"*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

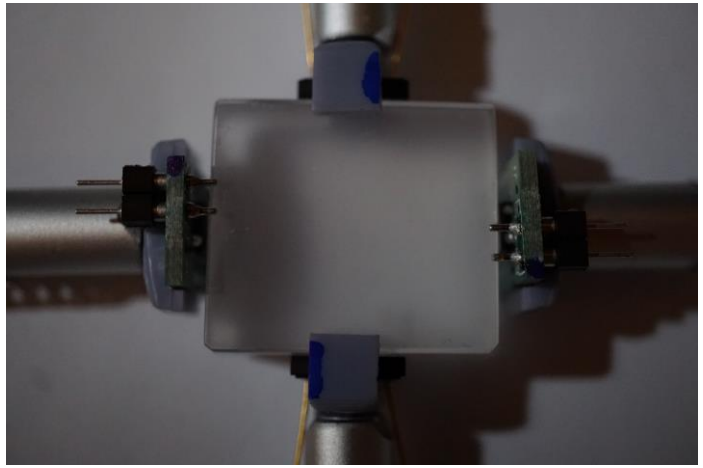
- Motivation for developing the prototype:
  - Study of the d-stilbene active target TaraT for the n-n scattering length LoI
  - A new detector to replace C6D6 for n-γ
  - n-n' measurements
- Stilbene scintillator characteristics
- The d-Stil prototype developed at INFN-Sezione di Catania
- Test and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

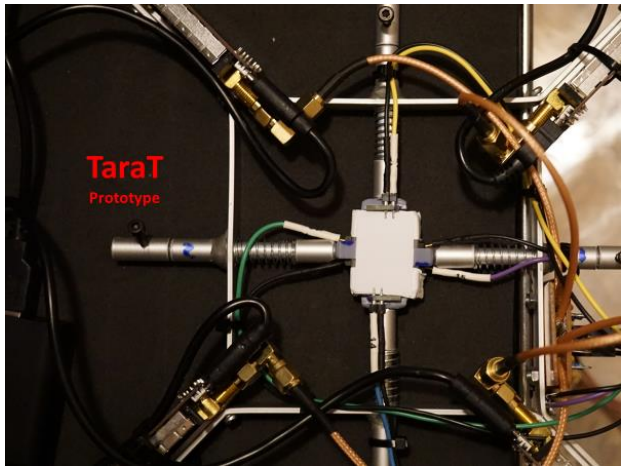
TaraT test run at NCSR Demokritos (Athens) June 2020 (see also Cristian talk)

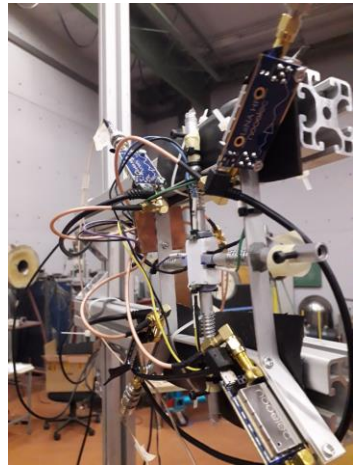
d-Stilbene

26 x 23 x 11 mm^3

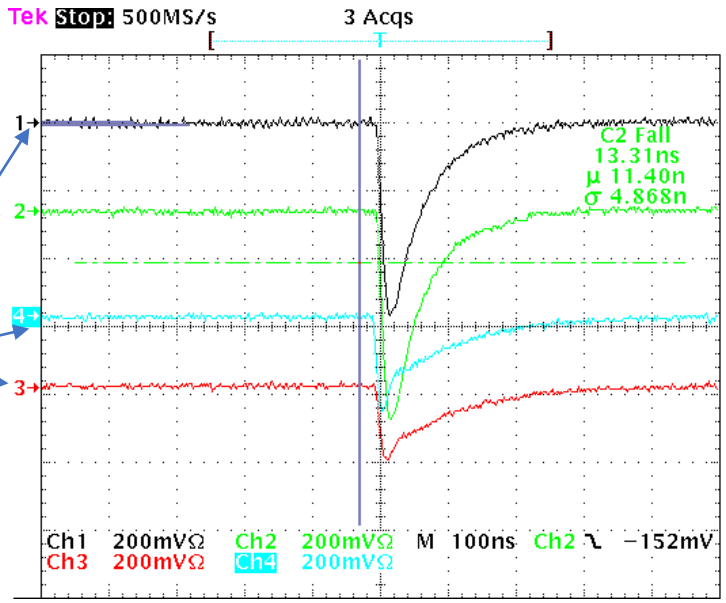
thanks to
Natalia P. Zaitseva
LLNL





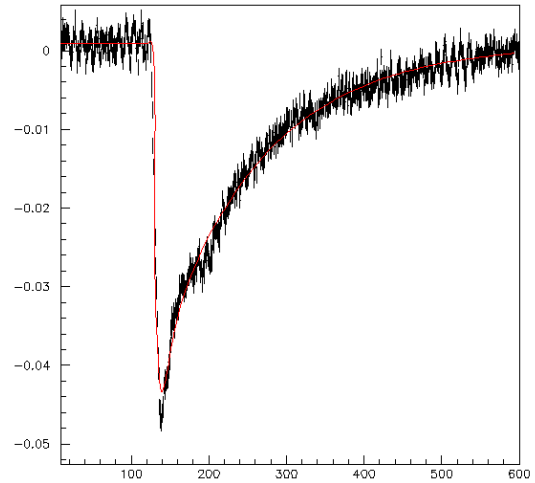


2 HAMAMATSU 6x6
2 AdvanSid 4x4



Signal parametrization

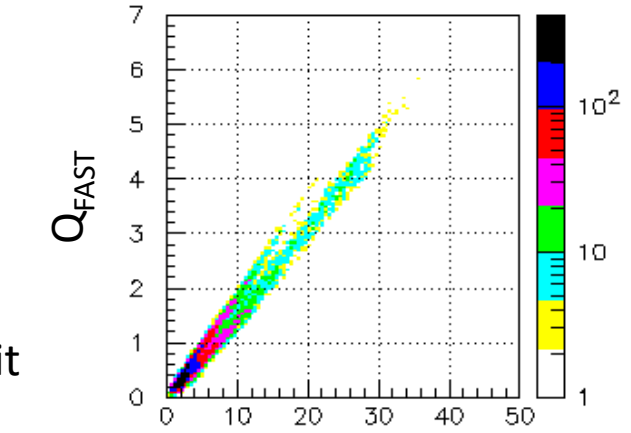
$$f(t) = P_0 + A * (\rho * (\exp(-\frac{t+t0}{\tau_{r1}}) - \exp(-\frac{t+t0}{\tau_{d1}})) + (1-\rho) * (\exp(-\frac{t+t0}{\tau_{r2}}) - \exp(-\frac{t+t0}{\tau_{d2}})))$$

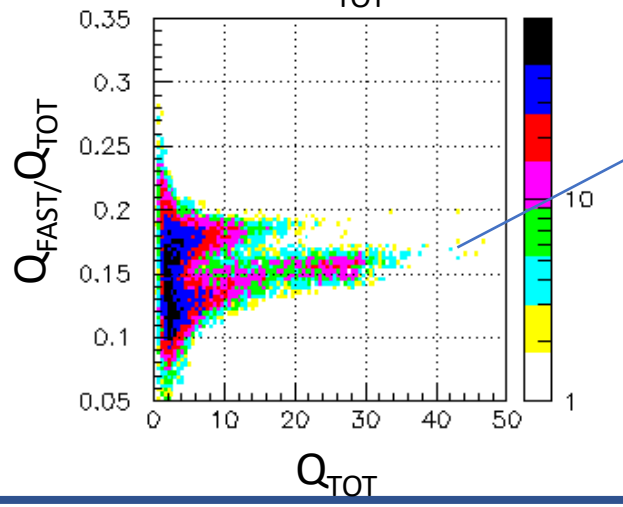


Windows from leading-edge: 25 ns for Q_{FAST} and 430 ns for Q_{TOT}

E_{beam}=15MeV

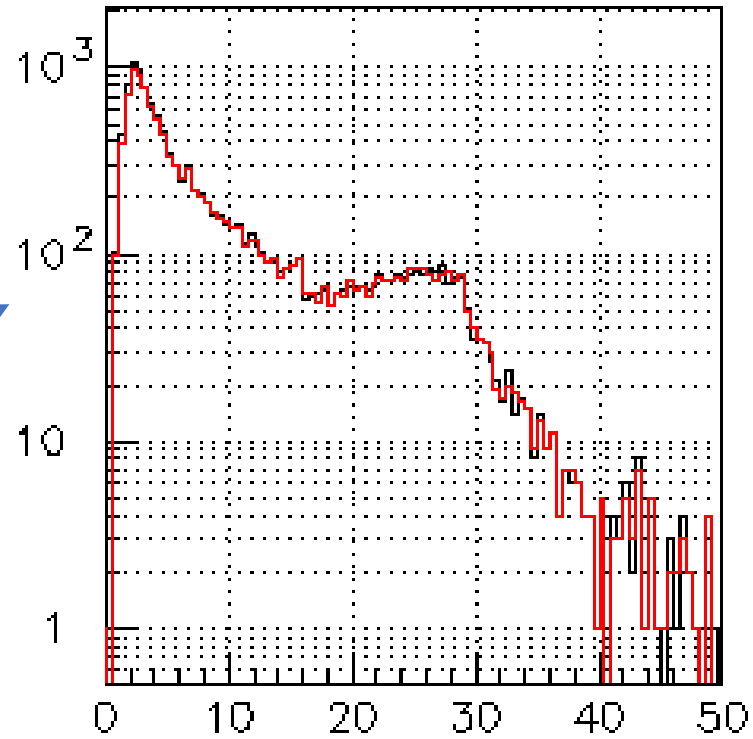
AVANSID 1
Integral of Fit function





Neutron gate

AVANSID 1



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

Isotropic for γ detection

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

Contents lists available at ScienceDirect

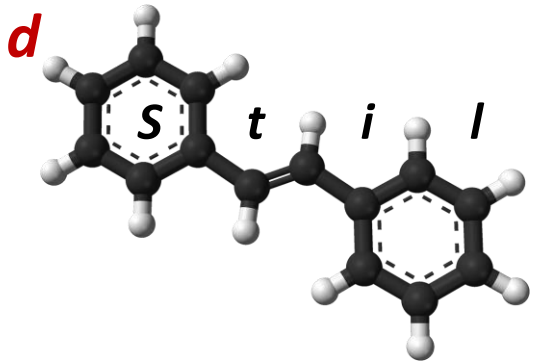
Nuclear Inst. and Methods in Physics Research, A

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]

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

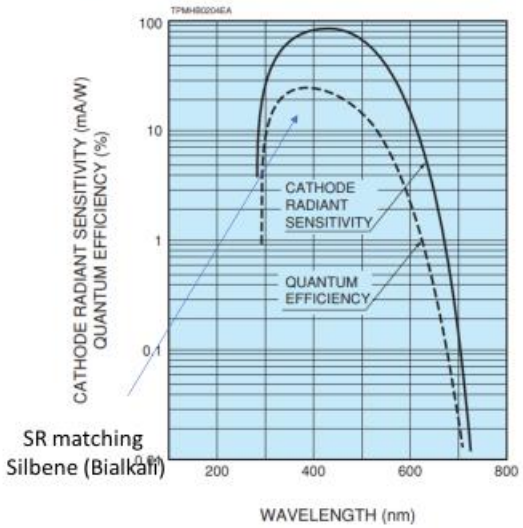
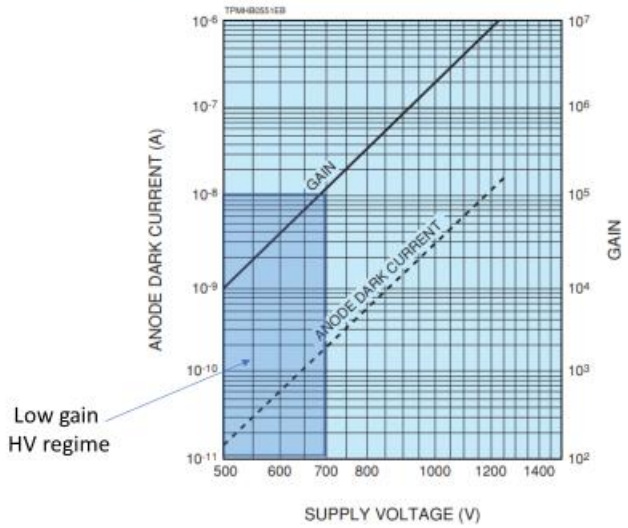


Figure 2: Typical gain and dark current characteristics



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

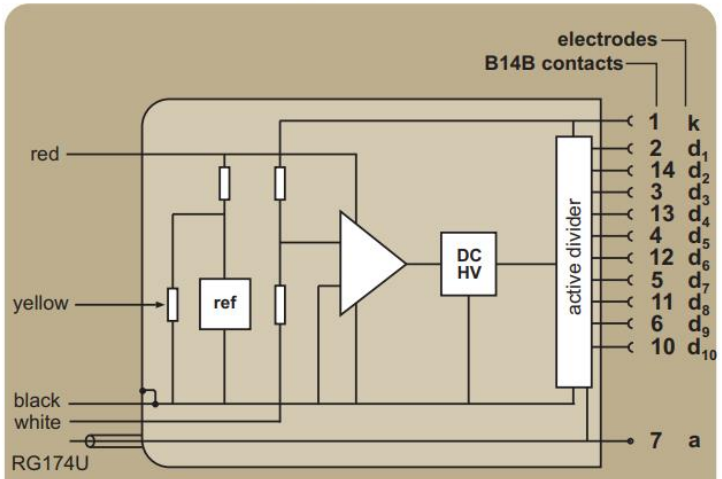
3 features

- 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

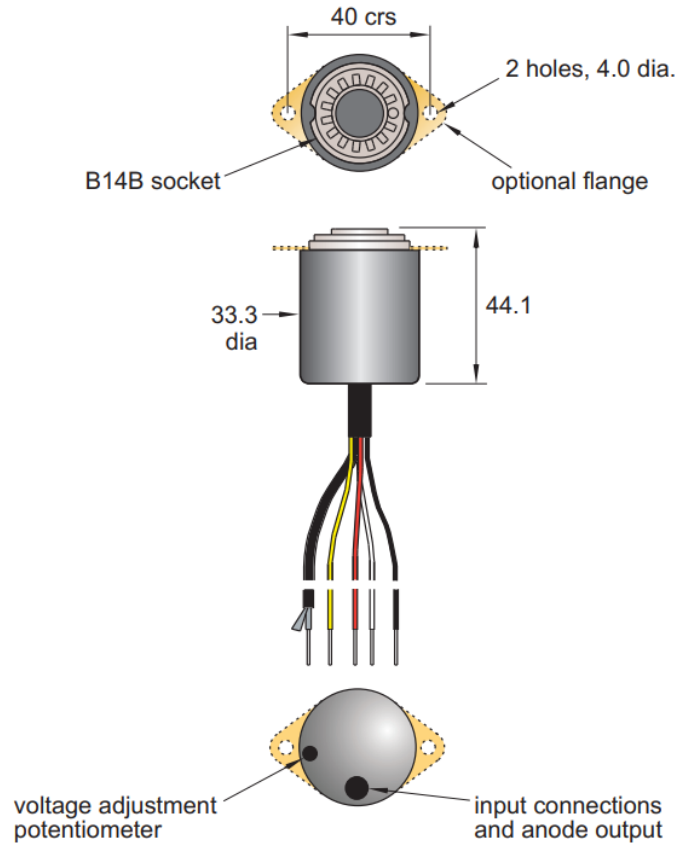
6 schematic diagram



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



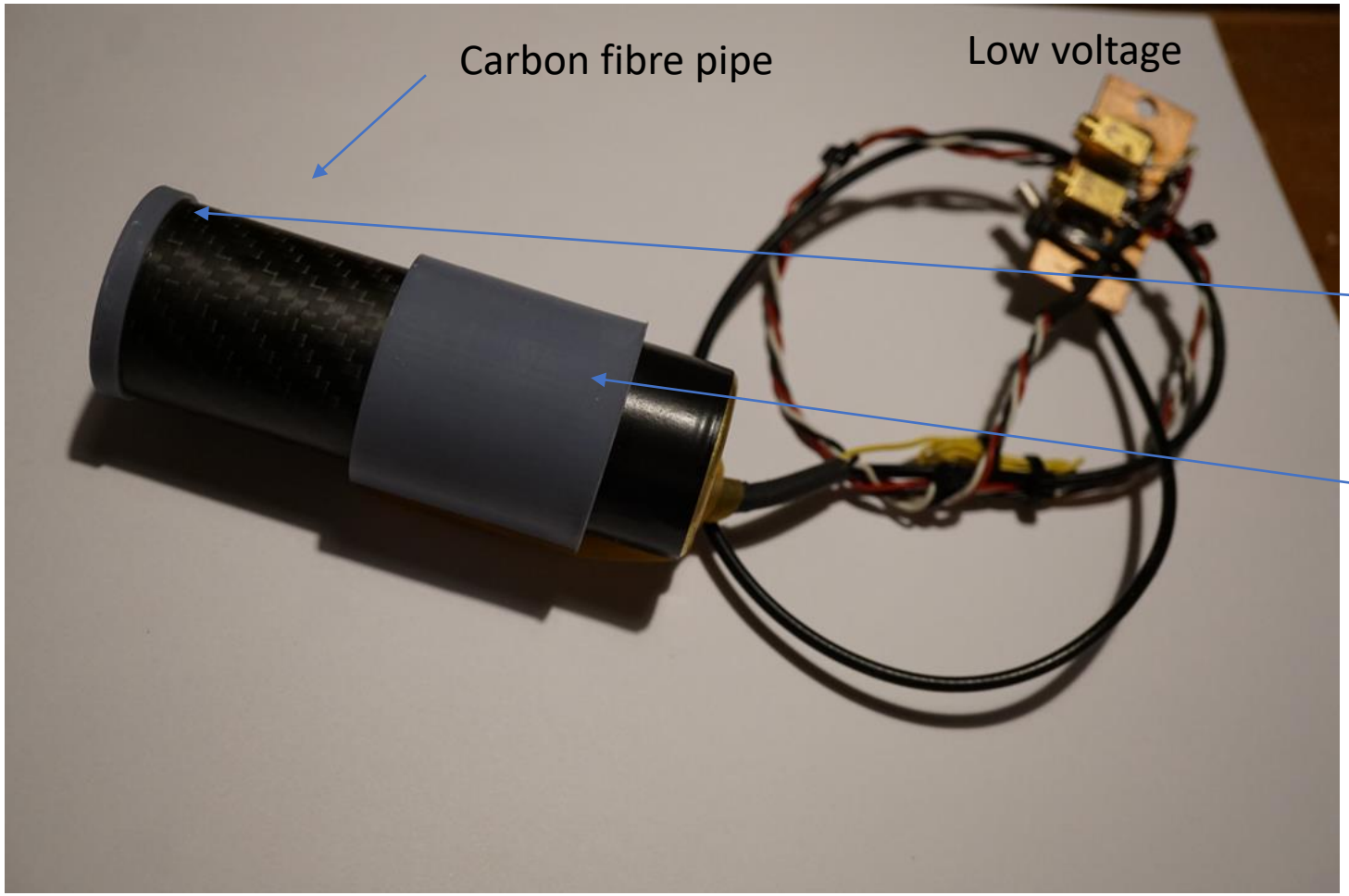
Ultra compact active base with DC-DC converter
no HV needed

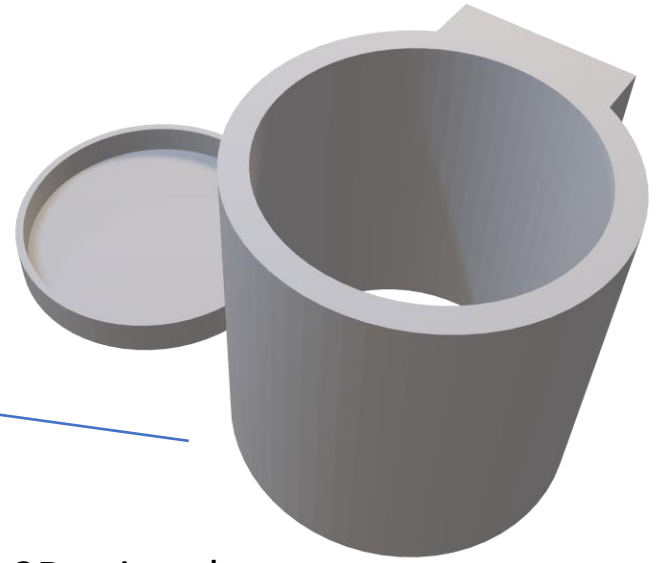
This power base was tested for a self-powering device and high counting rate

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





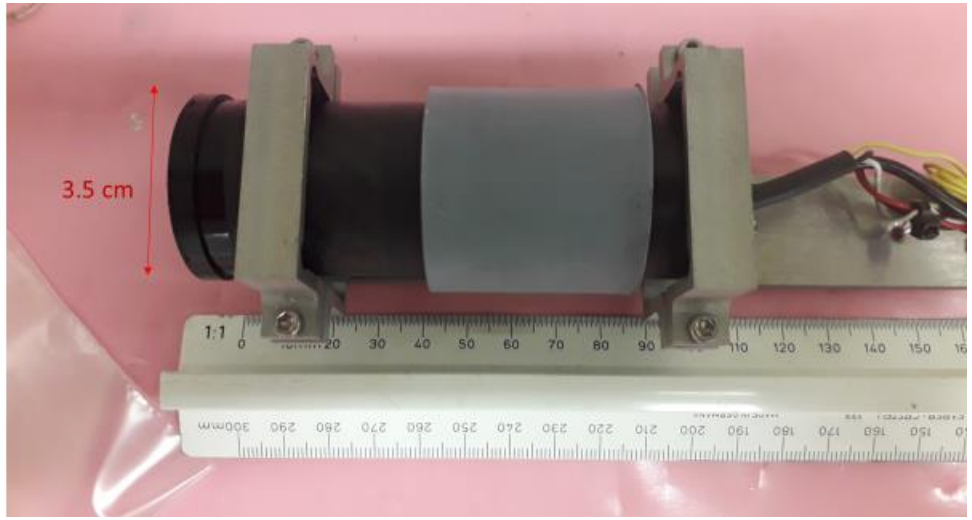
3D printed
holder
and cup

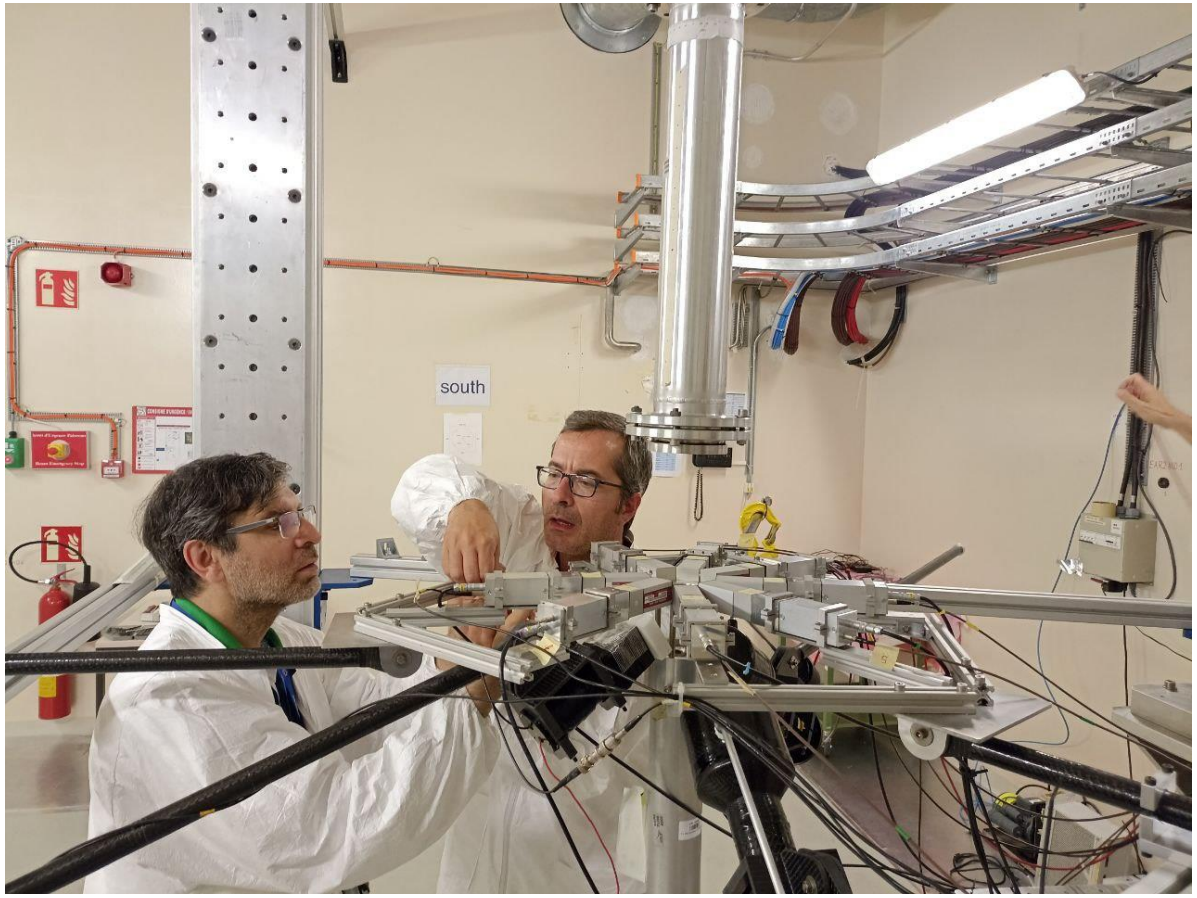
First test @EAR2

The holder was fitting with the S-TED frame

main geometry unchanged for the test

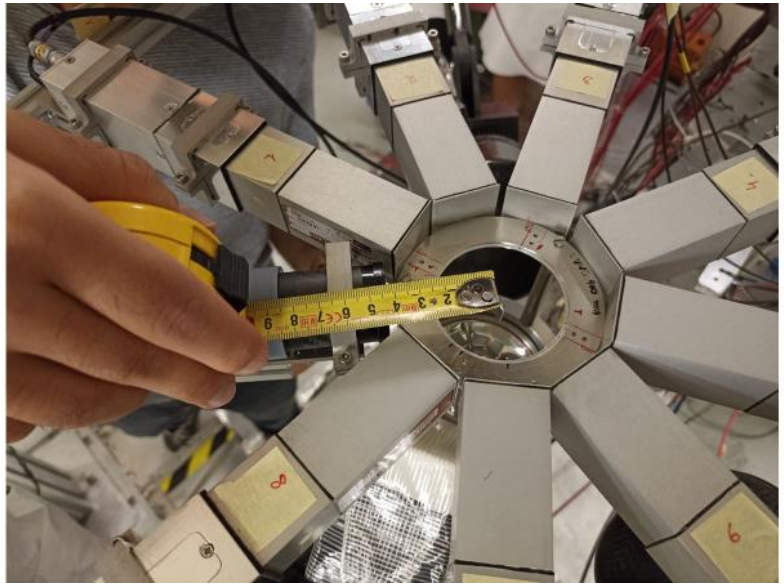
relaxed mechanical constraints





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

Same distance from the beam

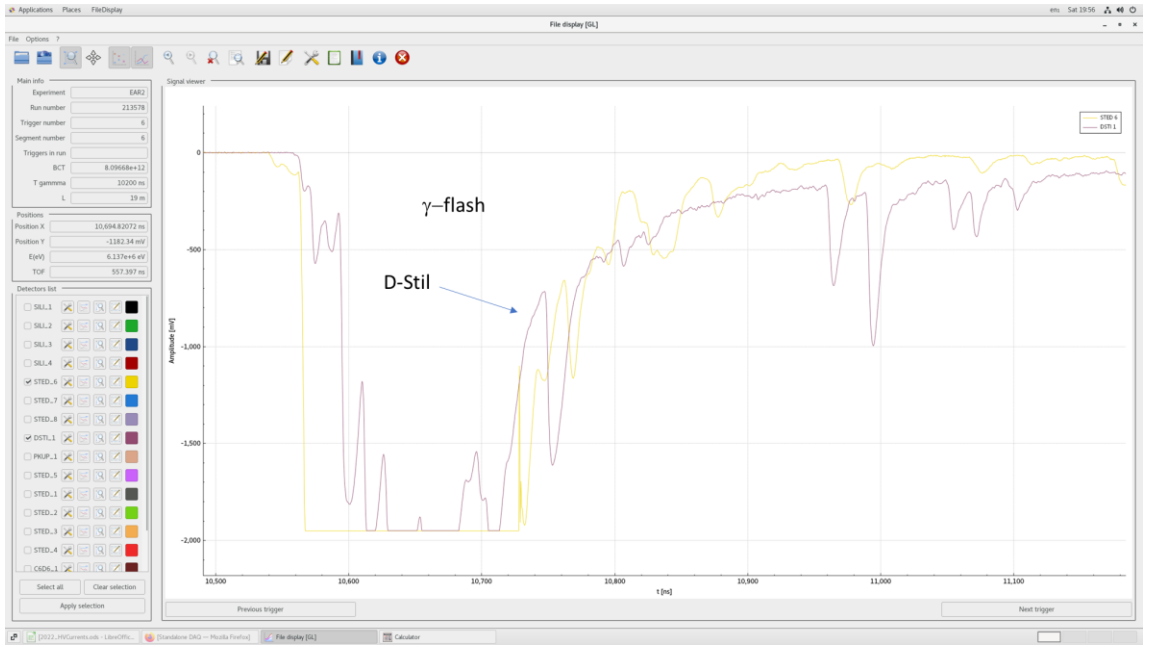


First signals

Present further improvements with respect to the prototype:

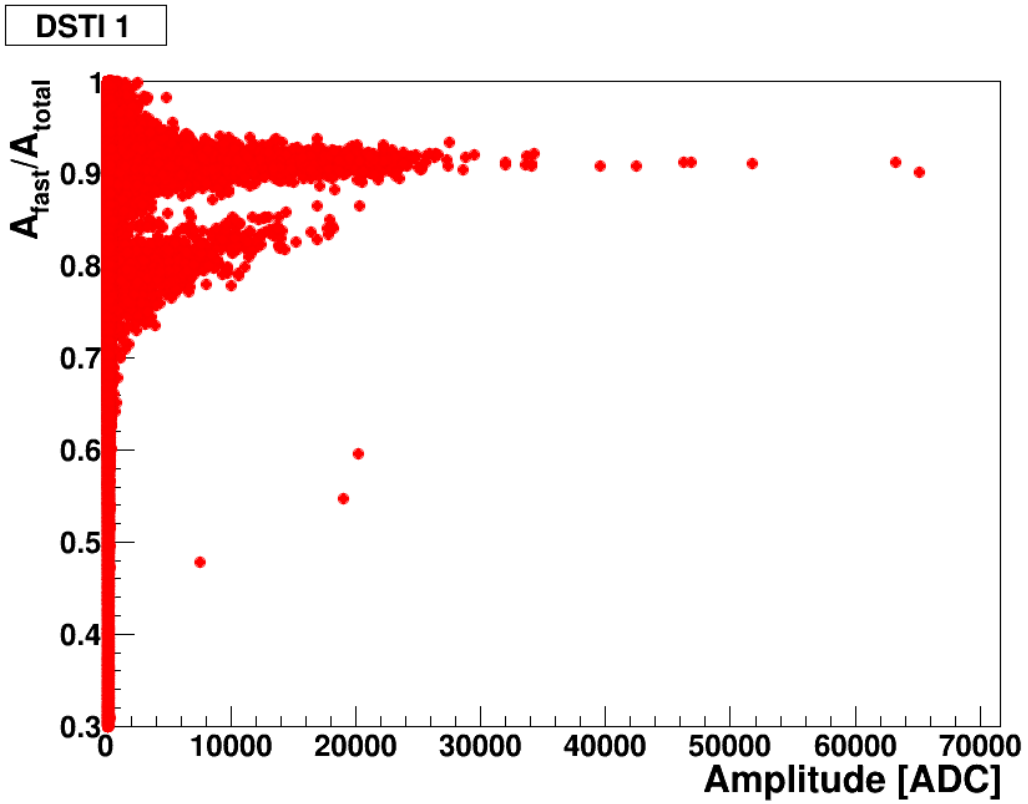
- **PM quartz window**
- **lower PM voltage**
- **Improved holder**
- **larger Stilbene thickness (1 inch)**

Concerning γ-flash

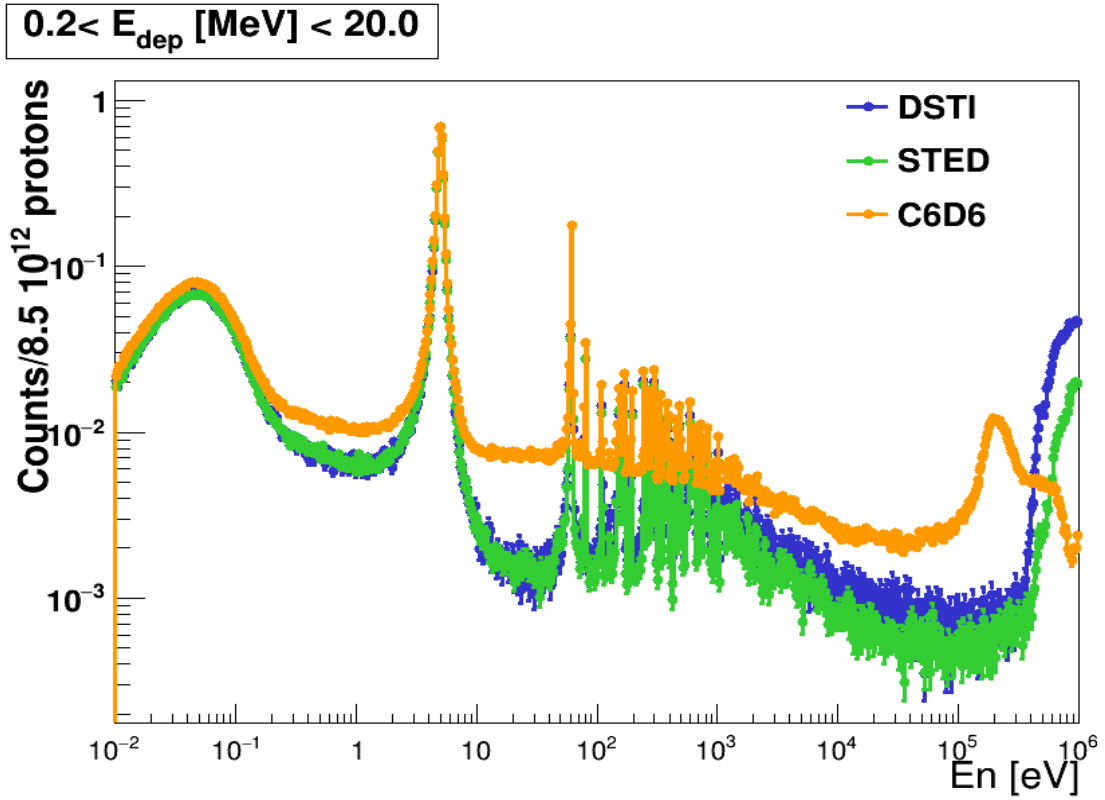


In spite of d-Stil gain was larger and the PM photocathode was very close to the beam

Analysis



ToF spectra normalized to saturated resonance

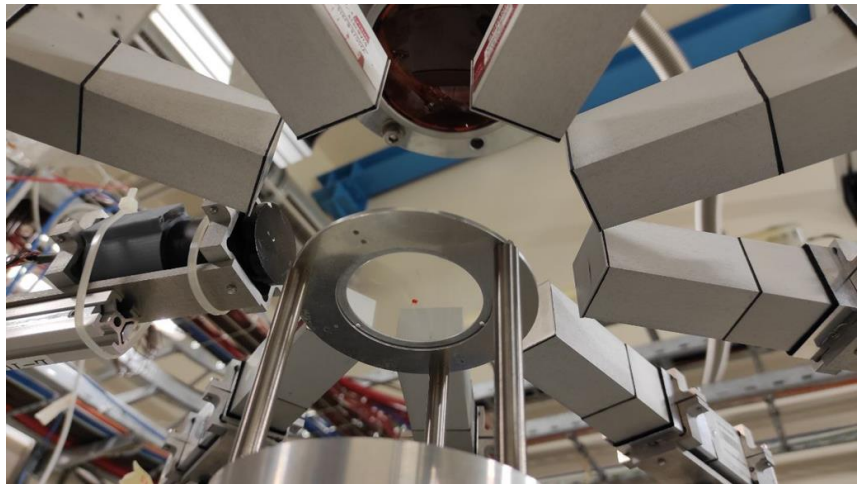


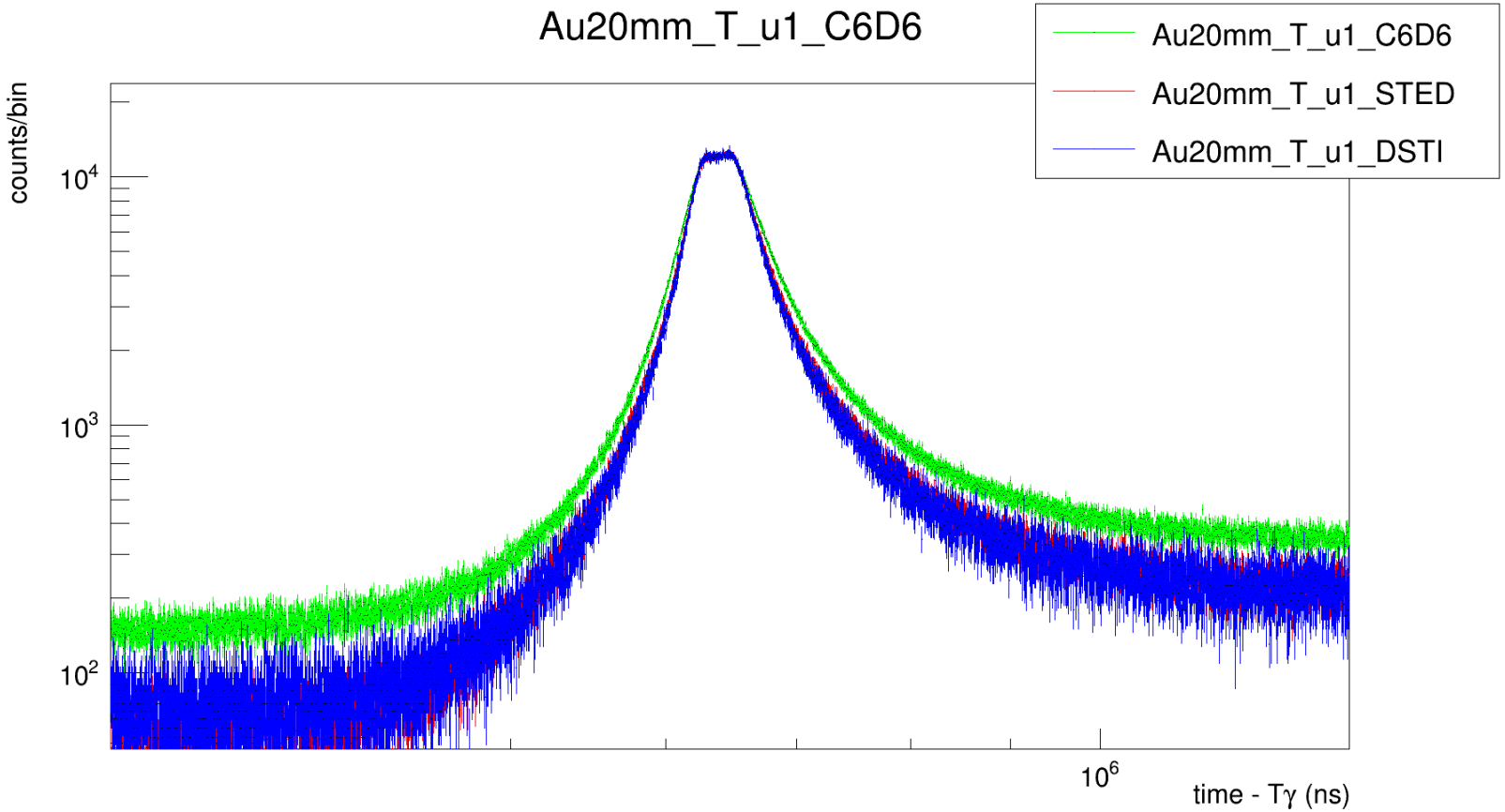
ToF spectras for DSTI and STED have similar shape

By Javi Balibrea

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

New setup HV=600 V





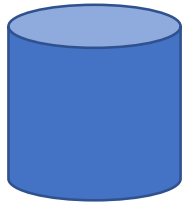
By_Riccardo_Mucciola

Conclusions: upgrades and future possible set-up for test

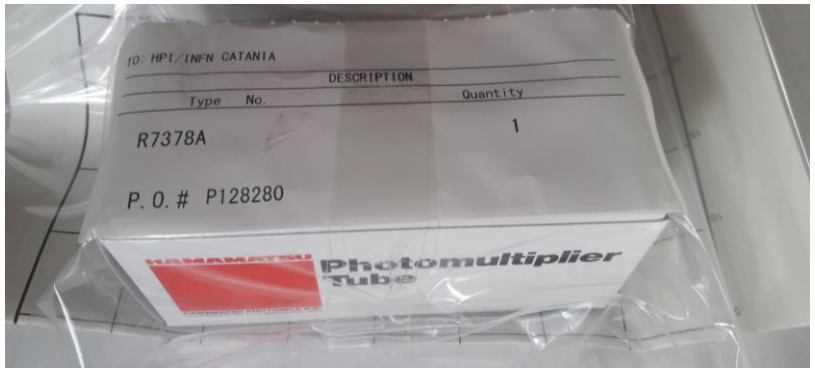
4 new Modules ready to be assembled @ INFN-Sezione di Catania with same power bases

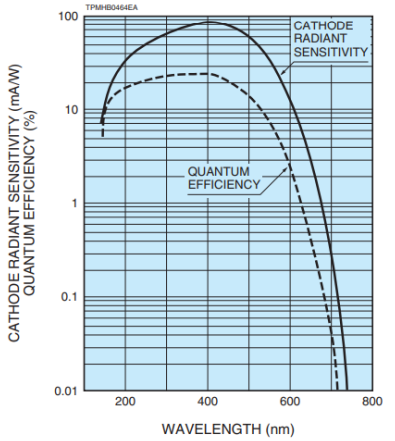
Standard type «Scintinel» (no deuterated *p*-type) @ INFN_CT

Diameter: 25.4 mm,
Thickness: 25.4 mm



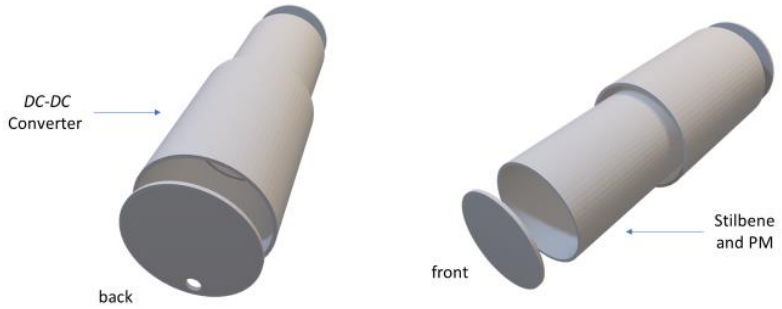
R7378A – Synthetic silica window (**no Borosilicate**) (Nikolas@CERN)





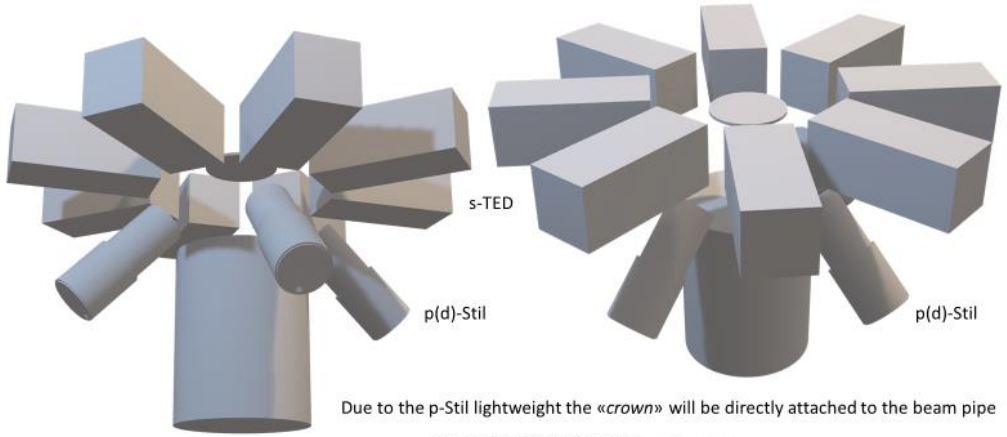
p-Stil holder

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 !!