# "*d-Stil*", prototype design and test


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***for the n_TOF collaboration***



**N_TOF Collaboration Meeting, Edinburgh, 13-14 December 2022**

# Outlook

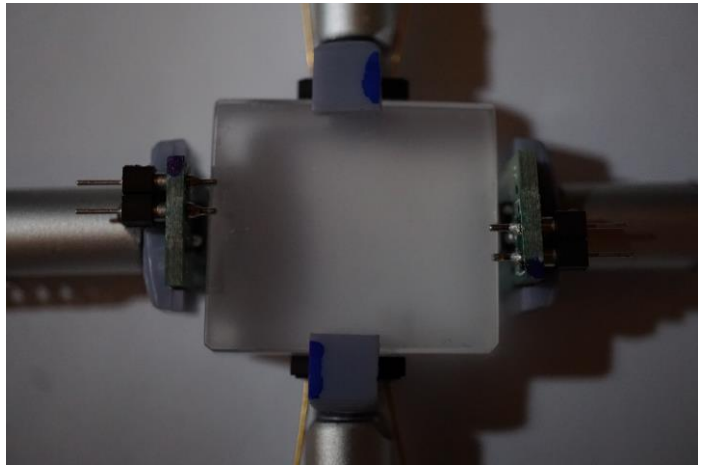
- Motivation for developing the prototype:
  - Study of the d-stilbene active target TaraT for the n-n scattering length LoI
  - A new detector to replace C6D6 for n-$\gamma$
  - n-n' measurements
- Stilbene scintillator characteristics
- The d-Stil prototype developed at INFN-Sezione di Catania
- Test and comparison with S-TED and C6D6 with the Spanish group
- Conclusions

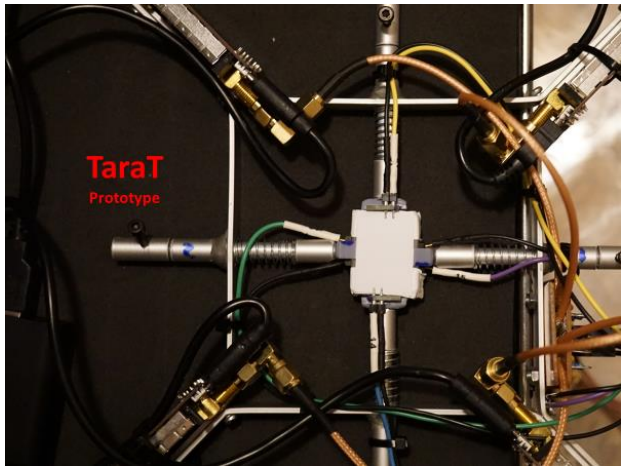
# TaraT test run at NCSR Demokritos (Athens) June 2020 (see also Cristian talk)

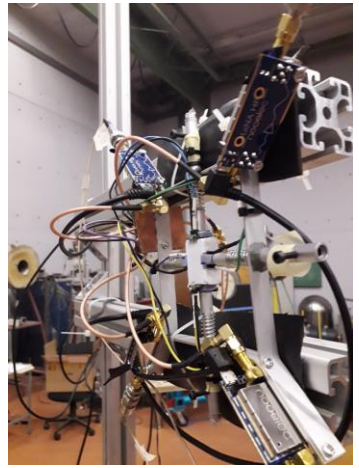
*d*-Stilbene

26 x 23 x 11 $mm^3$

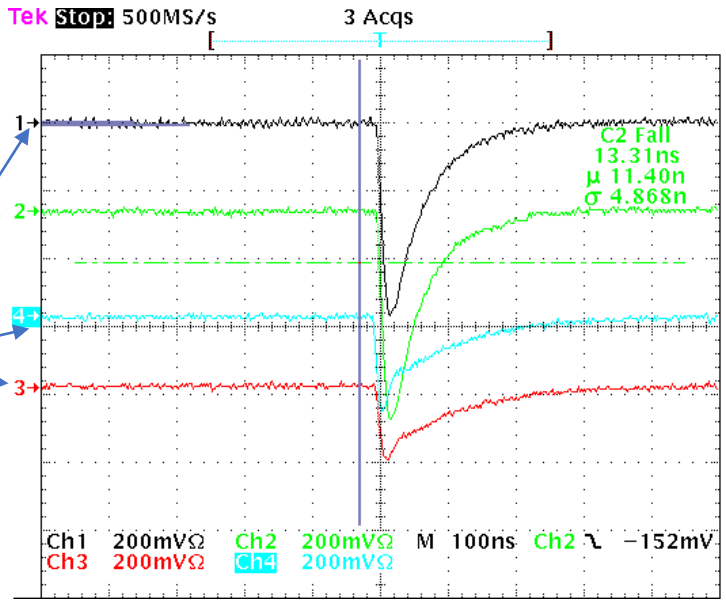
thanks to
Natalia P. Zaitseva
LLNL





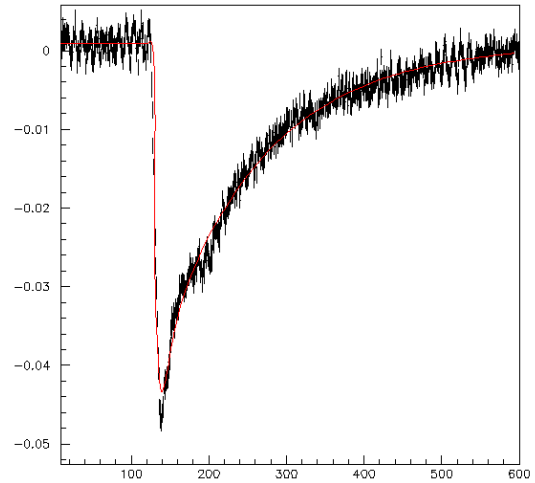



***2 HAMAMATSU 6x6***
***2 AdvanSid 4x4***




Signal parametrization

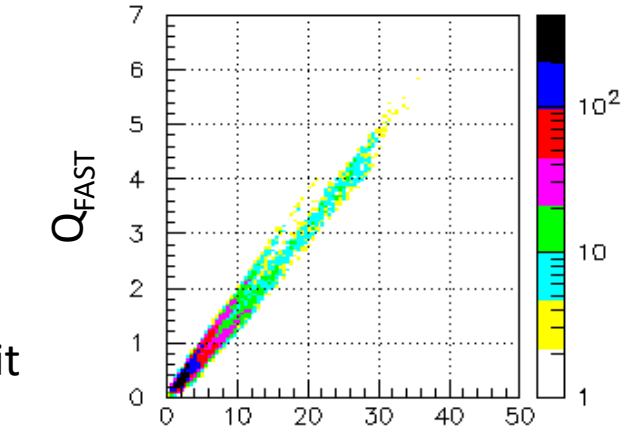
$$f(t) = P_0 + A * (\rho * (\exp(-\frac{t+t0}{\tau_{r1}}) - \exp(-\frac{t+t0}{\tau_{d1}})) + (1-\rho) * (\exp(-\frac{t+t0}{\tau_{r2}}) - \exp(-\frac{t+t0}{\tau_{d2}})))$$

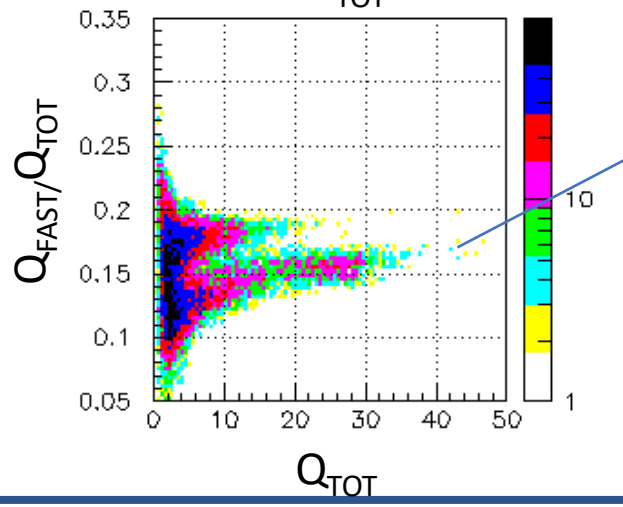


# Windows from leading-edge: 25 ns for $Q_{FAST}$ and 430 ns for $Q_{TOT}$

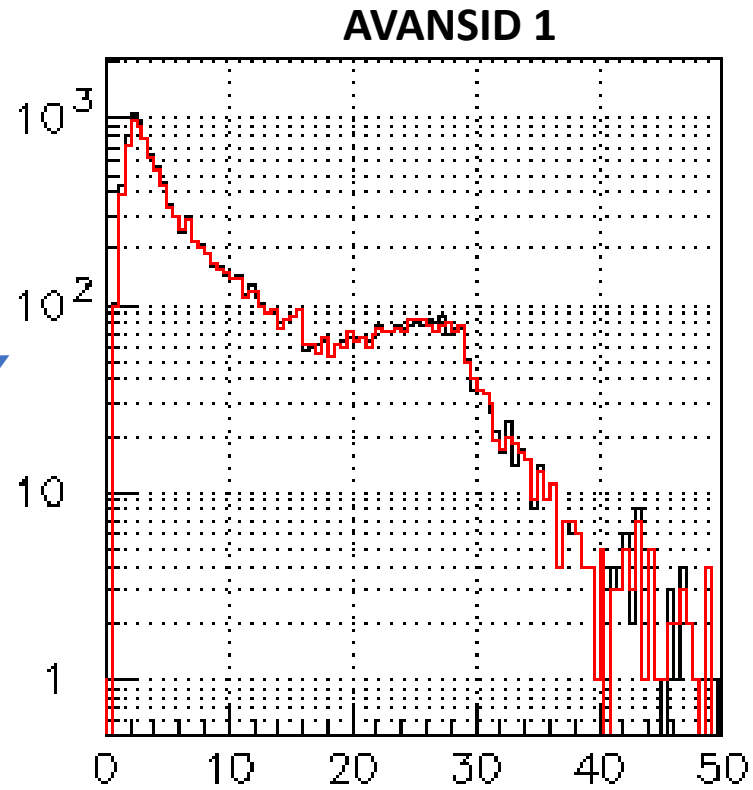
$E_{beam}$=15MeV

**AVANSID 1**
Integral of Fit function




Neutron gate



# Stilbene characteristics

Nuclear Inst. and Methods in Physics Research, A 1034 (2022) 166740

Contents lists available at ScienceDirect

Nuclear Inst. and Methods in Physics Research, A

journal homepage: www.elsevier.com/locate/nima


Gamma-response characterization of a solution-grown stilbene based detector assembly in the 59 keV–4.44 MeV energy range; an alternative low-resolution gamma spectrometer

Augusto Di Chicco [a,d], Alix Sardet [b,*], Michaël Petit [c], Robert Jacqmin [a], Vincent Gressier [c], Brian Stout [d]

Linear response in energy

Nuclear Inst. and Methods in Physics Research, A 977 (2020) 164178

Contents lists available at ScienceDirect

Nuclear Inst. and Methods in Physics Research, A

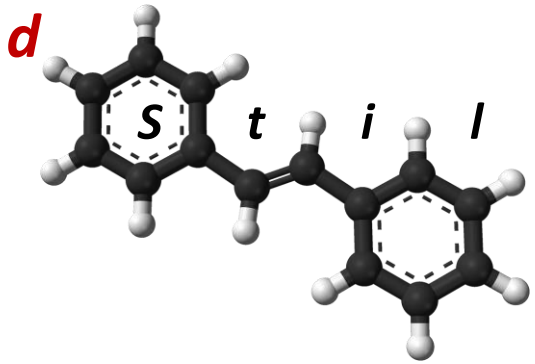
journal homepage: www.elsevier.com/locate/nima


Characterization of stilbene's scintillation anisotropy for recoil protons between 0.56 and 10 MeV

R.A. Weldon Jr. [a,*], J.M. Mueller [a], C. Awe [b], P. Barbeau [b], S. Hedges [b], L. Li [b], M. Mishra [a], J. Mattingly [a]

Isotropic for $\gamma$ detection

# *d-Stil* philosophy for prototype development




Just three basic elements

**1 - Stilbene-*d12* (LLNL & INRAD - *Nikolas*)**

**2 - PM (experience on laser facility - PALS)**

**3 - Active base DC-DC converter (Sens-Tech)**

As a result for n_TOF:

- compact and lightweight device (less material)
- not expensive (2 Keuro/module)
- reliable (no liquid – sturdy - atoxic)
- easy assembly (two days) and deployment

# 1 - Stilbene-*d12* (INRAD - *Nikolas*)


| | | |
|---|---|---|
| **STILBENE,OD31.75X10MM,P1S, W,T** | **715.00** | **$715.00** |

SCINTINEL (STILBENE) DISC
DIAMETER: 31.75MM ±0.15MM
THICKNESS: 10MM ±0.35MM
FINISH: S1: COMMERCIAL POLISH
S2: FINE GRIND
BEVEL: MINIMUM BREAK EDGE

WRAPPED IN PTFE TAPE, AND A BONDED FUSED SILICA WINDOW ON S1

The deuterium filling-factor must be characterized

# 2 - Photomultiplier: HAMAMATSU R1924A

## HAMAMATSU R1924A

### FEATURES

- For scintillation counting
- For photon counting
- Ruggedized, low profile structure

### APPLICATIONS

- Radiation measurement
- Particle counter

### SPECIFICATIONS

**GENERAL**

| Parameter | | Description | Unit |
|---|---|---|---|
| Spectral response | | 300 to 650 | nm |
| Wavelength of maximum response | | 420 | nm |
| Photocathode | Material | Bialkali | — |
| | Minimum effective area | φ22 | mm |
| Window material | | Borosilicate glass | — |
| Dynode | Structure | Circular and linear-focused | — |
| | Number of stages | 10 | — |
| Base | | 14 pin glass base | — |
| Suitable socket | | E678-14C (supplied) | — |
| Operating ambient temperature | | -30 to +50 | °C |
| Storage temperature | | -80 to +50 | °C |

Figure 1: Typical spectral response

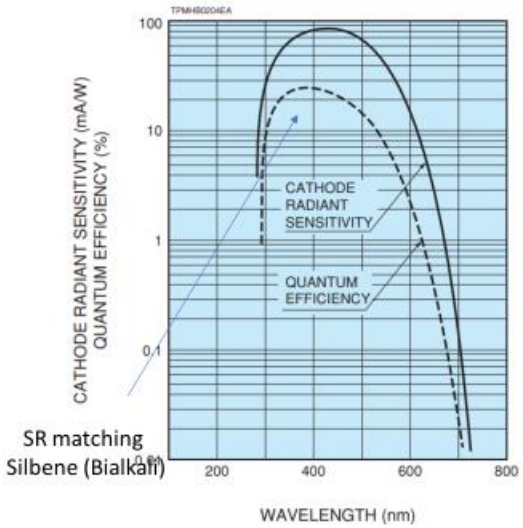
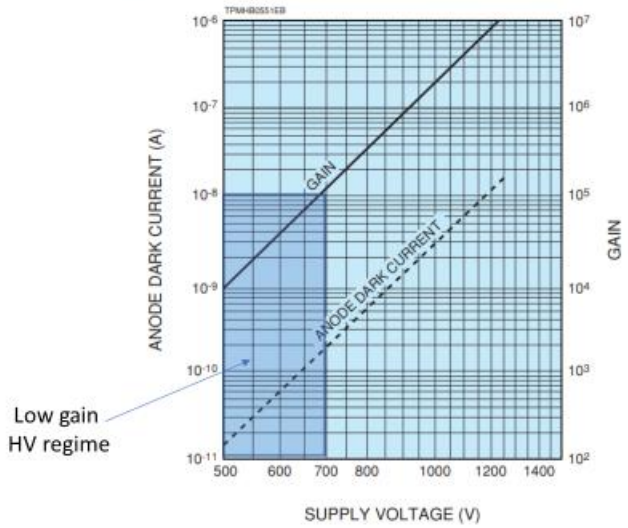



Figure 2: Typical gain and dark current characteristics




*Combination of large scintillation light yield and low PM gain is the key*

# 3 - Active base DC-DC converter (Sens-Tech)

## photomultiplier power base (negative)
## PS1807 data sheet

SENS-TECH
SENSOR TECHNOLOGIES

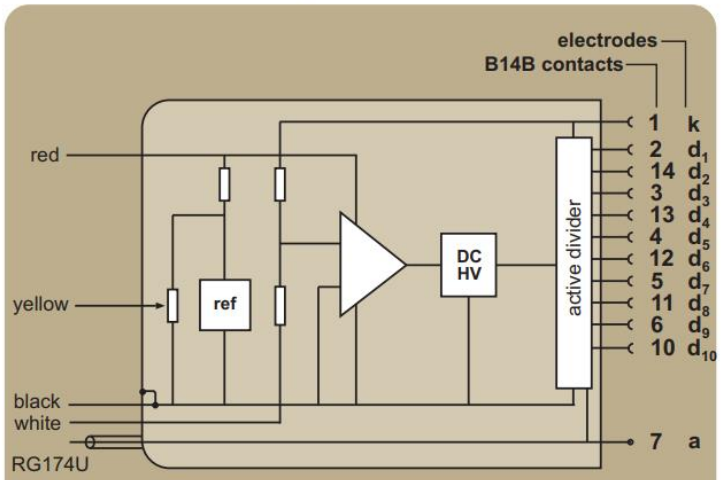
### 3 features

- compact design
- freedom from high voltage cables
- extremely low ripple
- exceptional voltage divider stability with varying anode current
- excellent pulse height linearity
- sleep mode

### 4 specification

| | |
|---|---|
| input power at $V_{max}$ = -1800 V | +5 V, 65 mA |
| power conversion efficiency, $P_O/P_{in}$ | 40 % for +5 V |
| input power at $V_{max}$ = -1800 V | +12 V, 20 mA |
| power conversion efficiency, $P_O/P_{in}$ | 50 % for +12 |
| output voltage range | -100 V to -1800 V |
| line regulation | 0.05 % /V |
| temperature coefficient | <0.02 % $°C^{-1}$ |
| warm up time to 0.3 % of final o/p | < 2 s |
| discharge time to <40 V with no load | < 2 s |
| maximum anode current, continuous | 100 µA |
| anode ripple with 100 kΩ //5 pF load | 100 µV |
| weight | 60 g |

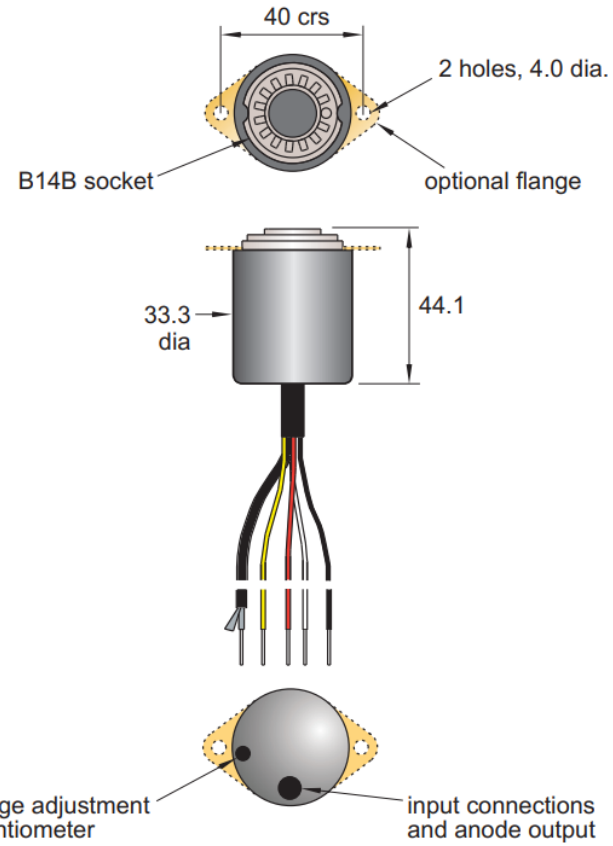
### 6 schematic diagram




example of output voltage with 1.300 volts applied to control (white) wire

| contact | electrode | voltage | contact | electrode | voltage |
|---|---|---|---|---|---|
| 1 | k | -1300 | 8 | nc | - |
| 2 | $d_1$ | -1000 | 9 | nc | - |
| 3 | $d_3$ | -800 | 10 | $d_{10}$ | -100 |
| 4 | $d_5$ | -600 | 11 | $d_8$ | -300 |
| 5 | $d_7$ | -400 | 12 | $d_6$ | -500 |
| 6 | $d_9$ | -200 | 13 | $d_4$ | -700 |
| 7 | a | floating | 14 | $d_2$ | -900 |

nc - no connection



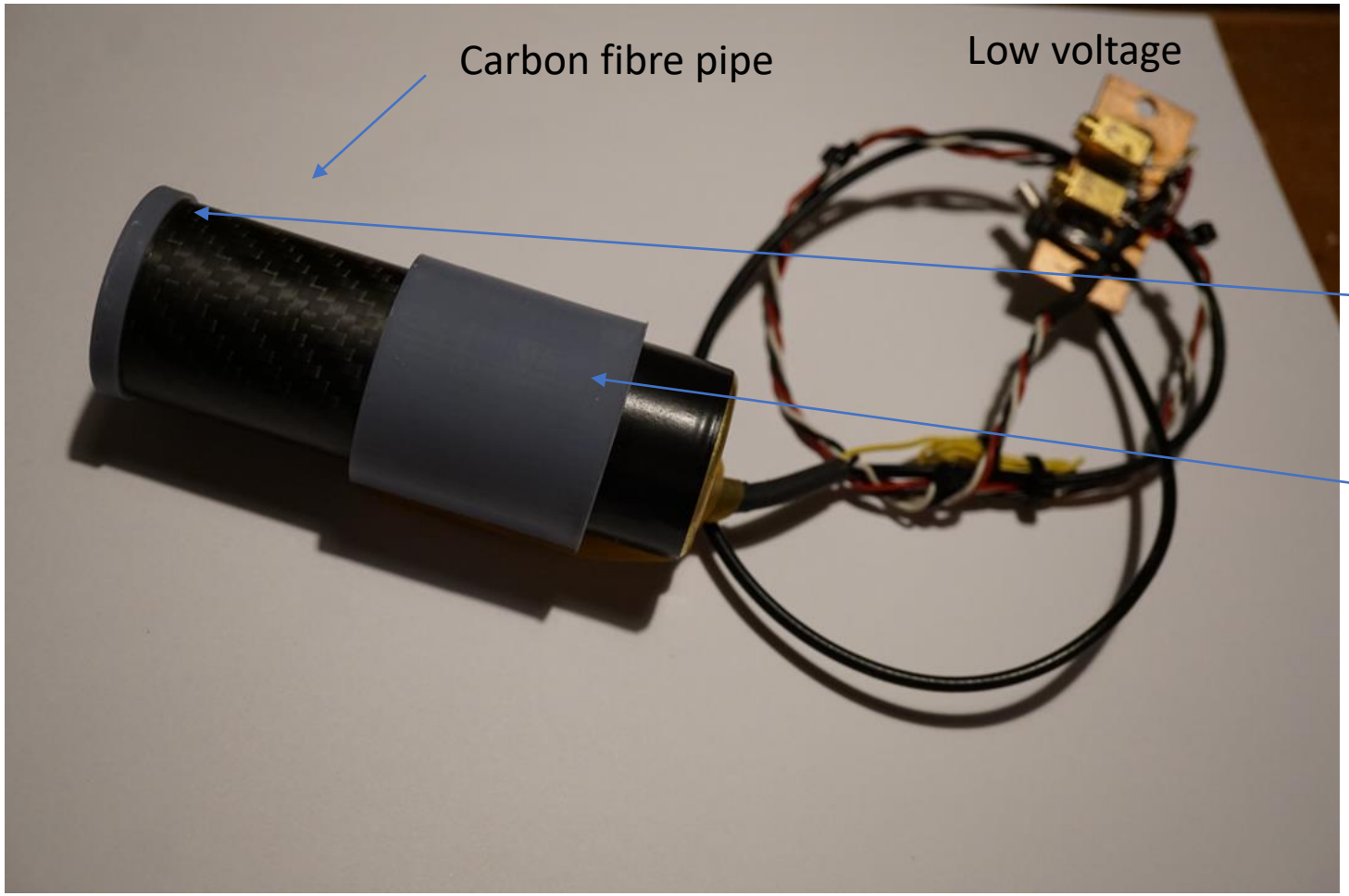

Ultra compact active base with DC-DC converter
**no HV needed**

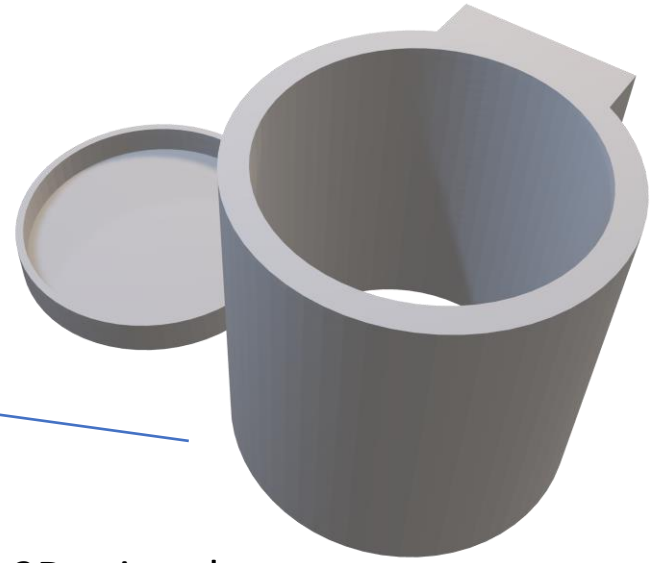
This power base was tested for a self-powering device and high counting rate

# Detector assembly

- Standard carbon pipe
- Holder and cup by 3D printing

The design can be rearranged on-the-fly
obtaining maximum flexibility
for any set-up



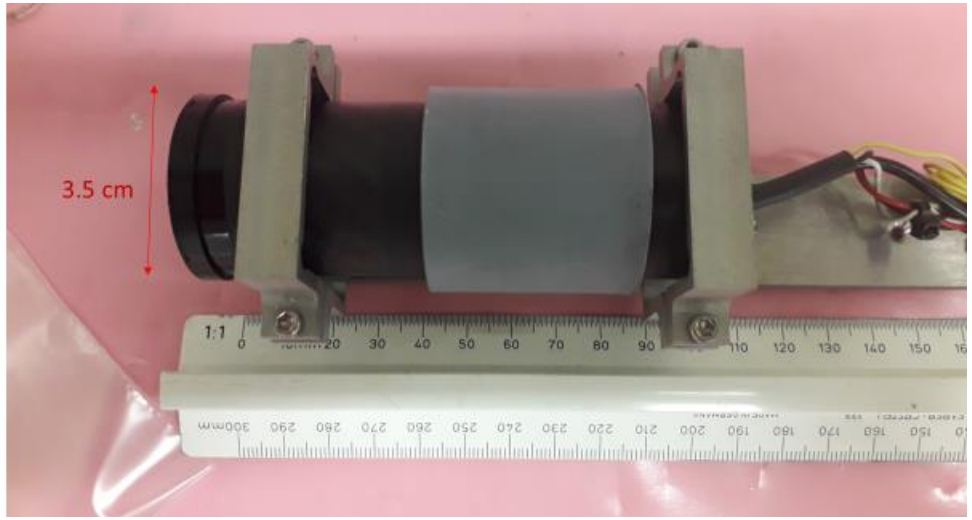
3D printed
holder
and cup

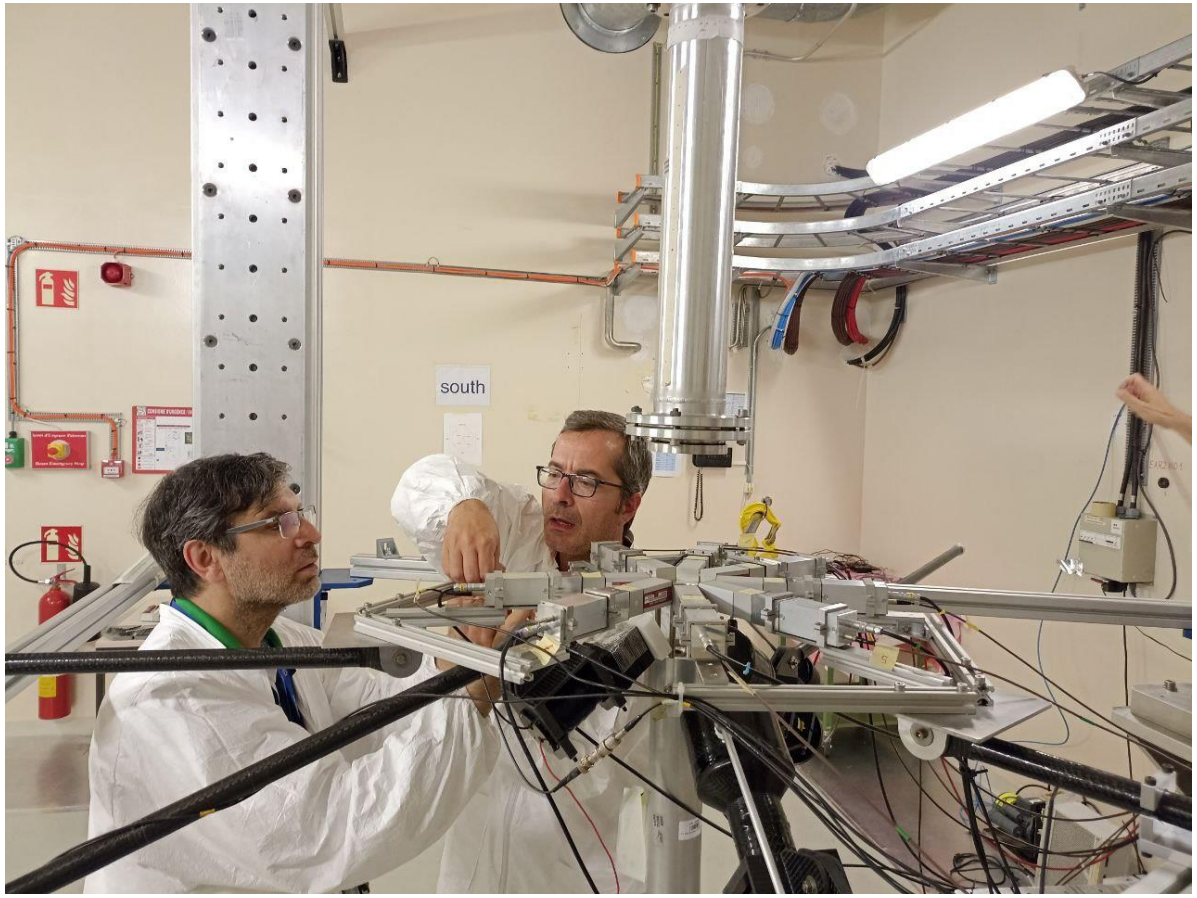
# First test @EAR2

The holder was fitting with the S-TED frame

main geometry unchanged for the test

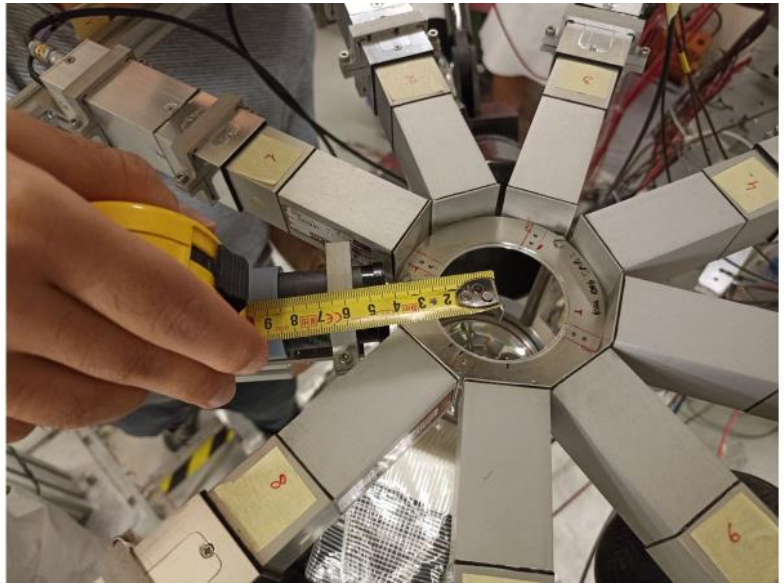
relaxed mechanical constraints




Front window was aligned with respect to the S-TED modules

Same distance from the beam

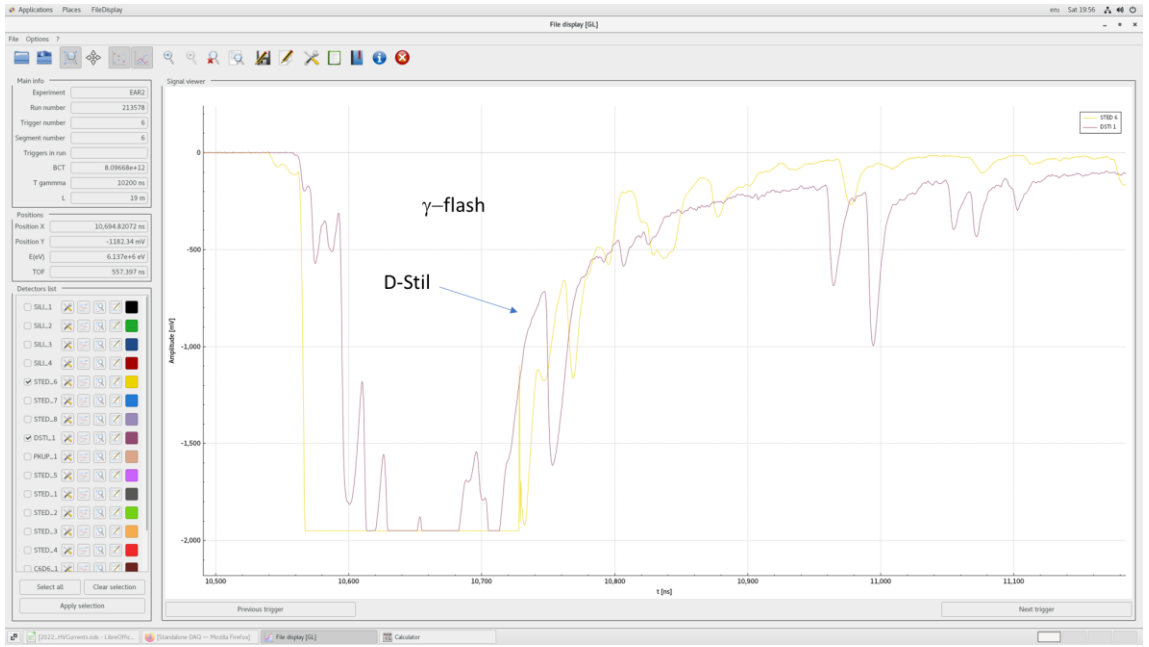


# First signals


**Present further improvements with respect to the prototype:**

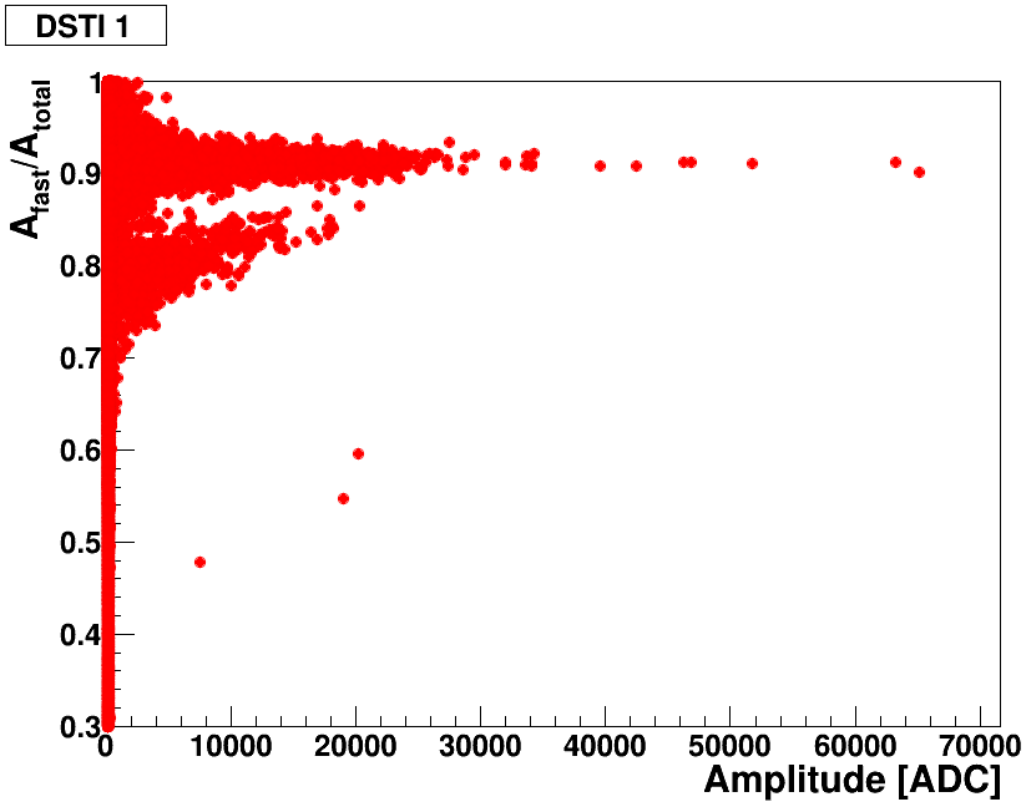
- **PM quartz window**
- **lower PM voltage**
- **Improved holder**
- **larger Stilbene thickness (1 inch)**

## Concerning γ-flash

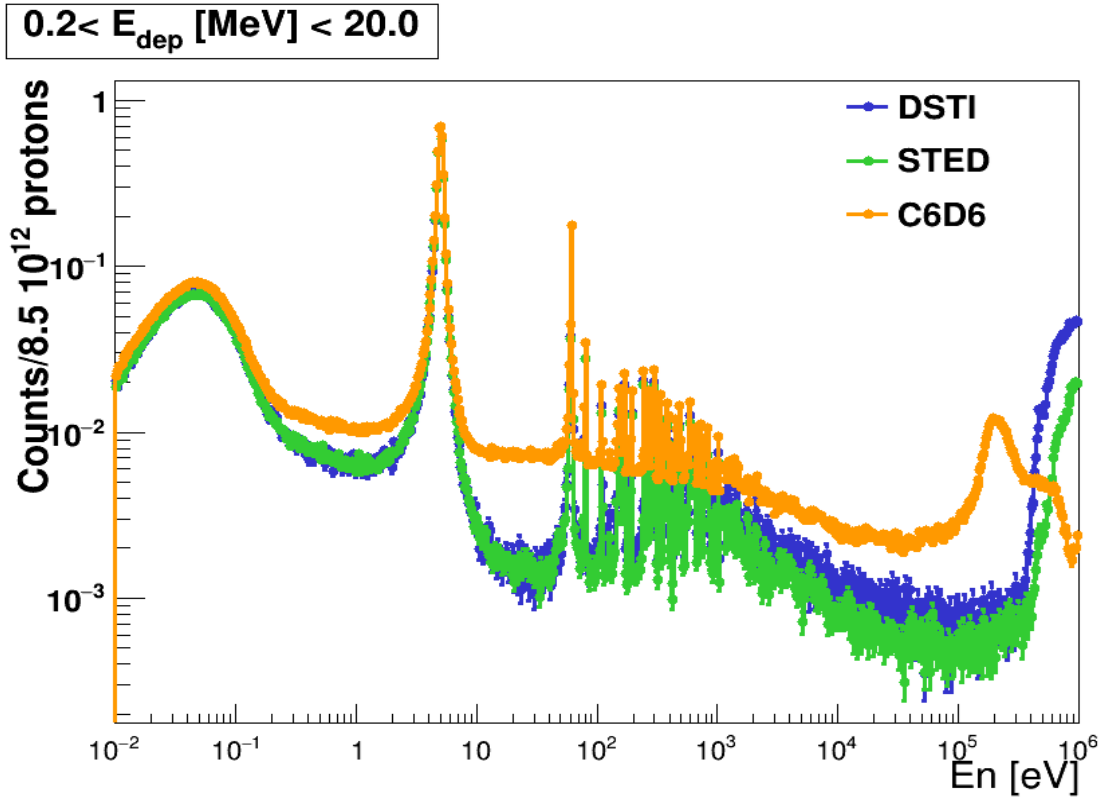



In spite of d-Stil gain was larger and the PM photocathode was very close to the beam

# Analysis




ToF spectra normalized to saturated resonance

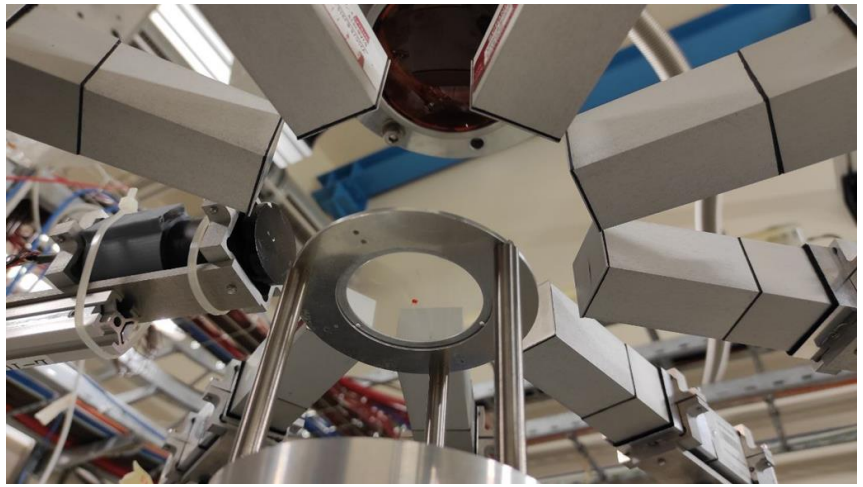


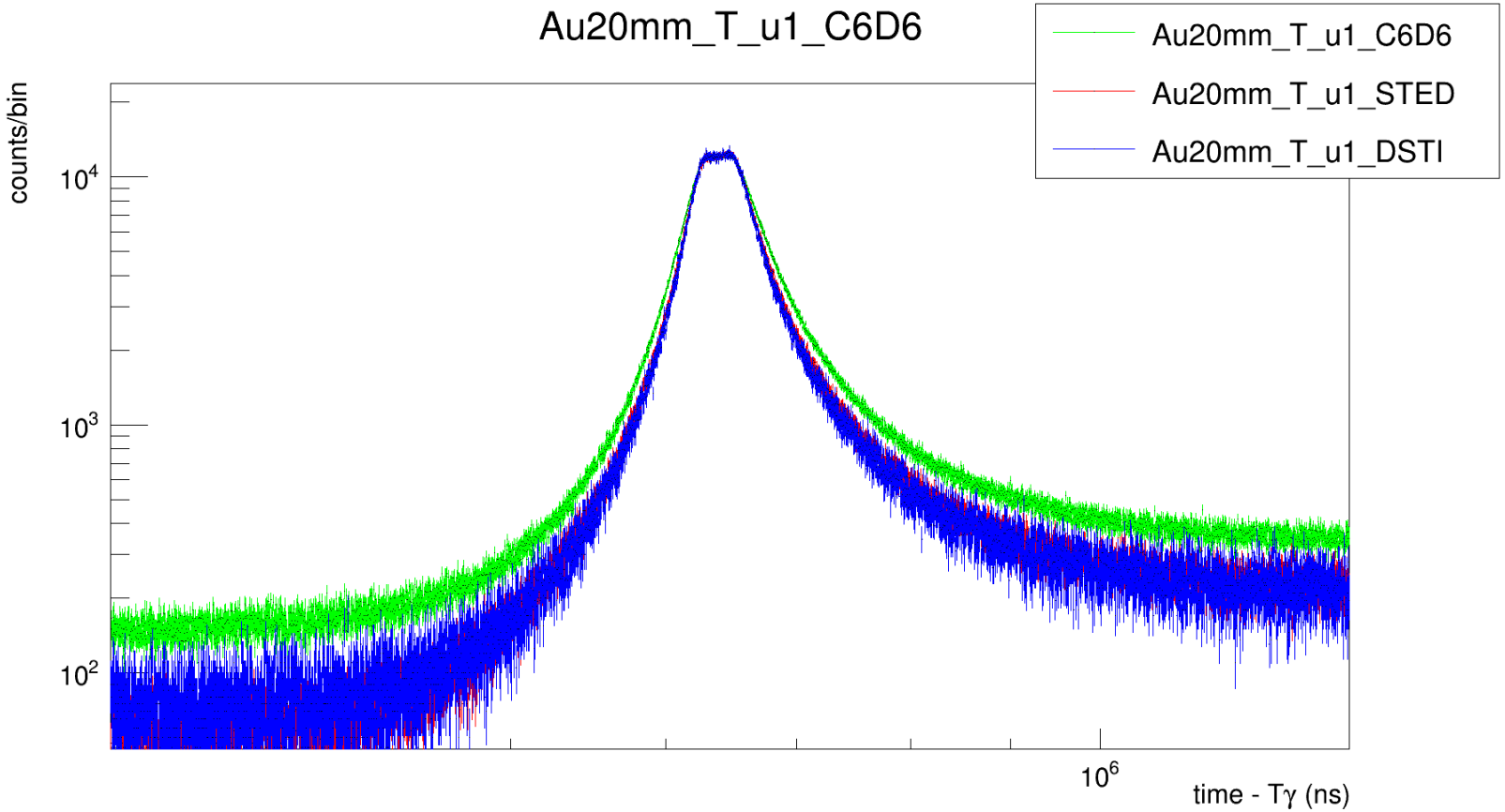

ToF spectras for DSTI and STED have similar shape

By Javi Balibrea

# Second test during Mo(n,γ) measurement in EAR2

*New setup HV=600 V*





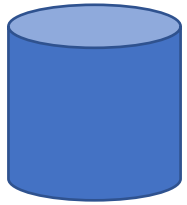

By_Riccardo_Mucciola

# Conclusions: upgrades and future possible set-up for test

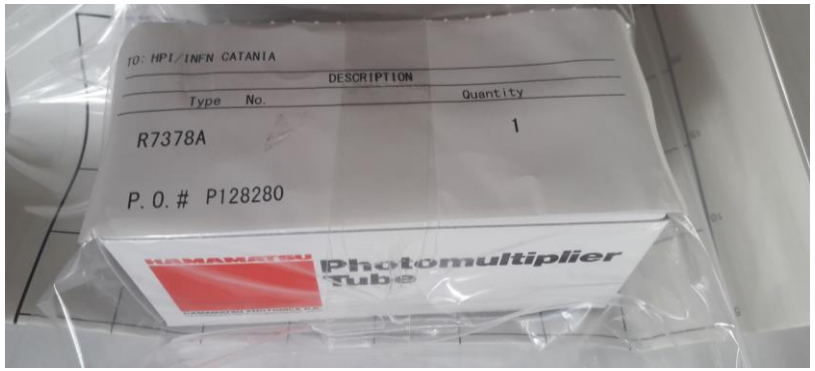
4 new Modules ready to be assembled @ INFN-Sezione di Catania with same power bases

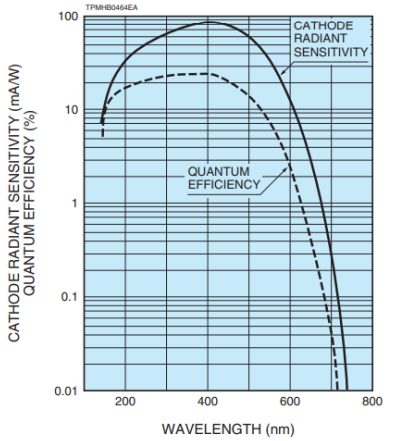
Standard type «Scintinel» (no deuterated *p*-type) @ INFN_CT

Diameter: 25.4 mm,
**Thickness: 25.4 mm**



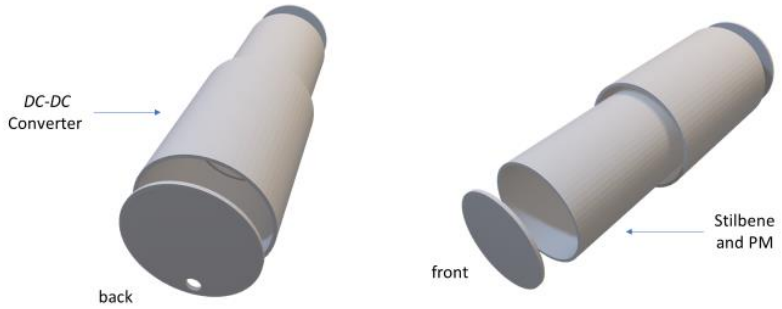

R7378A – Synthetic silica window (**no Borosilicate**) (Nikolas@CERN)



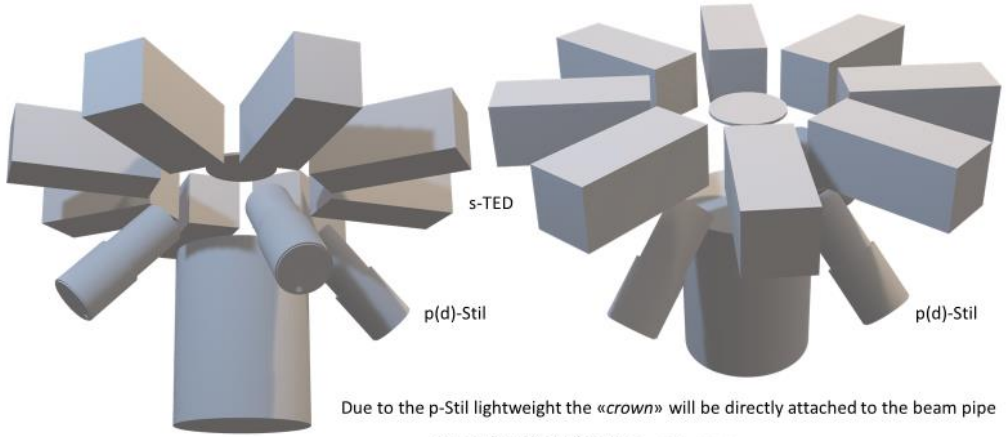

*p-Stil holder*

*We would like to maintain the same structure and material (carbon fiber)*




*p-Stil module*

*Preliminary in-beam setup*




Due to the p-Stil lightweight the «*crown*» will be directly attached to the beam pipe

*Angular distribution, γ-n, γ–γ…*

Thanks to the CERN n_TOF local team and to the Spanish group and

# Thank you for the attention and for hospitality here in Edinburgh !!