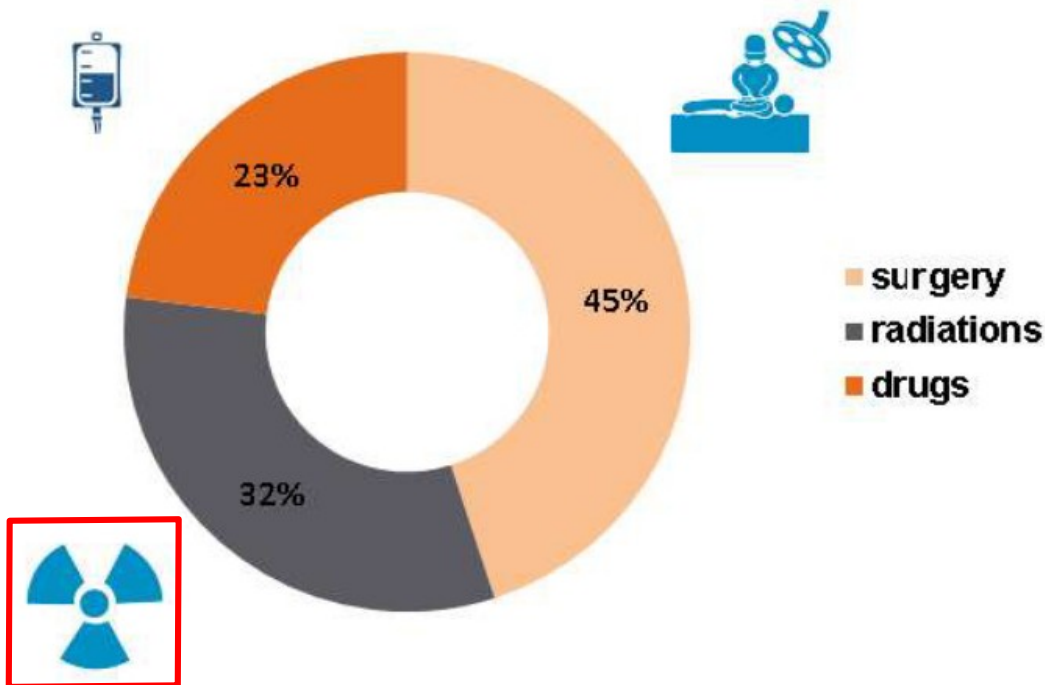




# 1 ■ Context

# 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**

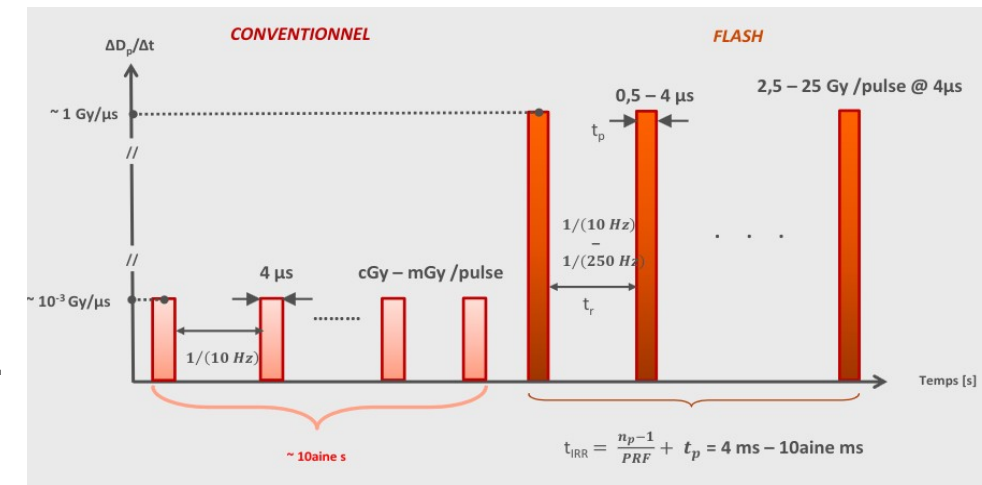
# Conventional and FLASH Beams



- Install in September 2020 in Centre de Recherche – Orsay



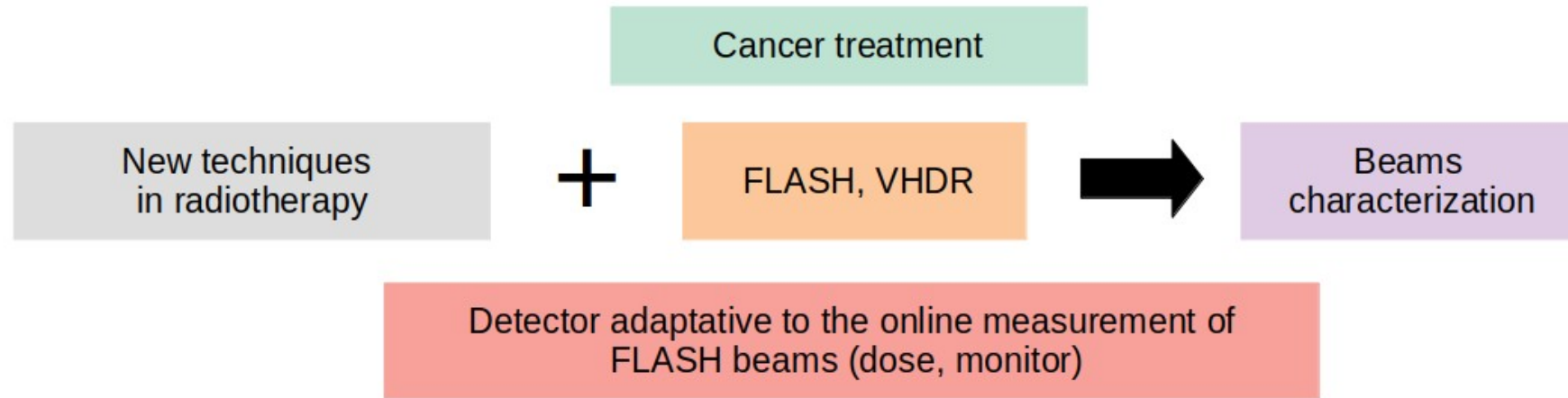
- Only electrons 5MeV or 7MeV.
- 2 modes : conventional and FLASH.
- Specific monitor system for each mode.
- Field size between 12cm and 1cm of diameter (applicators).
- Dose flowrate between 0.1-1000Gy/s on the field of diameter 10cm.
- Dose/pulse : [1,25] Gy/pulse.





# 2 ■ Motivations and contents

# Problematic



## Difficulties in FLASH beams :

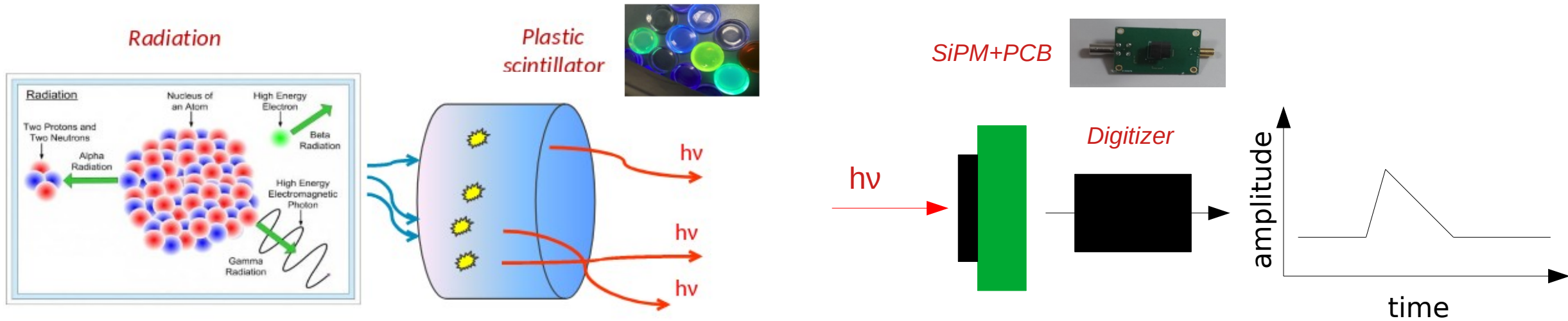
- Saturation of existing dosimeters :
  - Ionisation chambers
  - diodes
- EBT (passive dosimeters) not adapted for clinical uses.

## 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** **BE**am 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 $\mu$ s).
- $\lambda_{\text{emission}}$  : [420-600]nm.

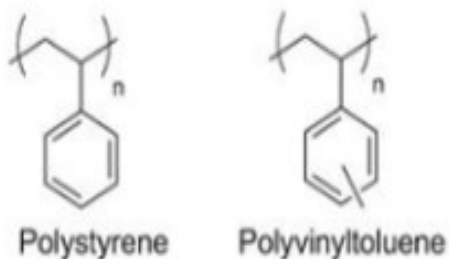


# 3 ■ Results

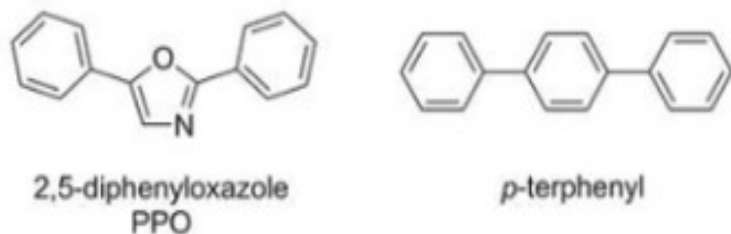
# Fast plastic scintillators synthesis



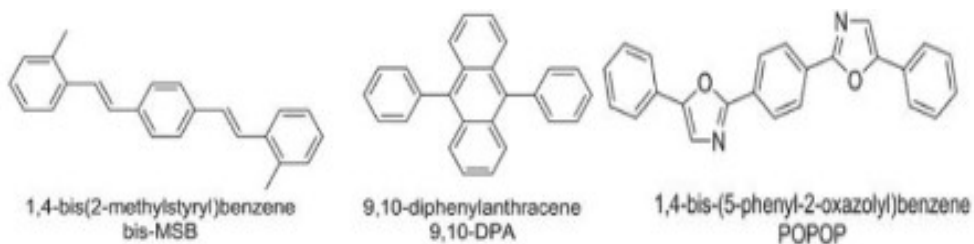
## Polymer matrice



## Primary fluorophore

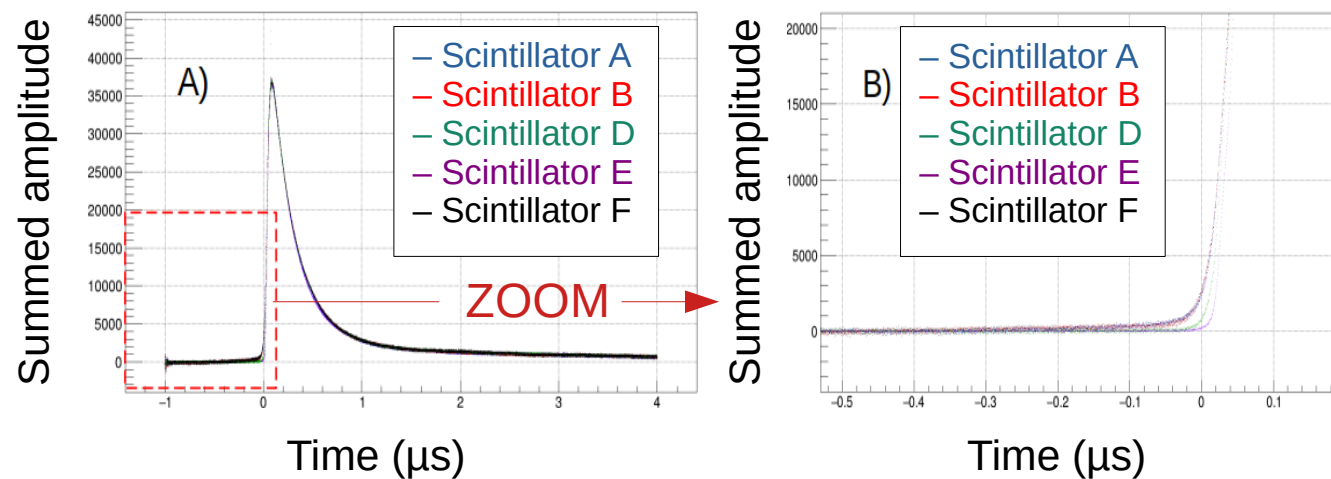
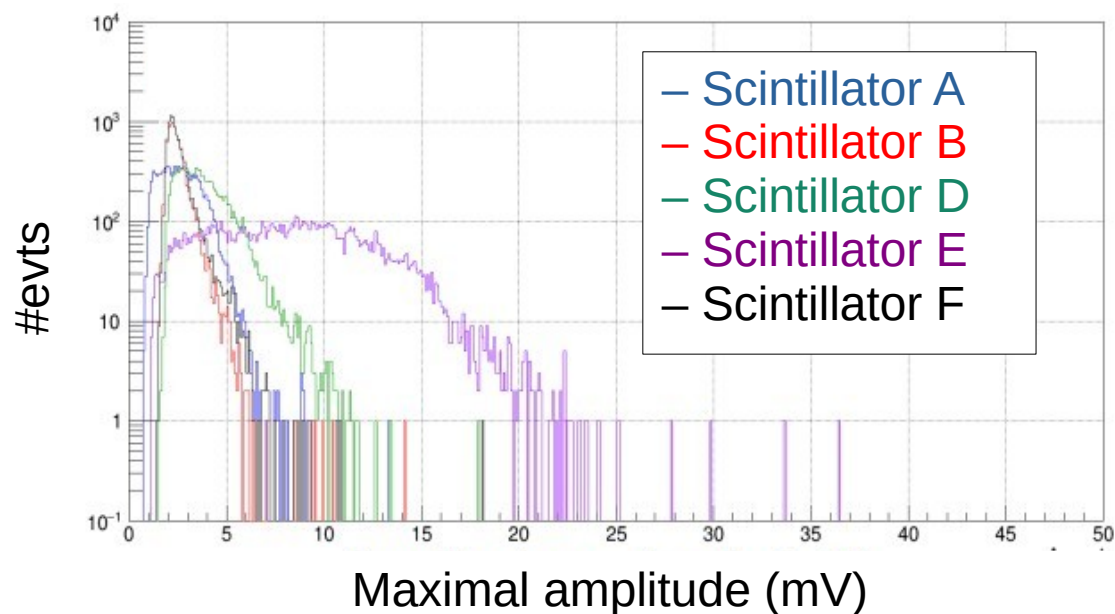
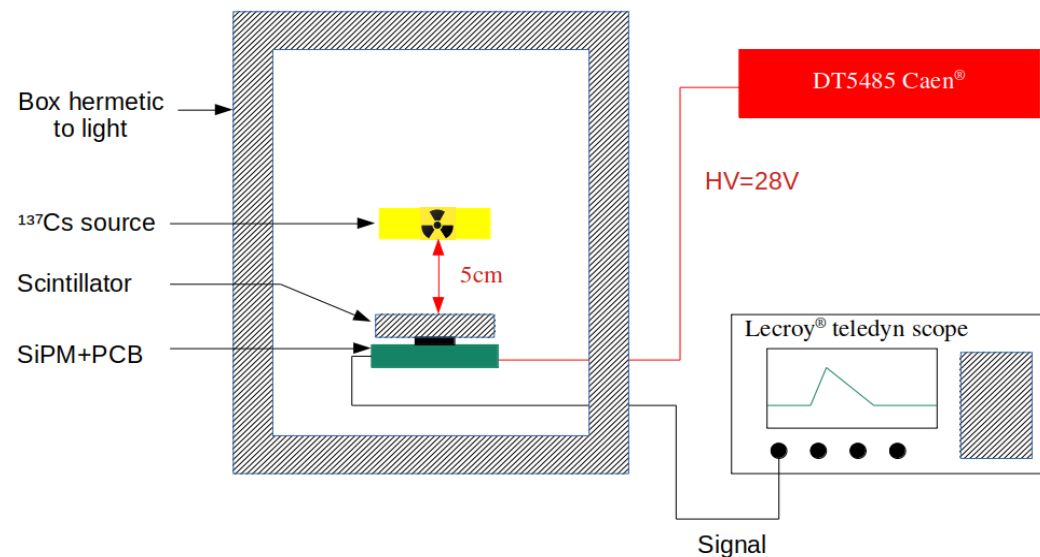
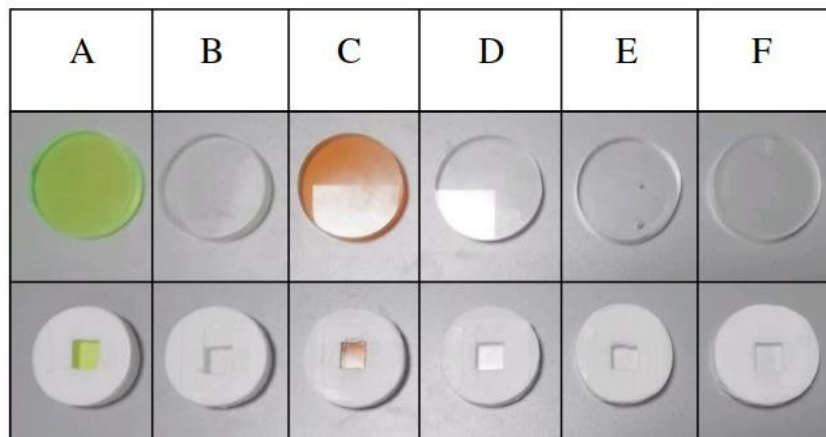


## Secondary fluorophore



Scintillators	Chemical composition (%)	$\lambda_{\max}$ 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)



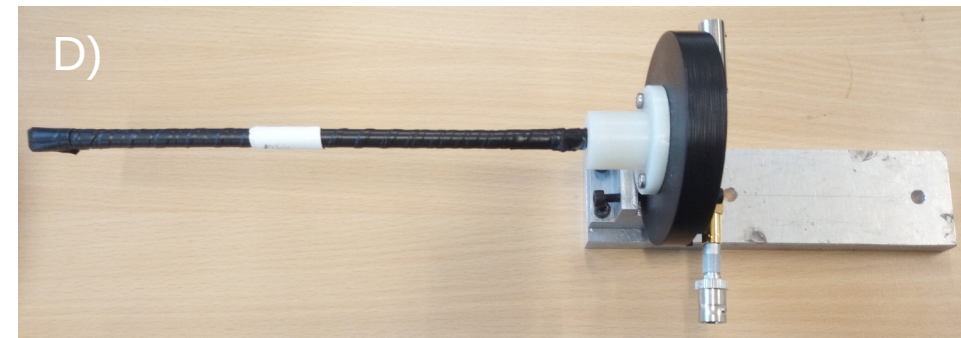
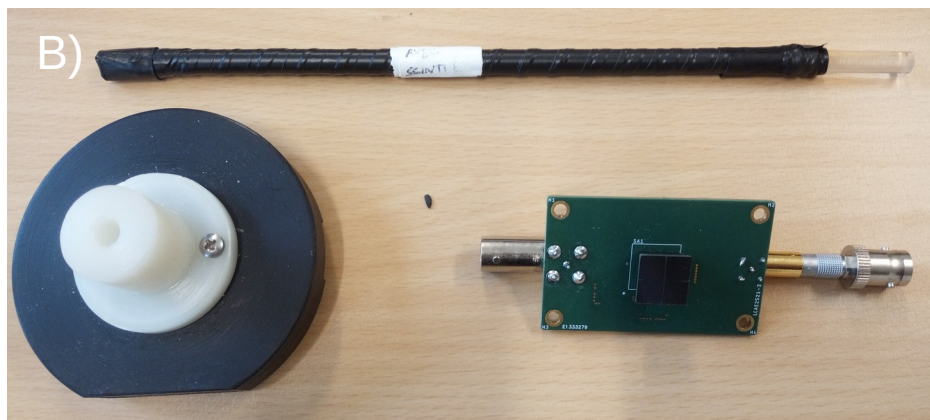
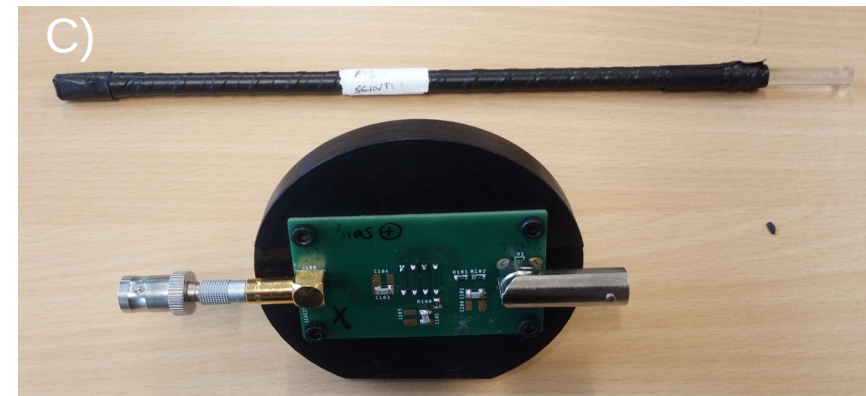
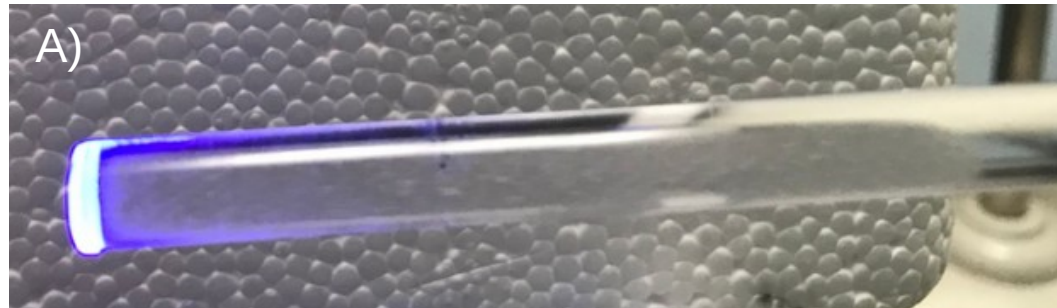
Scintillator E  
(Length : 0.6mm, Diam. : 6mm)

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

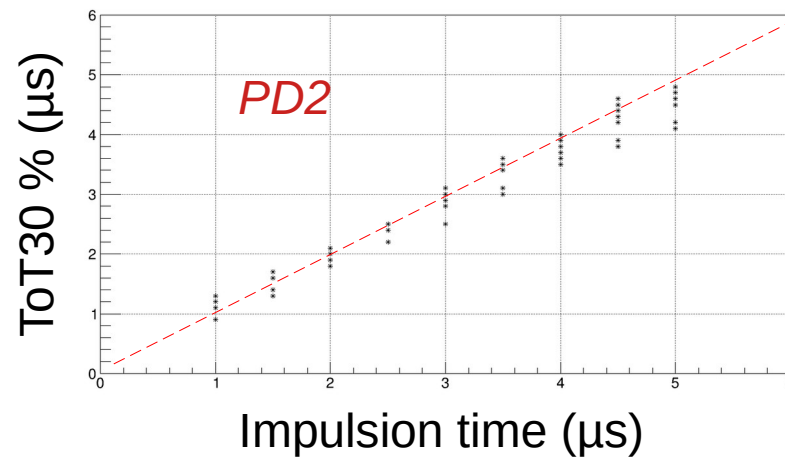
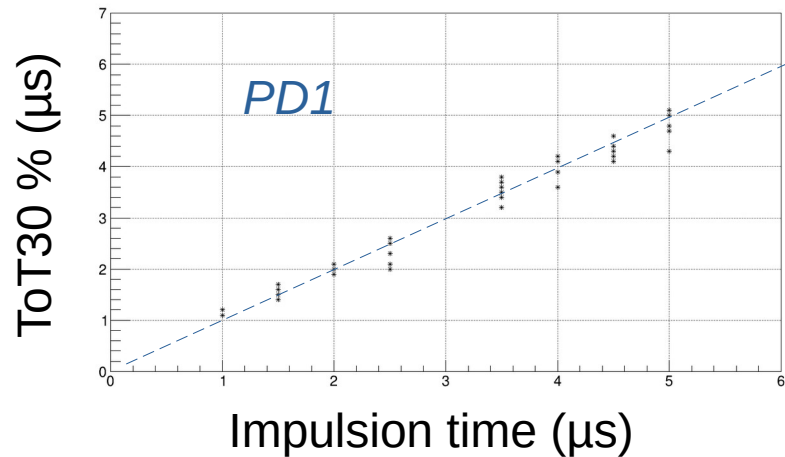
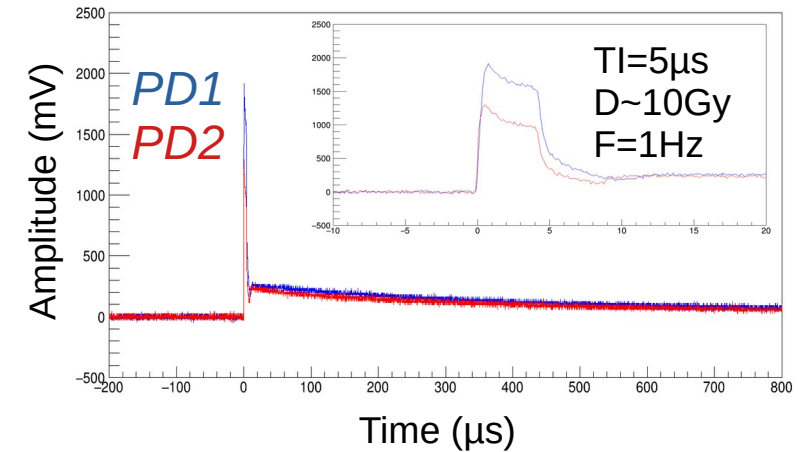
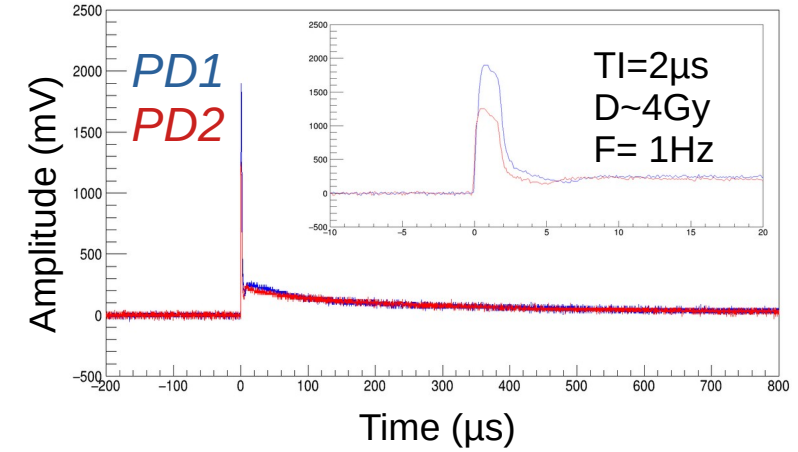
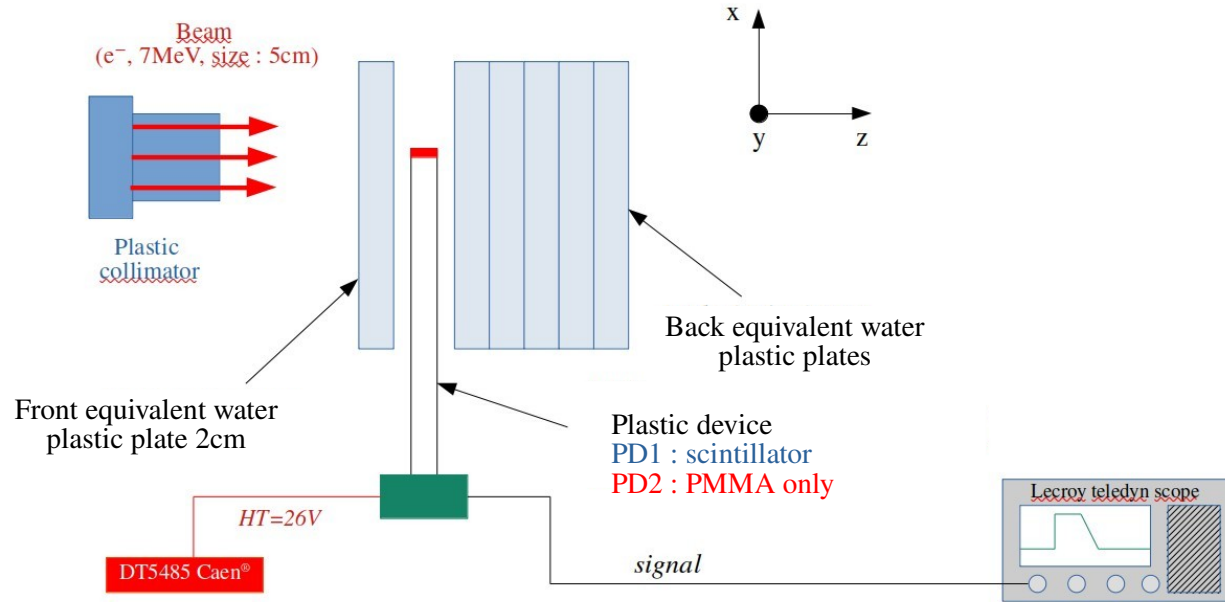
SiPM

Digitizer or  
scope

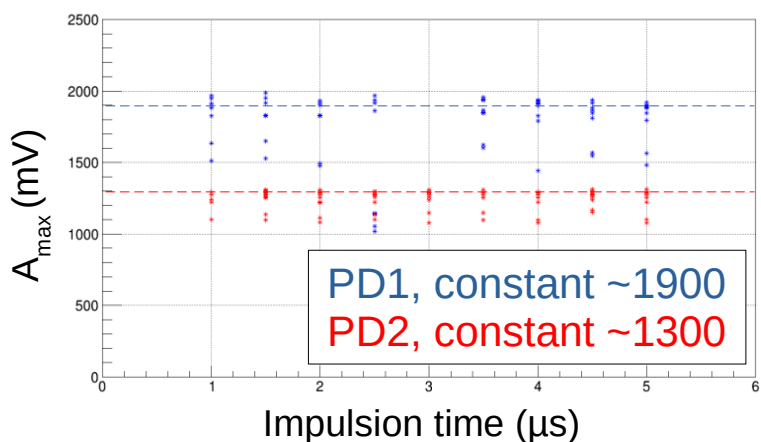
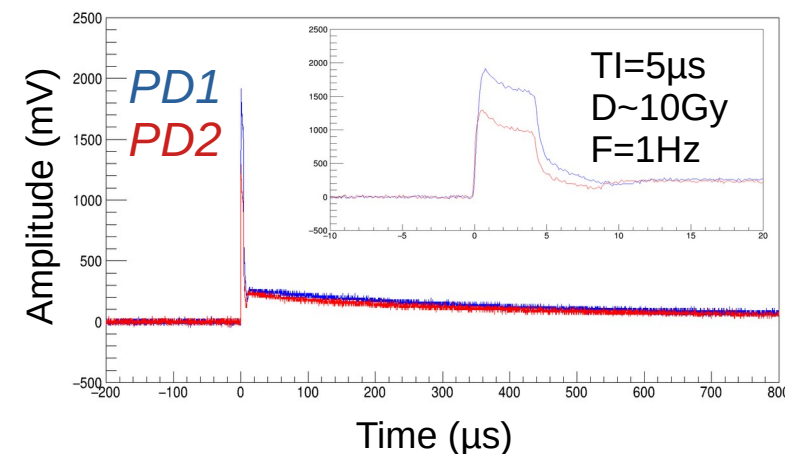
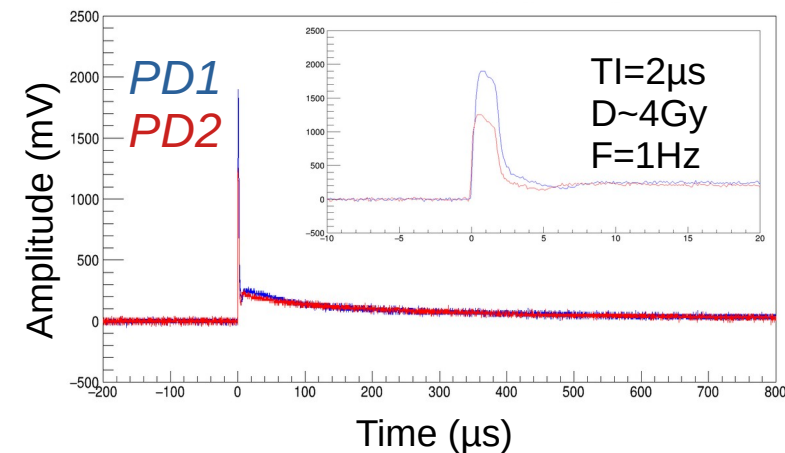
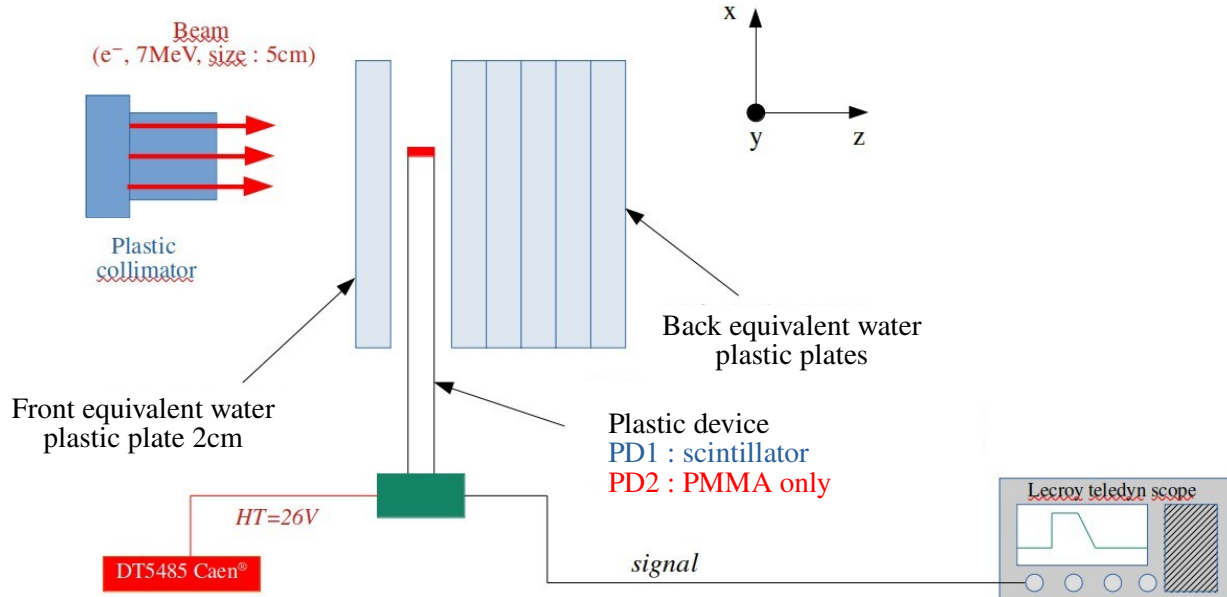
Computer



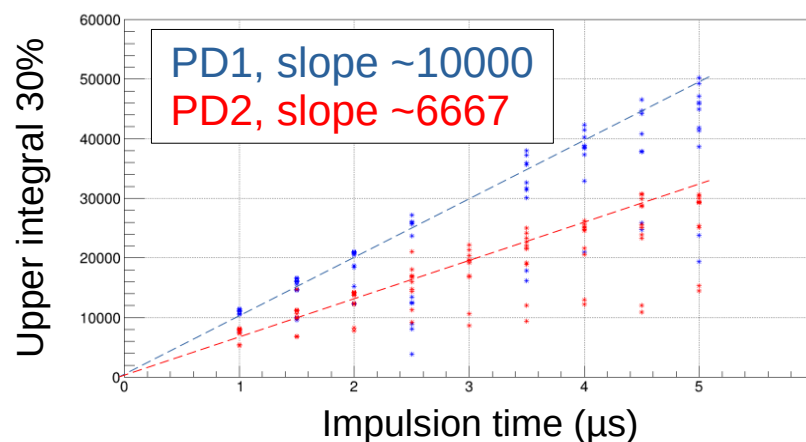
# Measurements on FLASH Beam



# Measurements on FLASH Beam

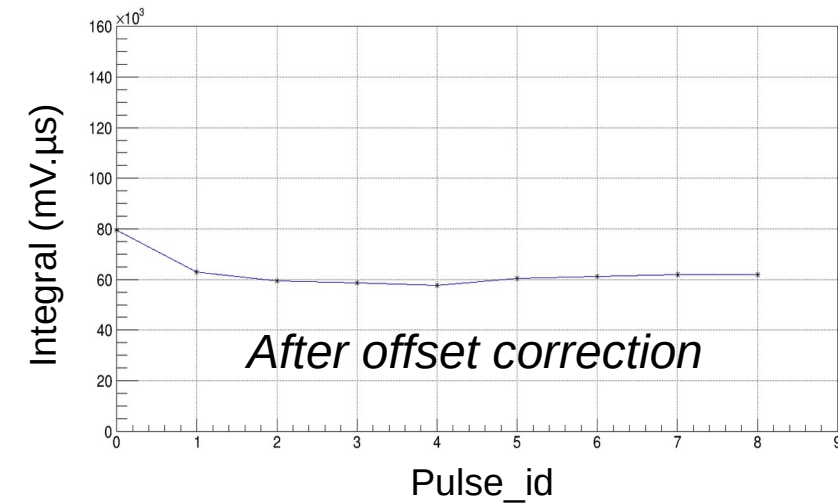
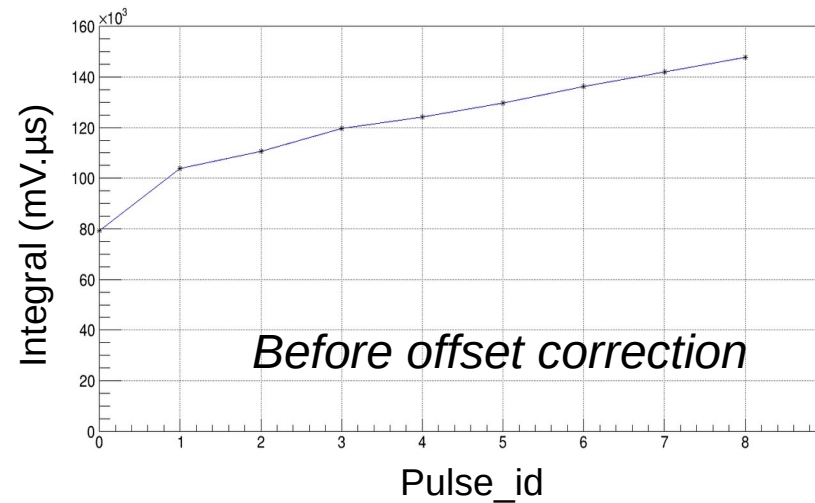
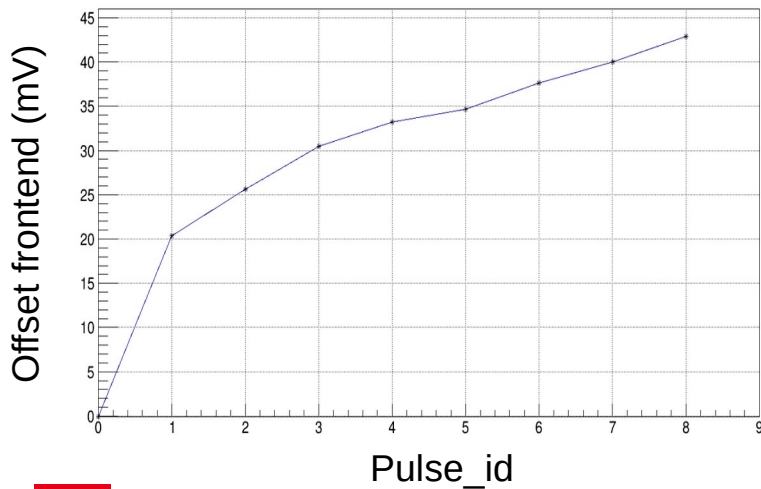
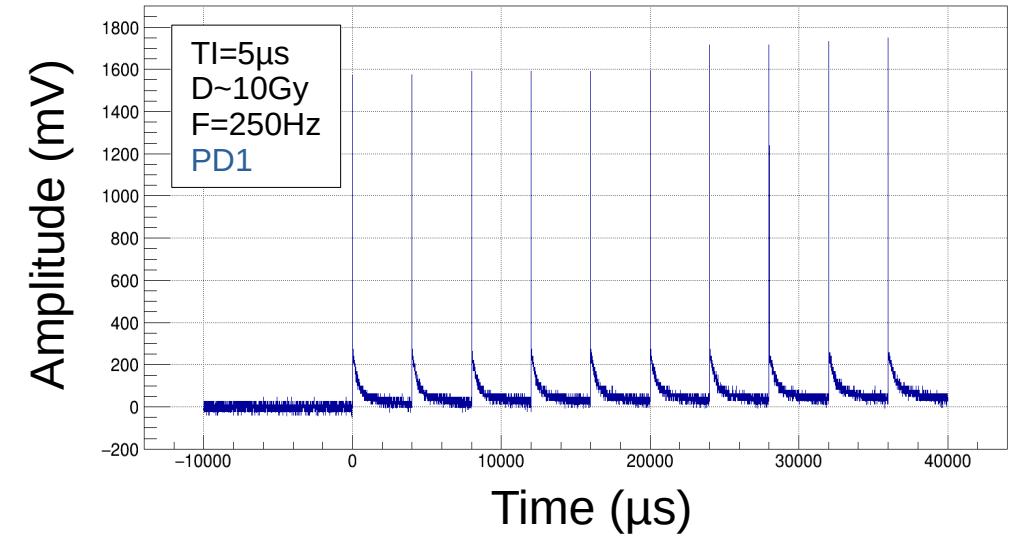
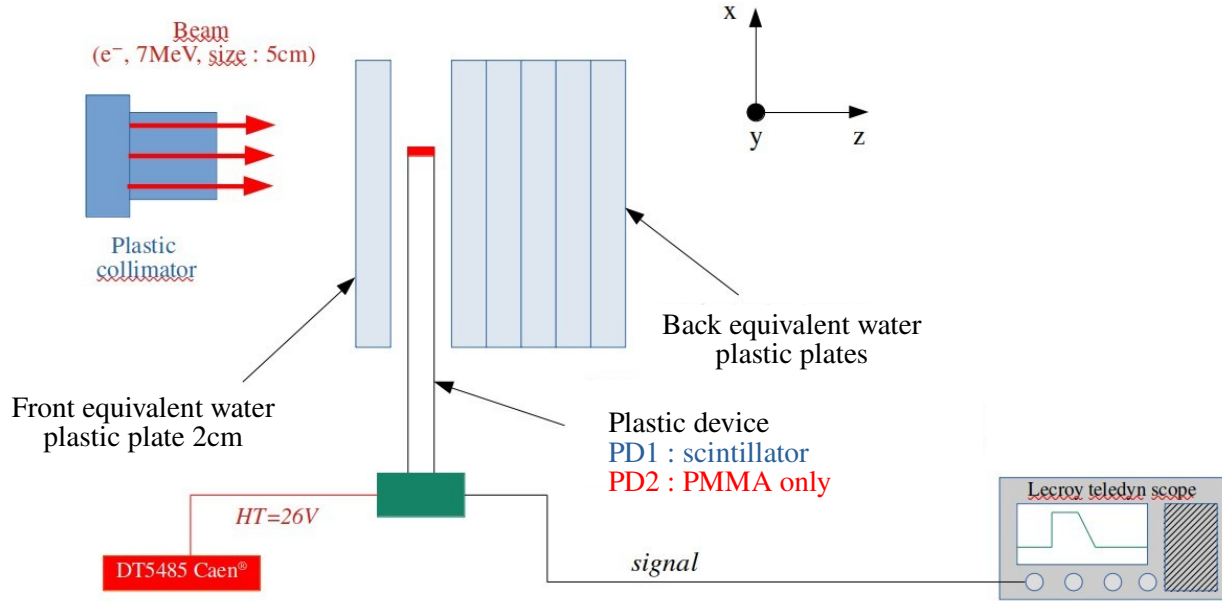


**Cerenkov = 68.42%**



**Cerenkov = 66.67%**

# Measurements on FLASH Beam





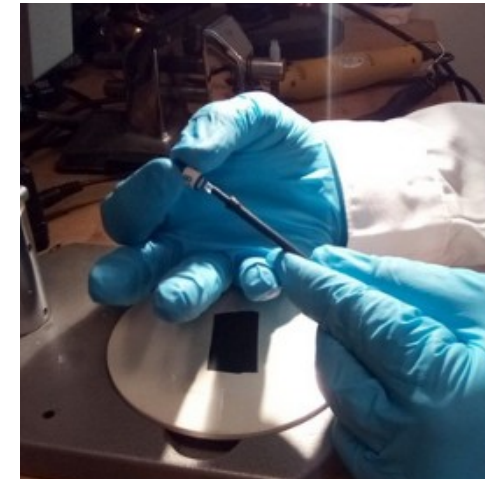
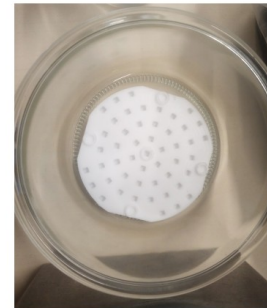


# 4 ■ Conclusions and future developments

# Conclusion and future developments

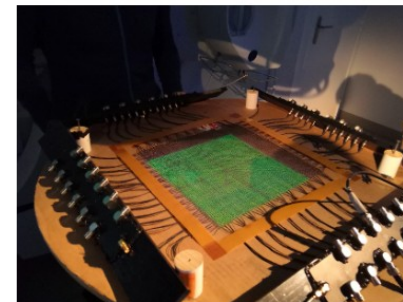
## Point dosimeter

- 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

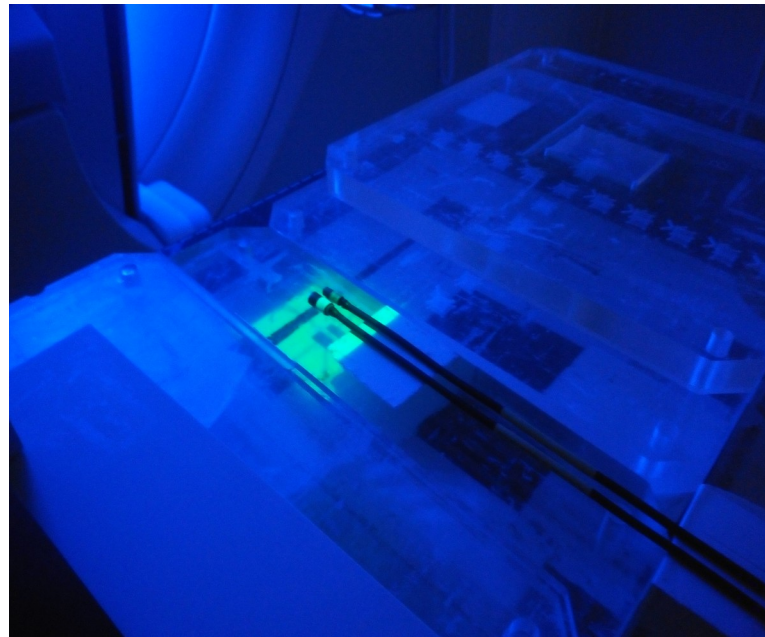
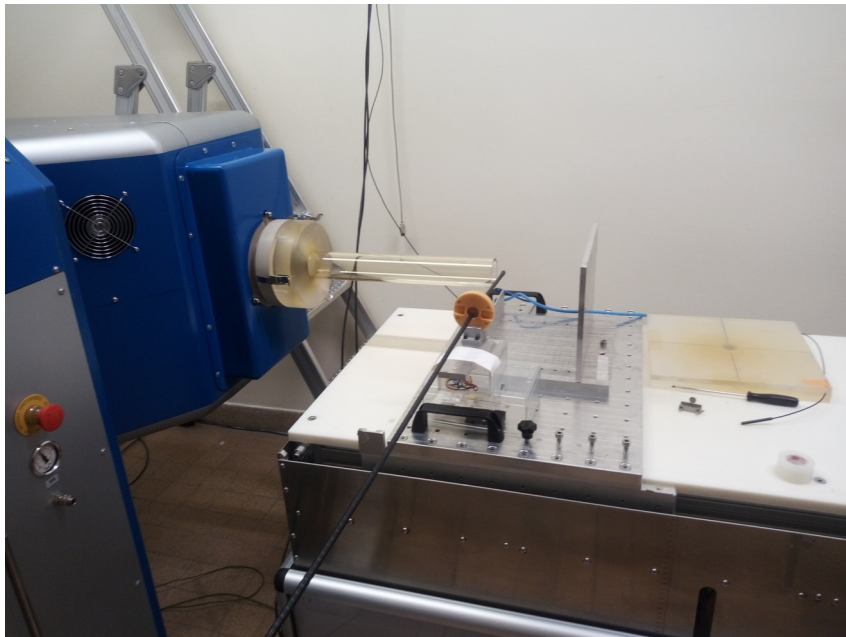
- Setup based on fibers “carpet”.



# 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