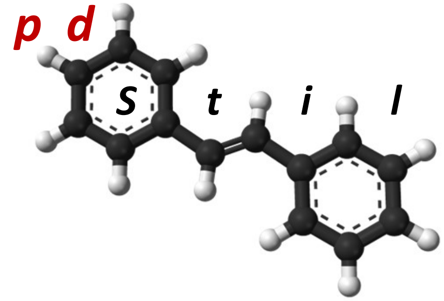
HINPw7   31/05 – 01/06/2024



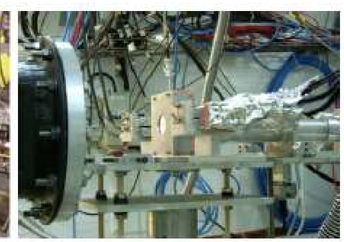
Towards the next generation of detectors for *n*-γ capture reactions at *n_TOF* (CERN)

A. Musumarra for the n_TOF collaboration

DFA University of Catania and INFN Sezione di Catania - Italy



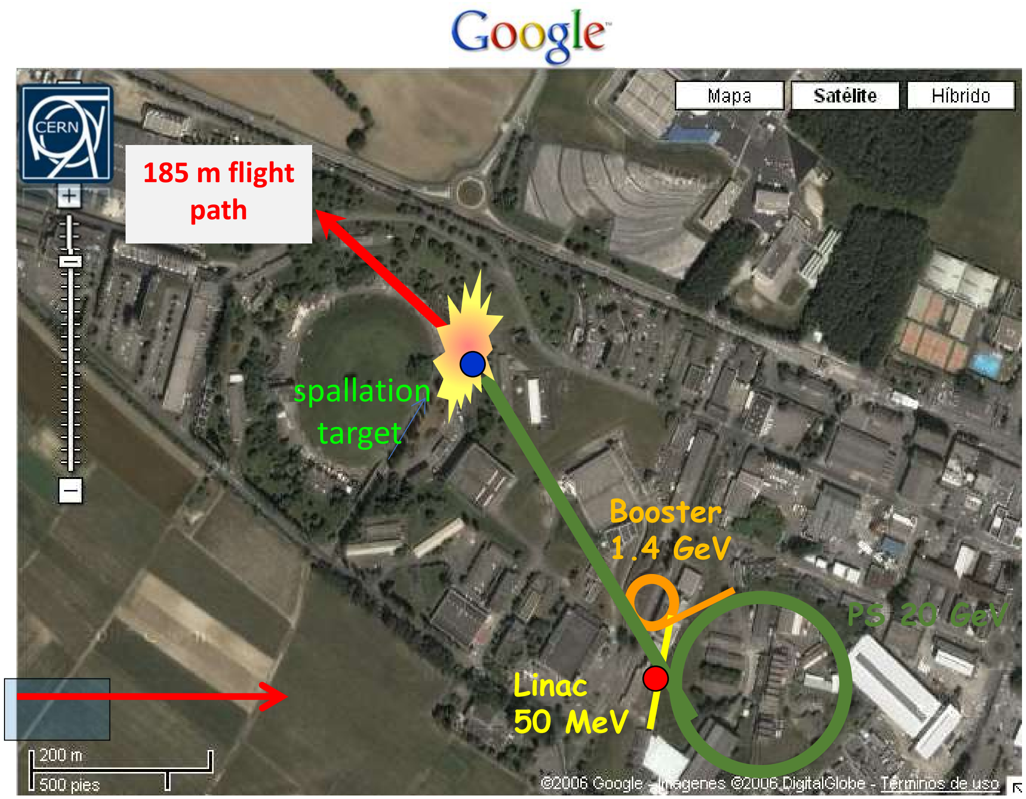




Outlook

- The *n_TOF* facility@CERN
- A new experimental approach for replacing the C_6D_6 for *n*-γ capture reactions
- Moving further to *n-n* and *n-n'* elastic and inelastic scattering measurements
- Experimental results
- The new array
- Perspectives

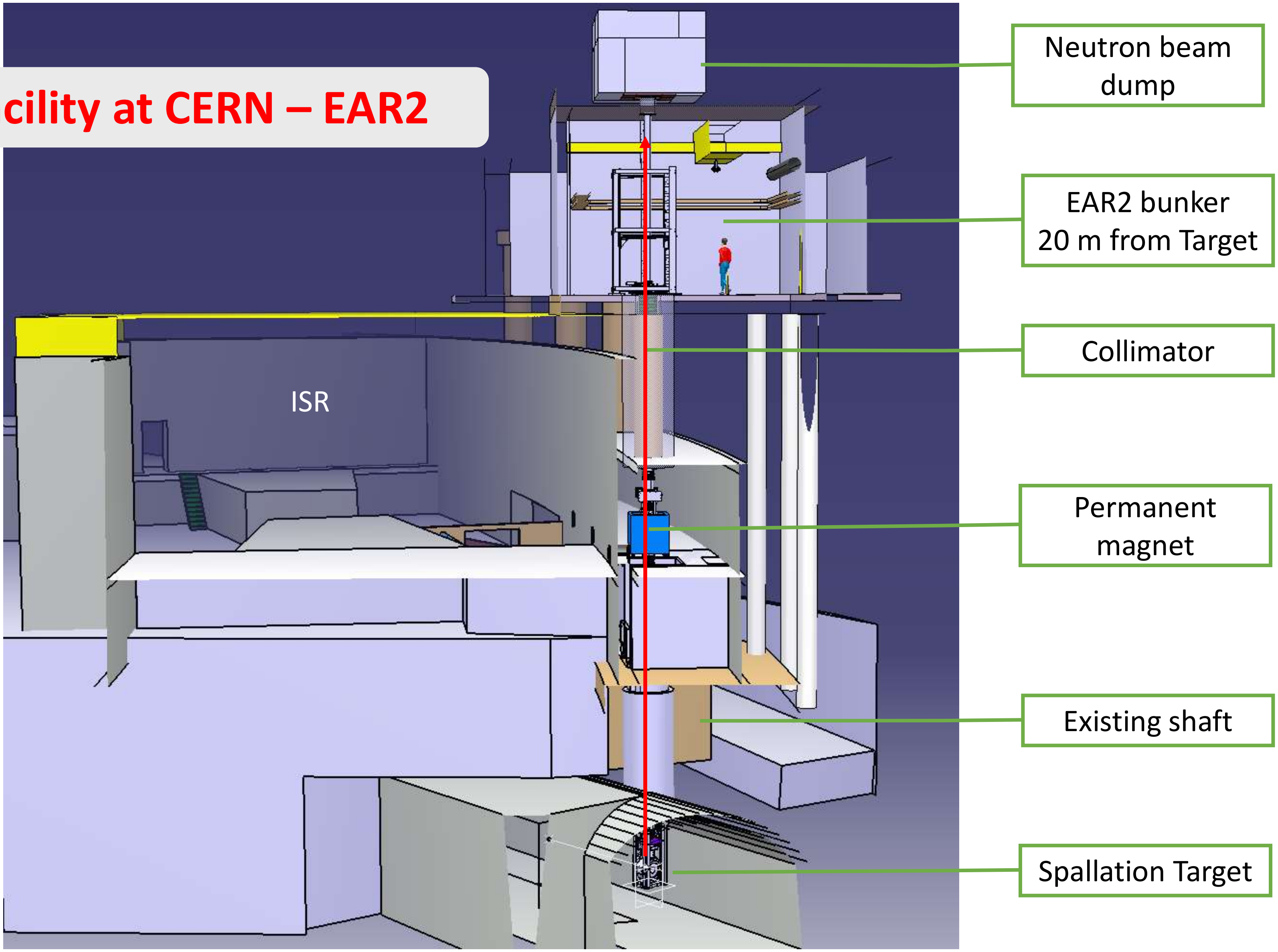
The *n_TOF* facility at CERN – EAR1



n_TOF is a **spallation** neutron source based on **20 GeV/c protons** from the CERN PS hitting a **Pb block** (~360 neutrons per proton).

EAR1 Experimental Area at **185 m**.

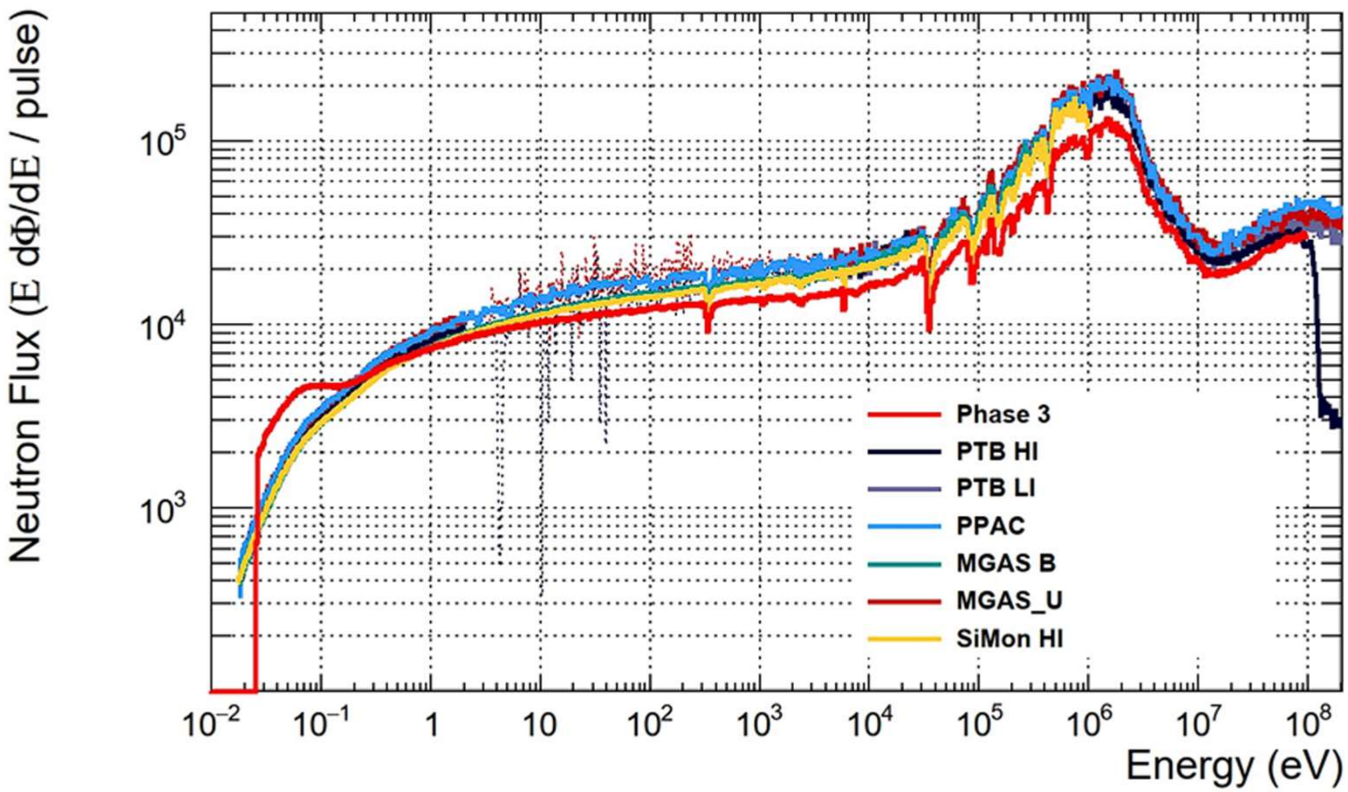
The *n_TOF* facility at CERN – EAR2



EAR1 neutron flux

Features of the neutron beam:

- high **resolution in energy** (*$\Delta E/E = 10^{-4}$*) - study **resonances**
- wide **energy range** (*25 meV<E_n<1GeV*) - measure **fission** from ther. to GeV
- low **repetition** rate (*< 0.8 Hz*) - no **wrap-around**

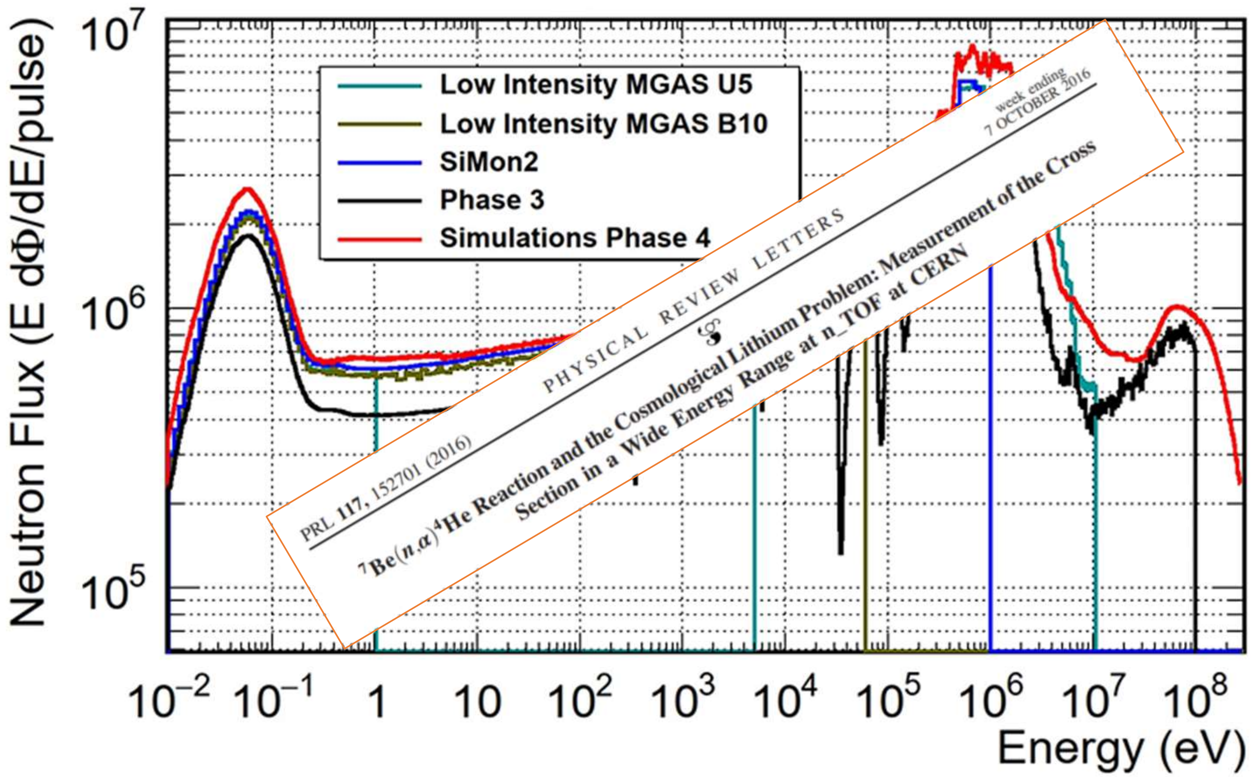


EAR2 neutron flux

- **Higher fluence**, by a factor of 25,(*30 exp*) relative to EAR1.
- The **shorter flight path** implies a factor of 10 smaller time-of-flight.

Global gain by a factor of **250 in the signal/background ratio** for radioactive isotopes!

The gain in signal-to-background ratio in EAR2 allows to measure radioactive isotopes with **half lives as low as a few years.**



$^7Be(n,\alpha)$ and $^7Be(n,p)$ measurements (Big-Bang Nucleosynthesis)

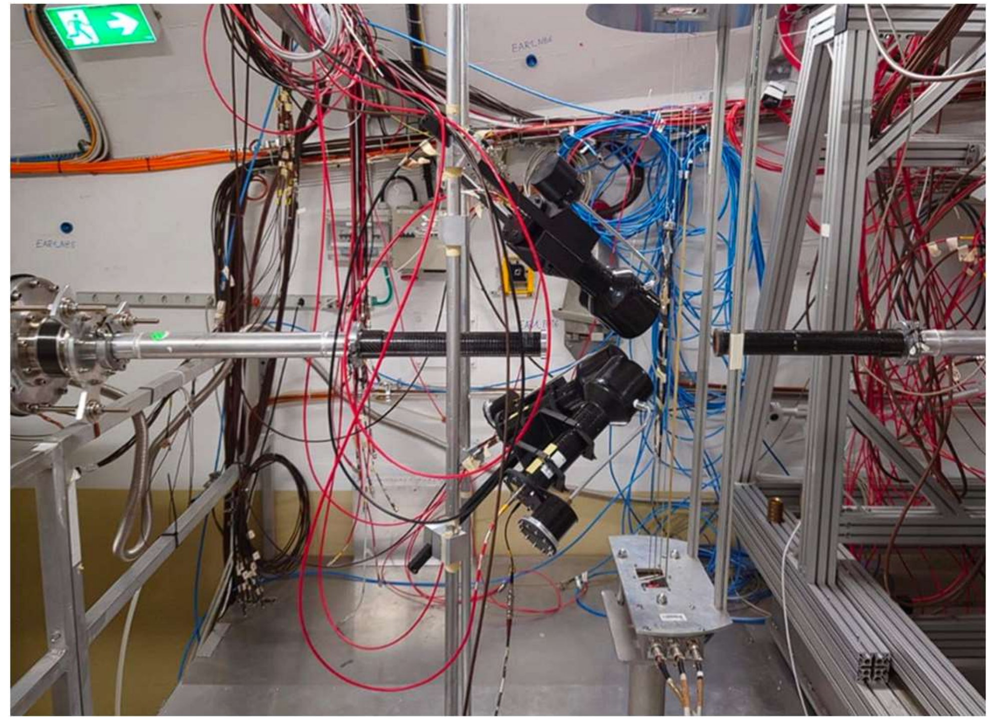
A. Musumarra, M. Barbagallo

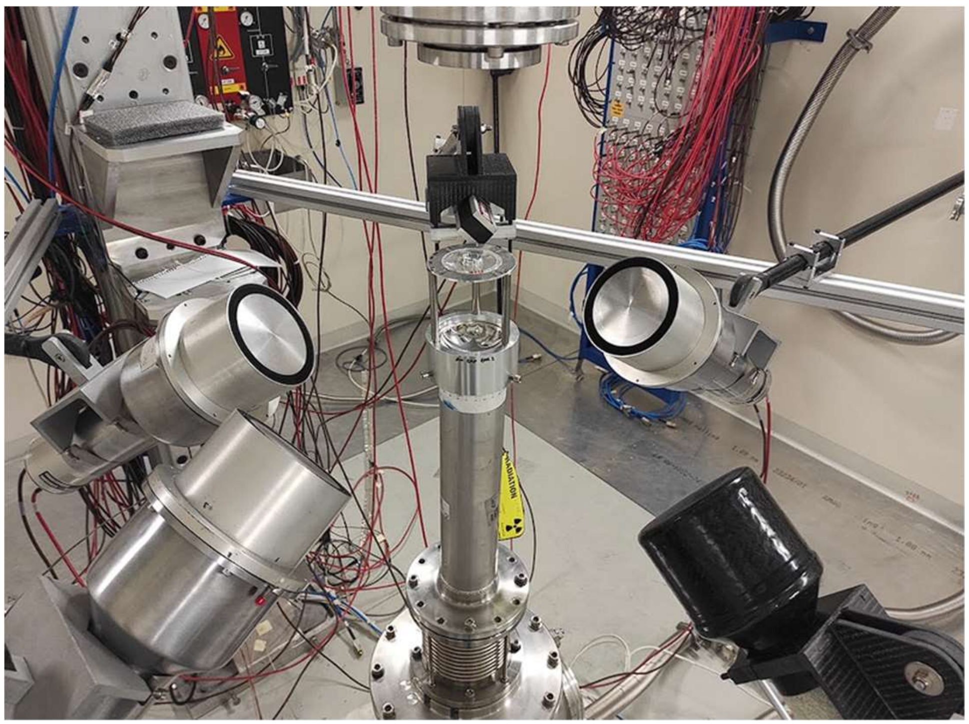
Facility milestone flagship - experiment

n_TOF Capture setup «*old-style*»

Scintillation material
C_6D_6

EAR1 →

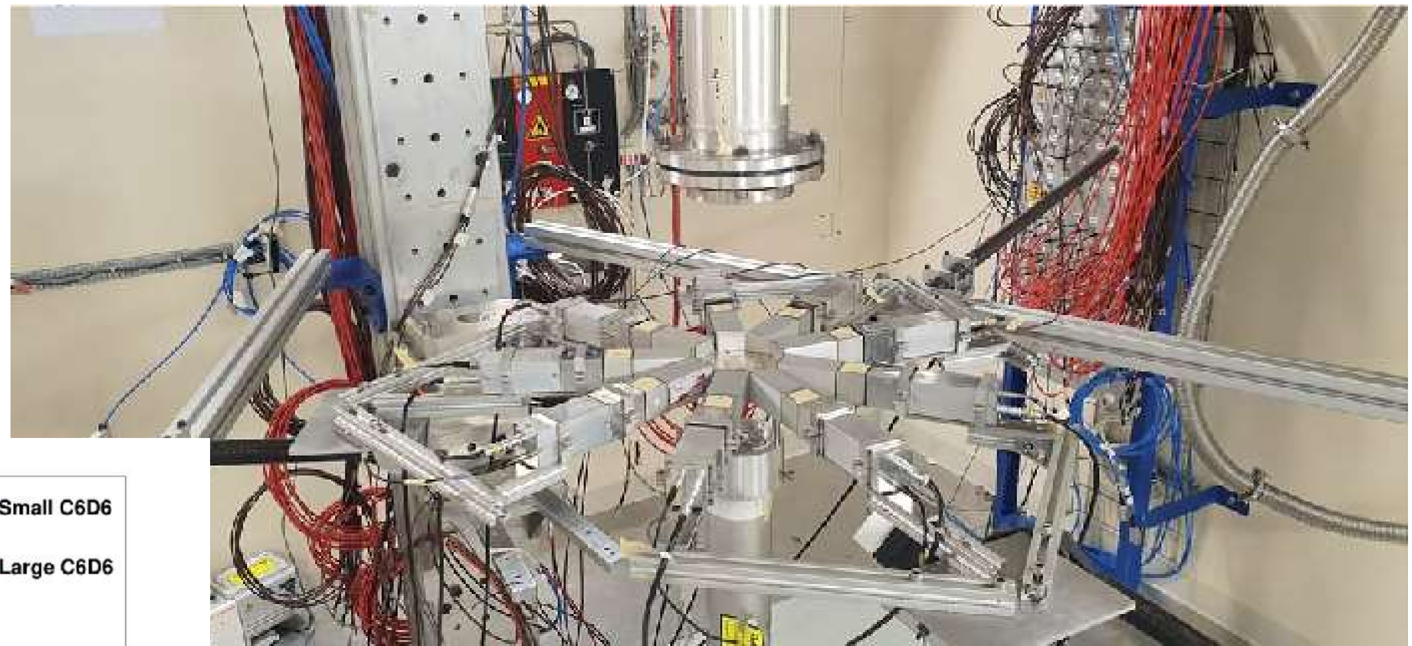


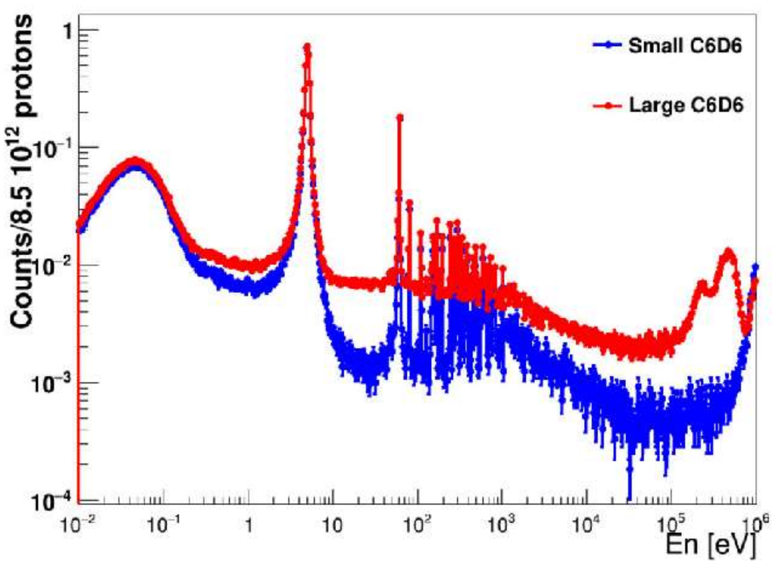


← *EAR2*

n_TOF Capture setup *S_TED*

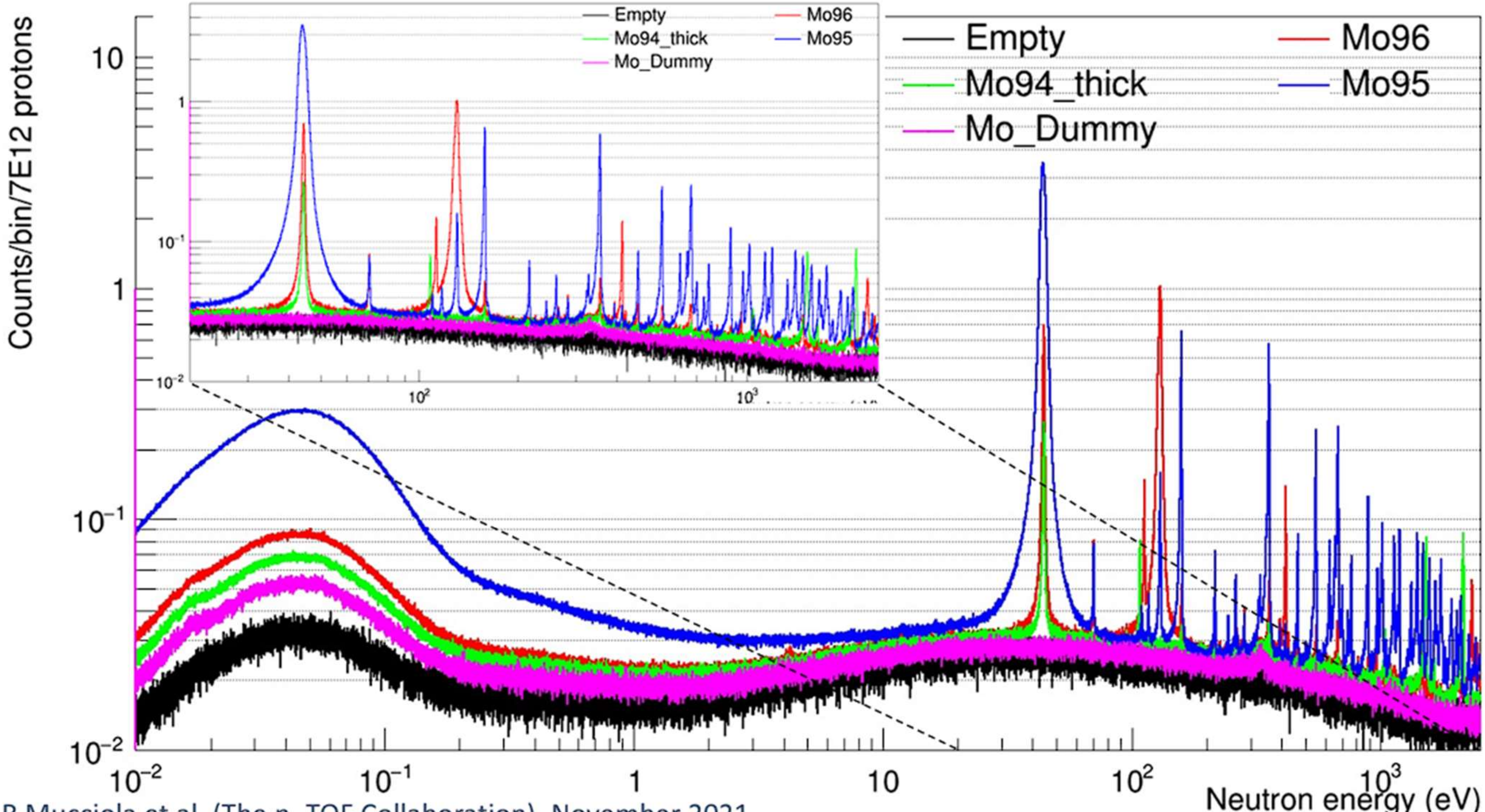
Scintillation material
C_6D_6





Improvement in S/R ratio

Measurement of $^{94,95,96}Mo(n,\gamma)$ relevant to Astrophysics and Nuclear Technology

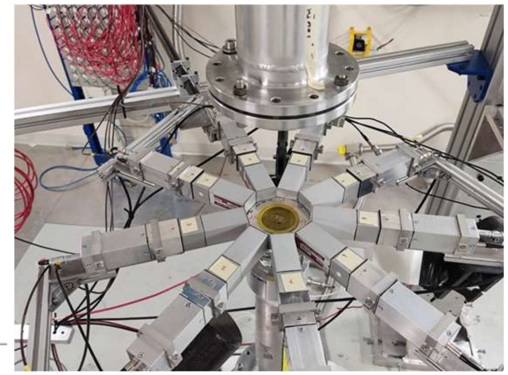


R Mucciola et al. (The n_TOF Collaboration), November 2021

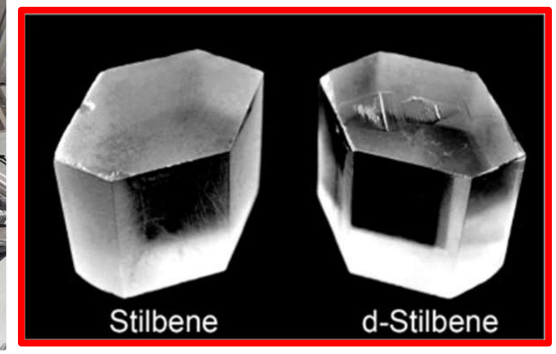
Motivations for developing a new prototype

“Big” C_6D_6 Liquid scintillators

Large & segmented C_6D_6

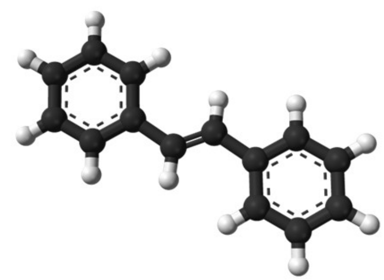


Compact array of small C_6D_6



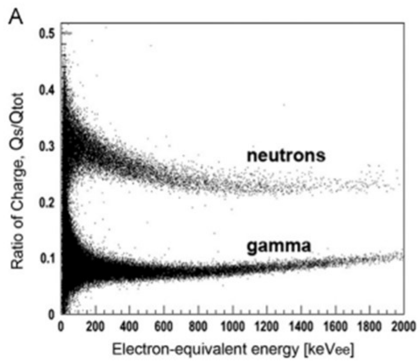
Solid organic scintillators
Read-outs/Power supplies

Solid
Higher density
No Chemical hazard
***n*/γ discrimination**



Stilbene characteristics

γ/n discrimination



Nuclear Instruments and Methods in Physics Research A 789 (2015) 8–15

Contents lists available at ScienceDirect

Nuclear Instruments and Methods in Physics Research A

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

Scintillation properties of solution-grown *trans*-stilbene single crystals

Natalia Zaitseva [a,*], Andrew Glenn [a], Leslie Carman [a], H. Paul Martinez [a], Robert Hatarik [a], Helmut Klapper [b], Stephen Payne [a]

Linear response in energy

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

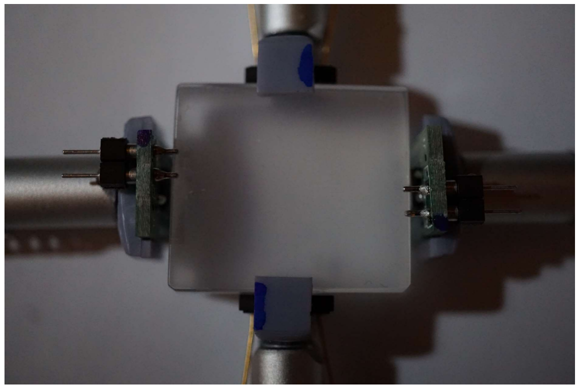
Augusto Di Chicco [a,d], Alix Sardet [b,*], Michaël Petit [c], Robert Jacqmin [a], Vincent Gressier [c], Brian Stout [d]

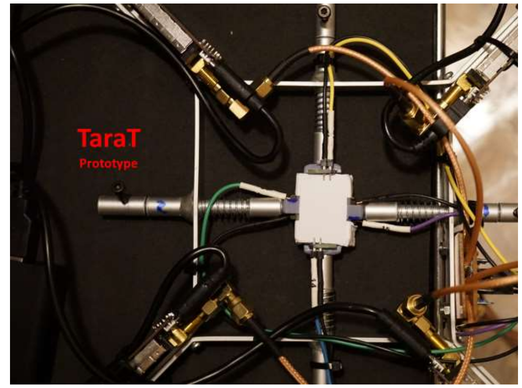
TaraT test run at *NCSR* Demokritos (Athens) June 2021

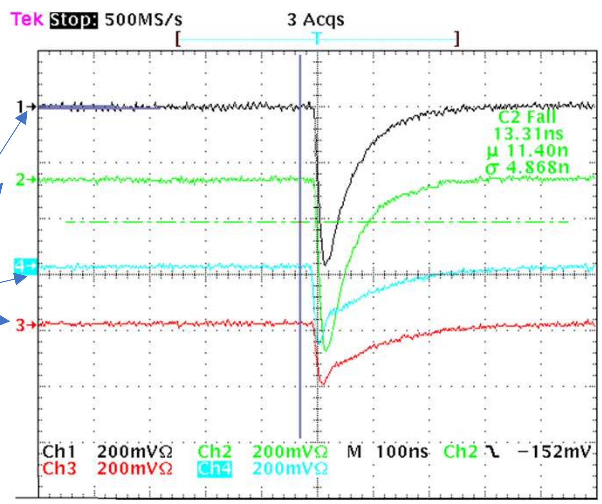
d-Stilbene

26 x 23 x 11 mm^3

thanks to
Natalia P. Zaitseva
from LLNL





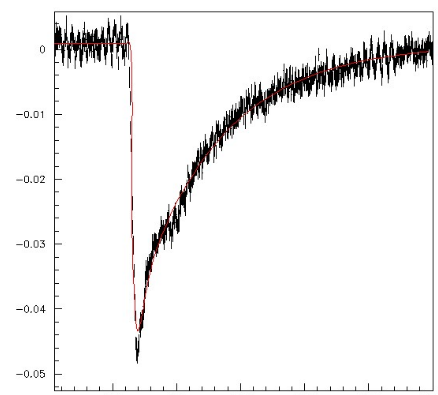


2 HAMAMATSU 6x6

2 AdvanSid 4x4

Signal parametrization

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



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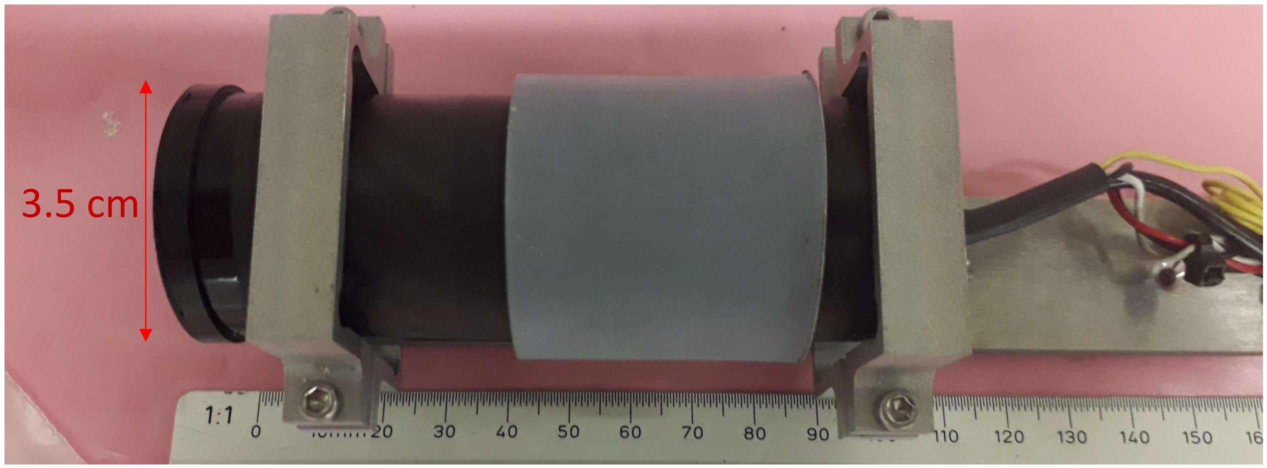
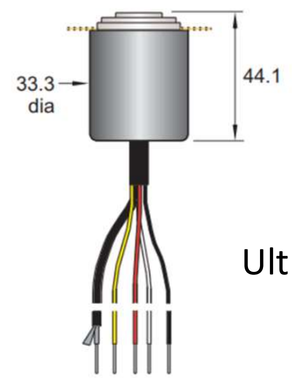
nTOF

d-stil first prototype - June 2022



HAMAMATSU R1924A



Sens-Tech PS1807
Ultra compact active base
with DC-DC converter
no HV needed

First test @ EAR2 – June 2022

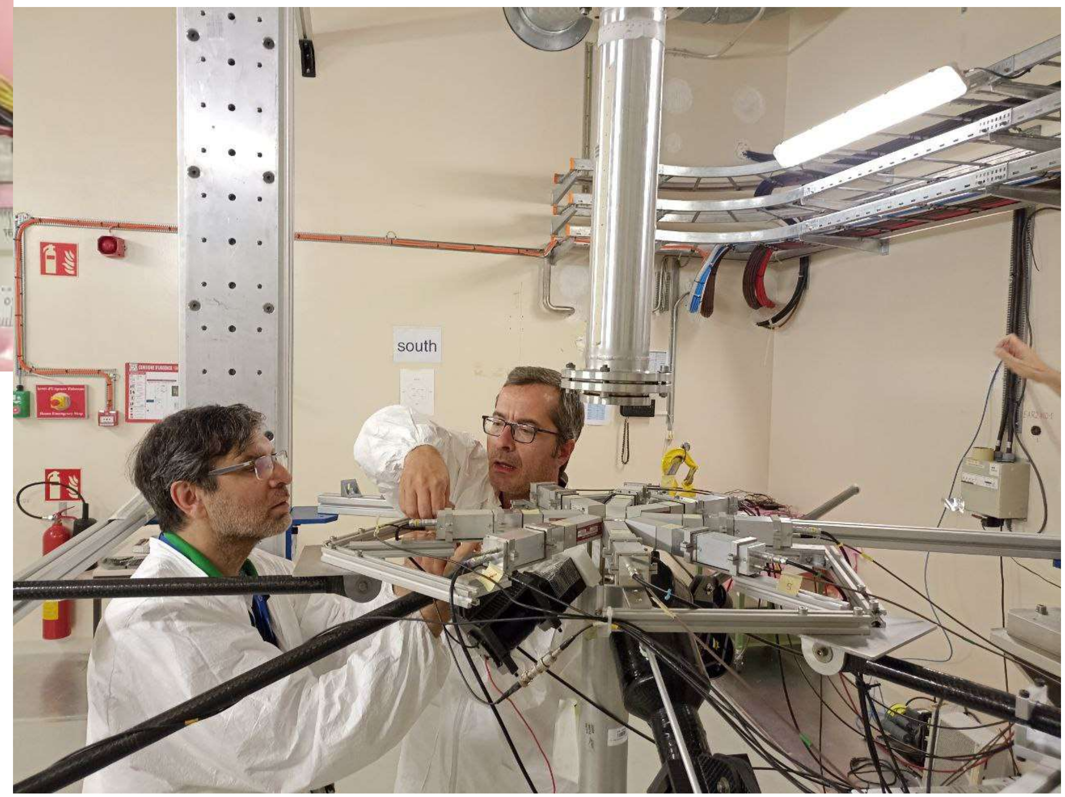
The holder was fitting with the S-TED frame

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



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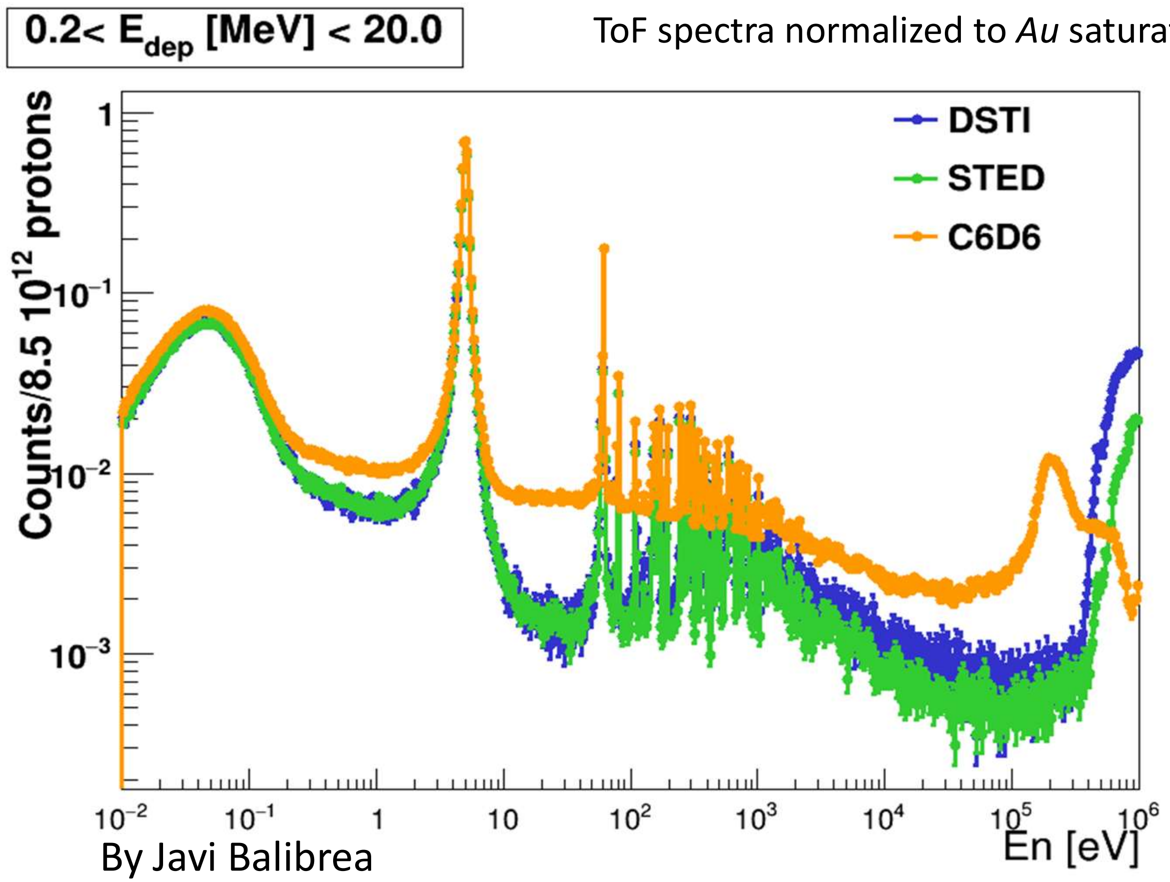
nTOF

Preliminary analysis

ToF spectra normalized to *Au* saturated resonance

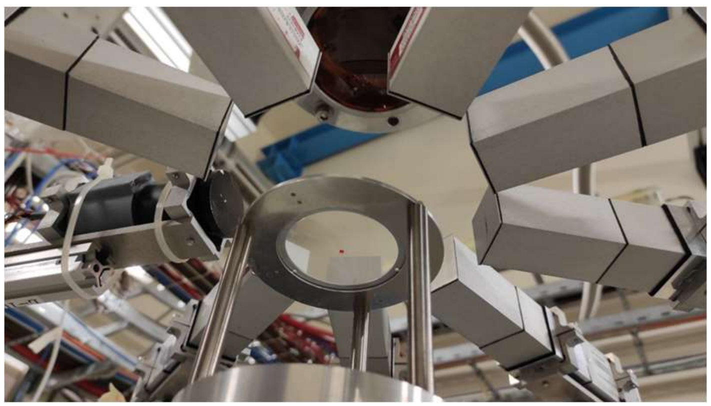


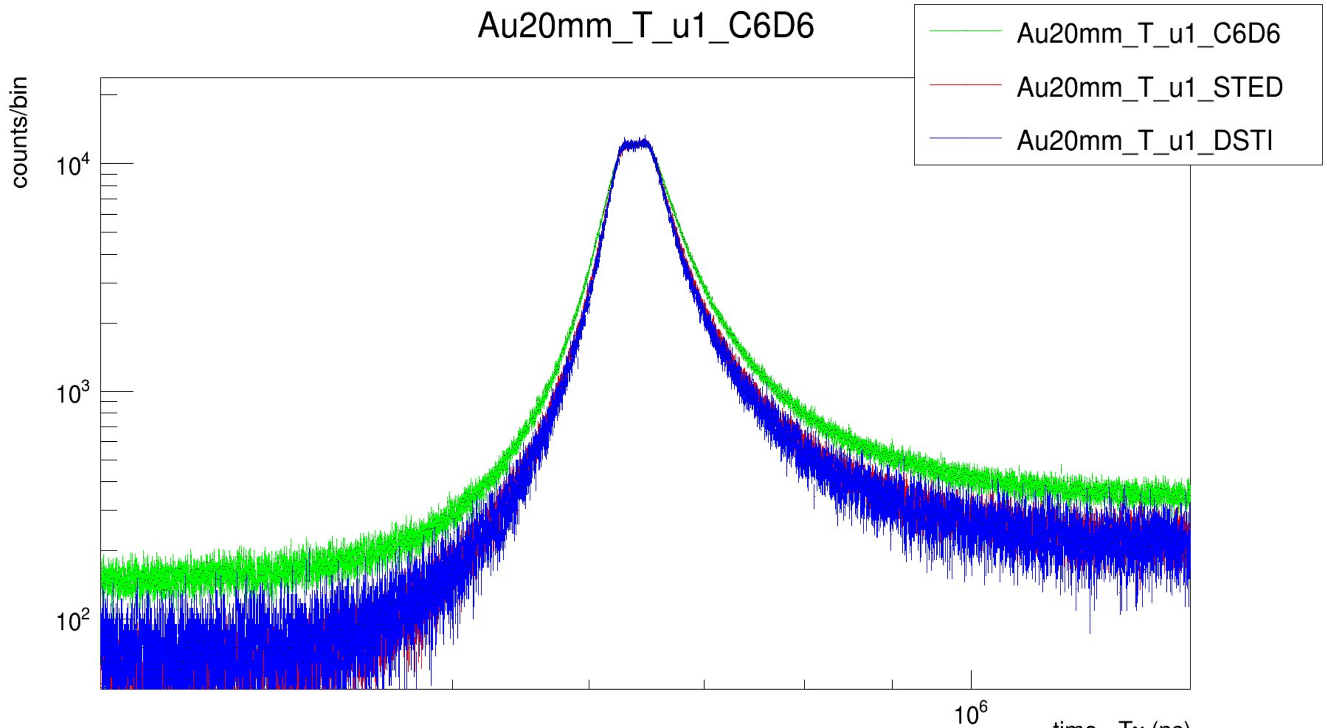
By Javi Balibrea

We got the same *S/N* ratio of STED by using a much simpler device !

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

New setup ***HV=600 V***





By_Riccardo_Mucciola

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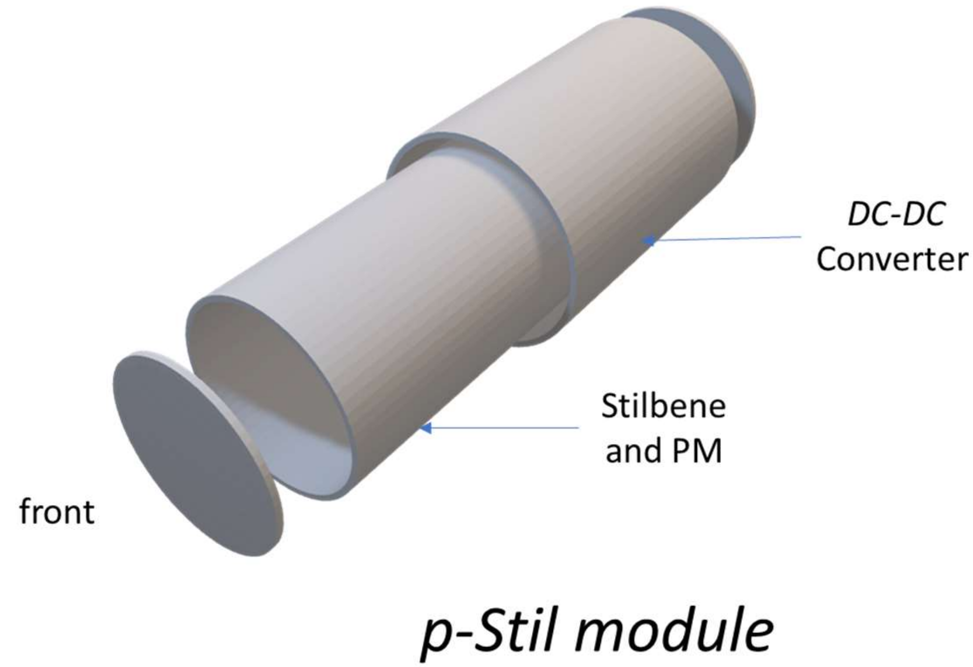
nTOF

The p-stil detectors - first array (n. 4 INRAD Scintinel^{TM} crystals)



1"x 1" 4 cylindrical ***INRAD*** p-stilbene detectors

LoI for stilbene detector development @ n_TOF – April 2023

Development of new solid-state total-energy detectors for neutron-capture measurements at CERN n_TOF

April 18, 2023

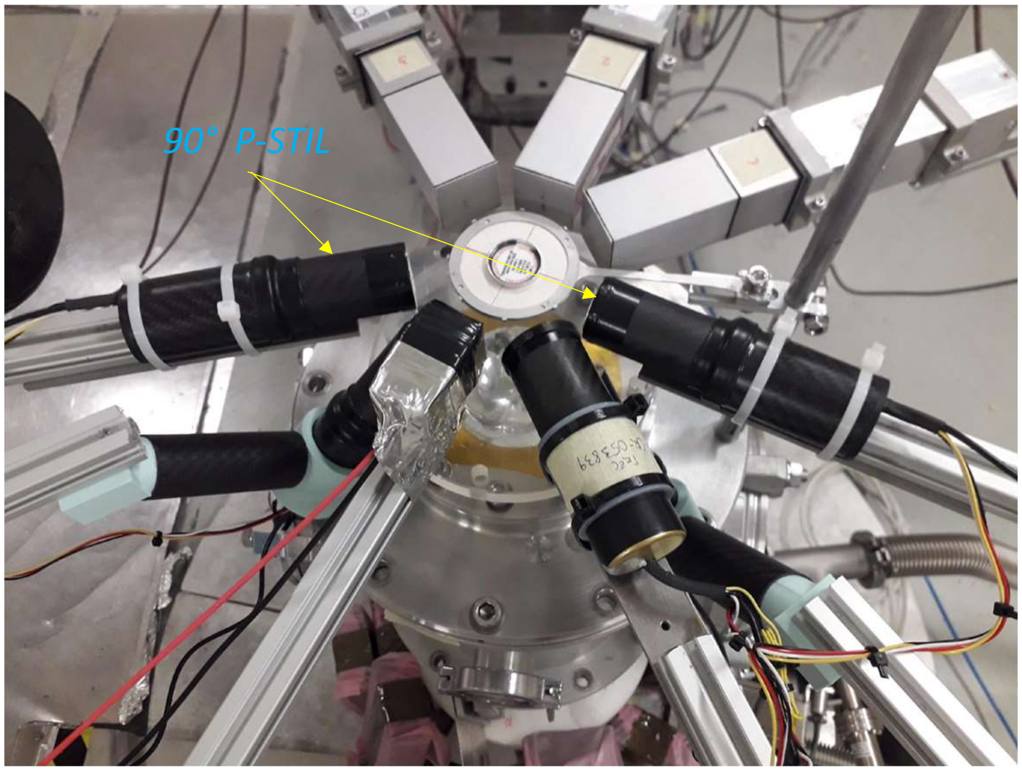
O. Aberle[1],V. Alcayne[2], M. Bacak[1], J. Balibrea-Correa[3], N. Colonna[4], D. Cano-Ott[2], A. Casanovas[5], C. Domingo-Pardo[3],O. Fjeld[1],F. Gunsing[6] J. Lerendegui-Marco[3], C. Lederer-Woods[7], C. Massimi[8,9], E. Mendoza[2],A. Mengoni[4,10], A. Manna[9,10], A. Musumarra[11,12], N. Patronis[1], M.G. Pellegriti[12]

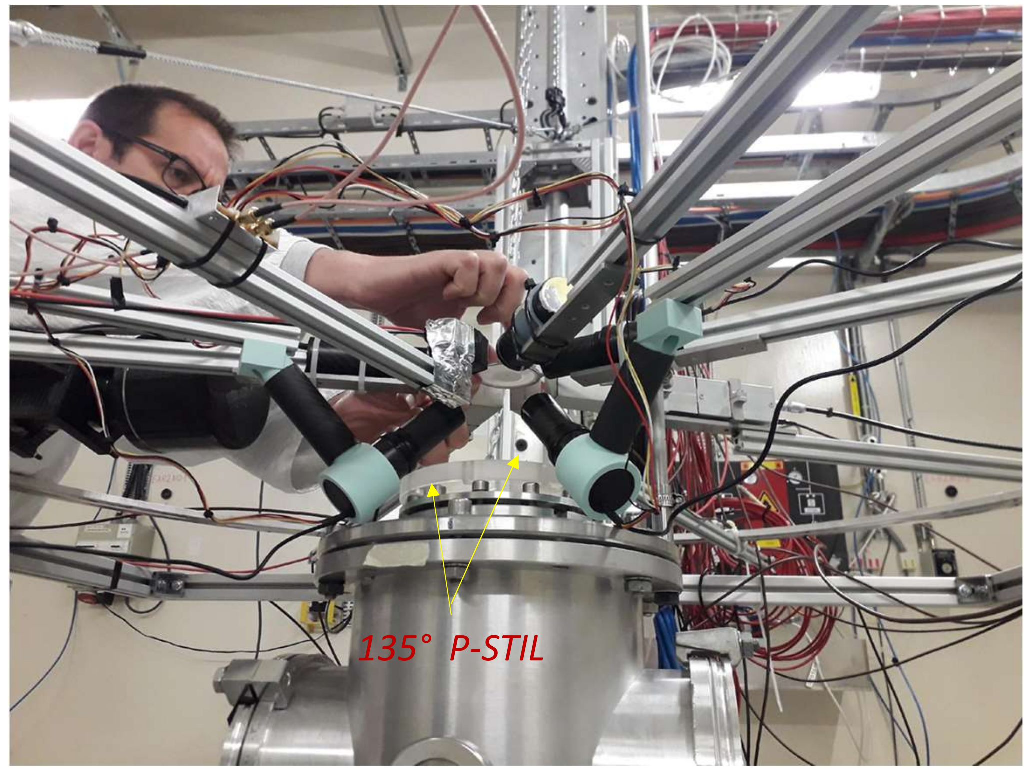
[1]*European Organization for Nuclear Research (CERN), Switzerland*
[2]*Centro de Investigaciones Energéticas Medioambientales y Tecnológicas (CIEMAT), Spain*
[3]*Instituto de Física Corpuscular, CSIC - Universidad de Valencia, Spain*
[4]*Istituto Nazionale di Fisica Nucleare, Sezione di Bari, Italy*
[5]*Universitat Politècnica de Catalunya, Spain*
[6]*CEA Irfu, Université Paris-Saclay, F-91191 Gif-sur-Yvette, France*
[7]*School of Physics and Astronomy, University of Edinburgh, United Kingdom*
[8]*Istituto Nazionale di Fisica Nucleare, Sezione di Pavia, Italy*
[9]*Dipartimento di Fisica e Astronomia, Università di Bologna, Italy*
[10]*Istituto Nazionale di Fisica Nucleare, Sezione di Bologna, Italy*
[11]*Dipartimento di Fisica e Astronomia, Università di Catania, Italy*
[12]*Istituto Nazionale di Fisica Nucleare, Sezione di Catania, Italy*

Spokespersons:
Javier Balibrea-Correa javier.balibrea@ific.uv.es
Agatino Musumarra musumarra@lns.infn.it
Technical coordinator: O. Aberle Oliver.Aberle@cern.ch

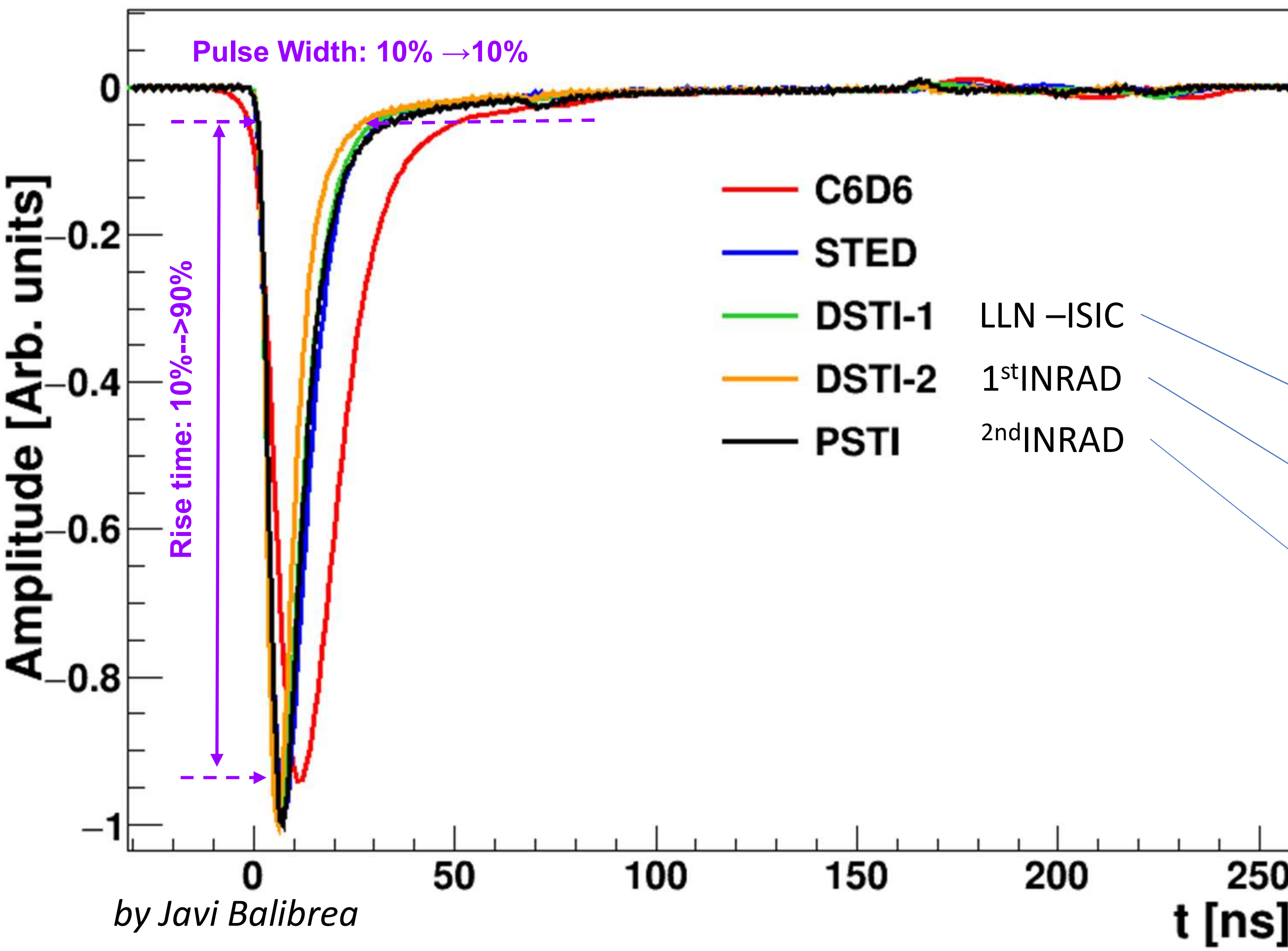
CERN-INTC-2023-034 / INTC-I-254
18/04/2023

EAR2 May 2023 set-up





Detectors’ pulse shape analysis (only γ)



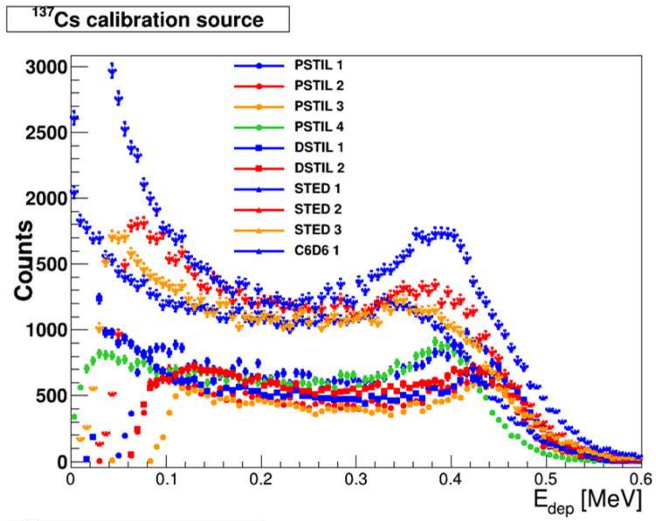
by Javi Balibrea

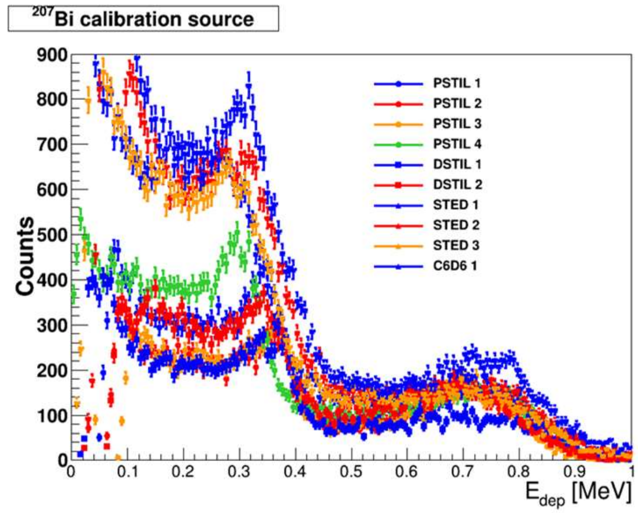
Average pulse shape calculated by ^{88}Y calibration source

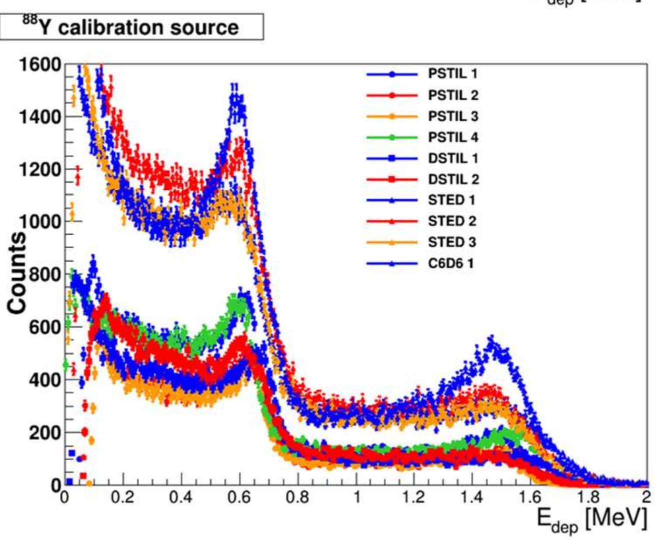
Detector	Rise time [ns]	Pulse width [ns]
L6D6	8	40
sTED	4.4	24
DSTI-1	3	23
DSTI-2	3.3	19
PSTI	3.9	20

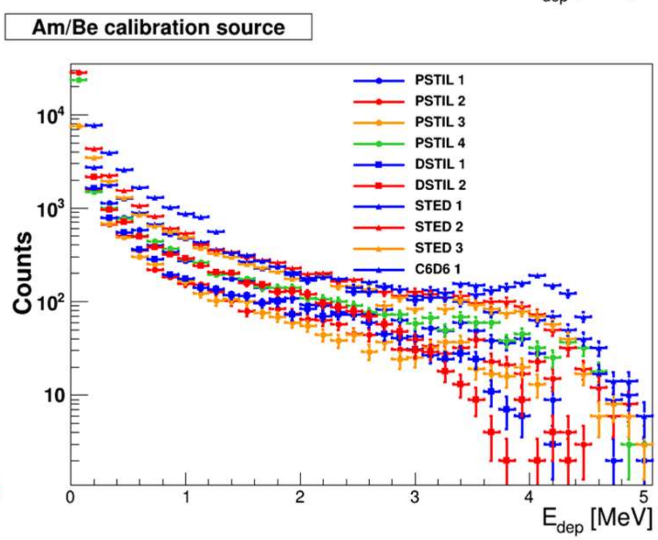
Deposited energy calibration

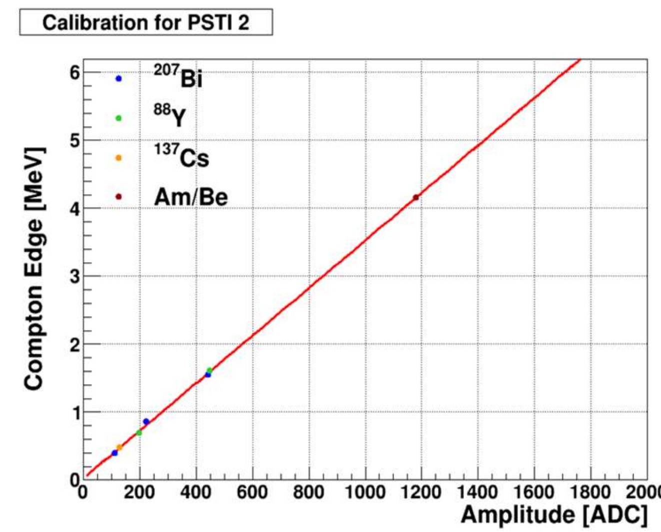
by Javi Balibrea







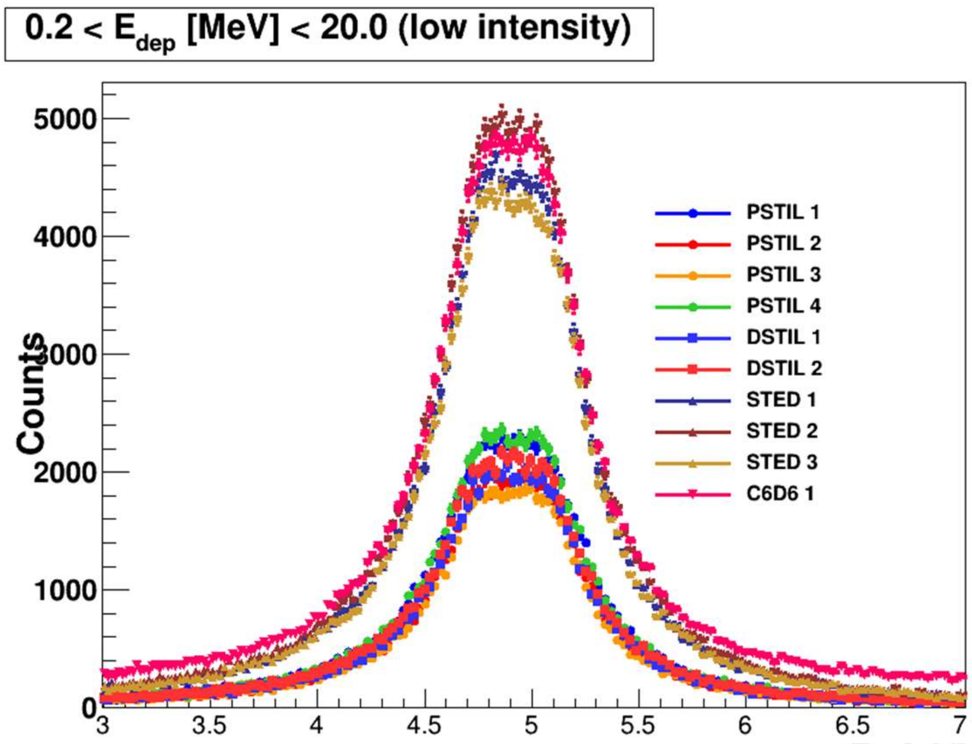


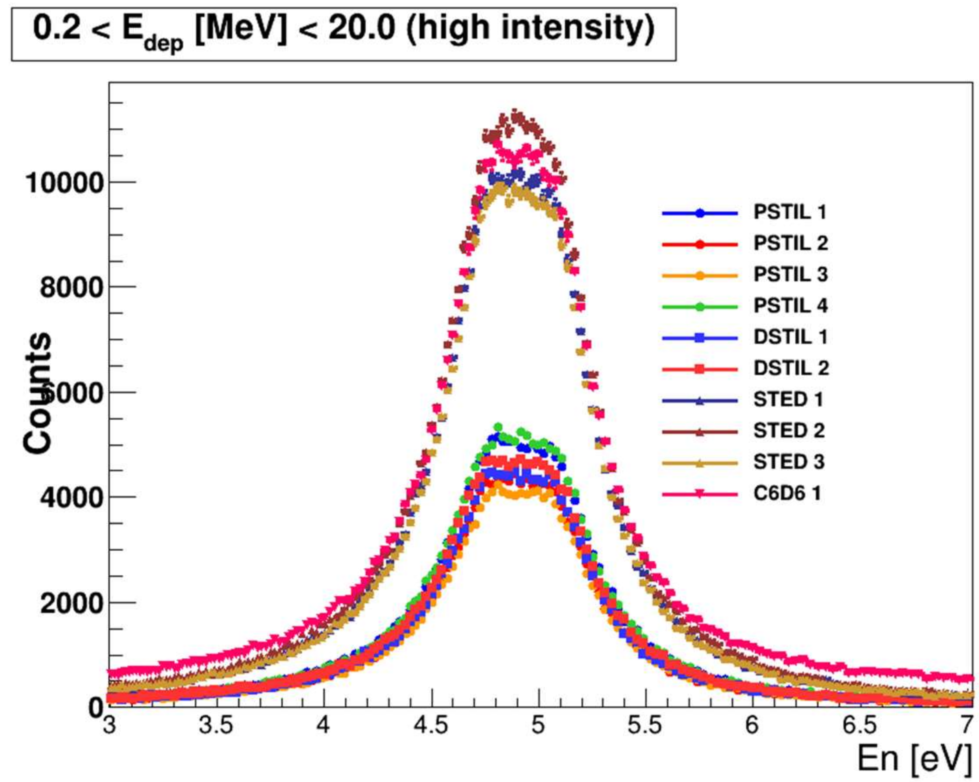


All **linear** Energy calibrated!

Small crystals→ Low threshold

^{197}Au(n,ɣ) saturated resonance





by Javi Balibrea

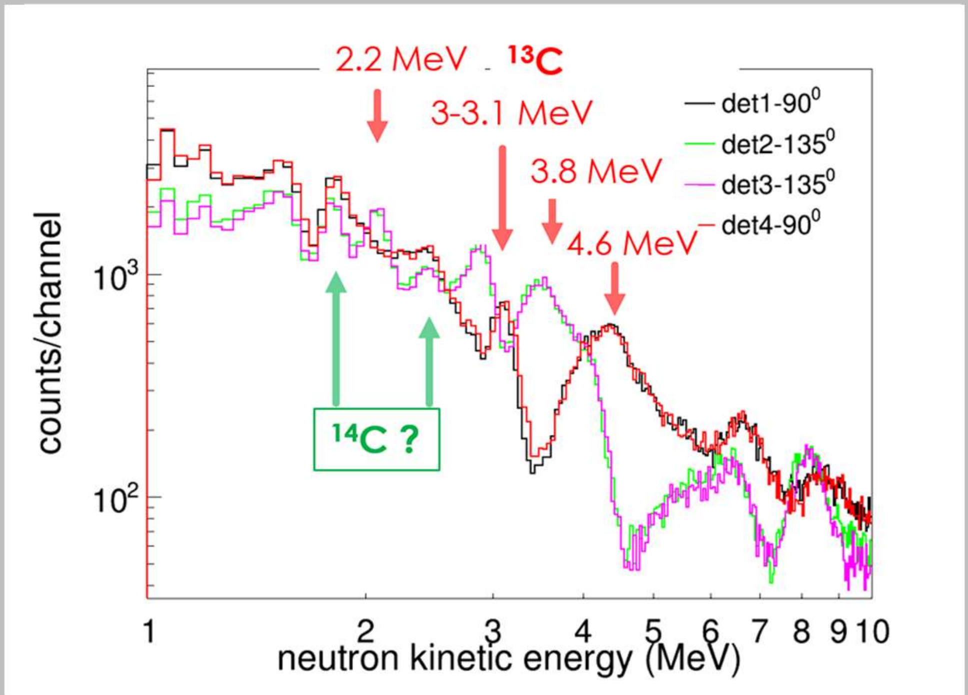
^{197}Au(n,ɣ) saturated resonance to establish relative efficiency between detectors

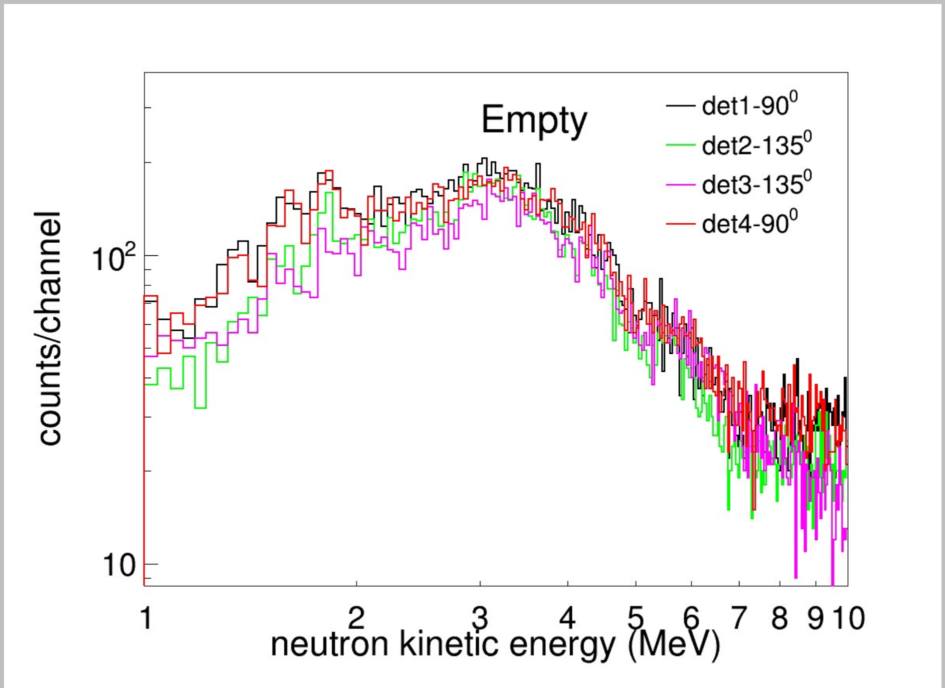
Excitation functions on ^{12}C @ EAR2(1-10 MeV)

for n+^{12}C and empty frame at two different laboratory angles, 90° and 135°

Analysis conditions:

Beam high intensity pulses
400 keV threshold to the deposited energy
*PSD condition for neutron selection: amp/area<0.074**





By Rudra, Cristian and Maria Grazia

According to the detector angular position:

- Detector responses are in agreement with each other
- Different structures can be observed with the ^{12}C target
- The background (empty frame) is structureless

LoI for elastic and inelastic measurements EAR1@n_TOF – April 2024

Informazioni | Discussioni (0) | File

Scientific Committee Paper

Report number	CERN-INTC-2024-028 ; INTC-I-274
Title	**Response of stilbene scintillator to (n,n) and (n,n') reaction channel in TOF experiments**
Project Manager/Technical Coordinator	Pellegriti, Maria Grazia; Sahoo, Rudra Narayan
Author(s)	Castelluccio, DM (ENEA-Bologna and INFN-Bologna, Italy) ; Console Camprini, P (ENEA-Bologna and INFN-Bologna, Italy) ; Diakaki, M (National Technical University of Athens, Greece) ; Elme, Z (University of Ioannina, Greece) ; Massimi, C (University of Bologna and INFN-Bologna, Italy) ; Mastromarco, M (University of Bari and INFN-Bari, Italy) ; Mucciola, R (INFN-Bari, Italy) ; Musumarra, A (University of Catania and INFN-Catania, Italy) ; Patronis, N (University of Ioannina, Greece) ; Pellegriti, MG (INFN-Catania, Italy) *Visualizza tutti i 11 autori*
Corporate author(s)	CERN. Geneva. ISOLDE and neutron Time-of-Flight Experiments Committee ; INTC
Series	(Letter of Intent)
Note	Requested protons: 6*10^17 protons on target
Submitted by	maria.grazia.pellegriti@cern.ch on 08 Apr 2024
Subject category	Detectors and Experimental Techniques

Email contact(s) : mariagrazia.pellegriti@ct.infn.it ; RudraNarayan.Sahoo@bo.infn.it ; Oliver.Aberle@cern.ch

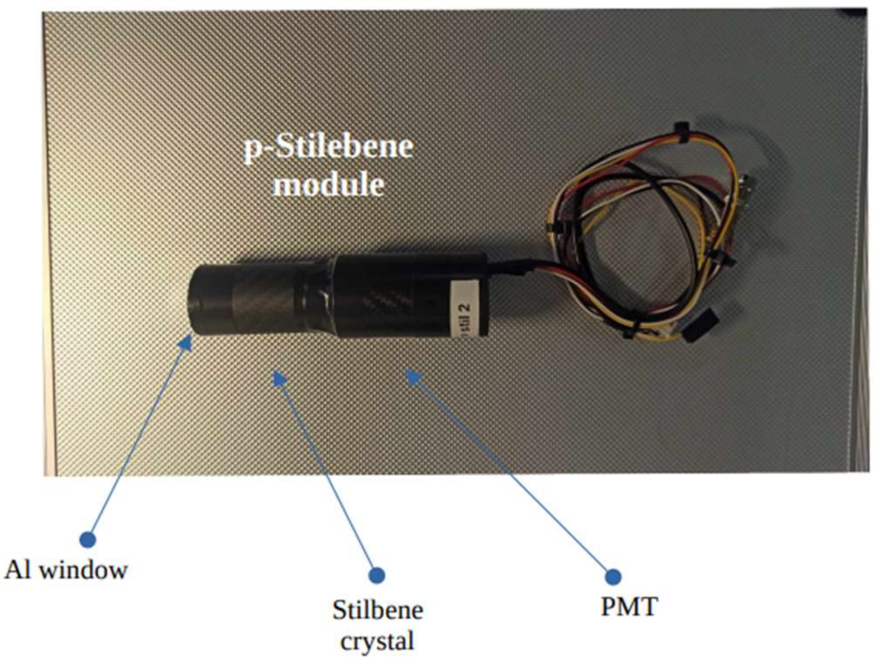
Back to search

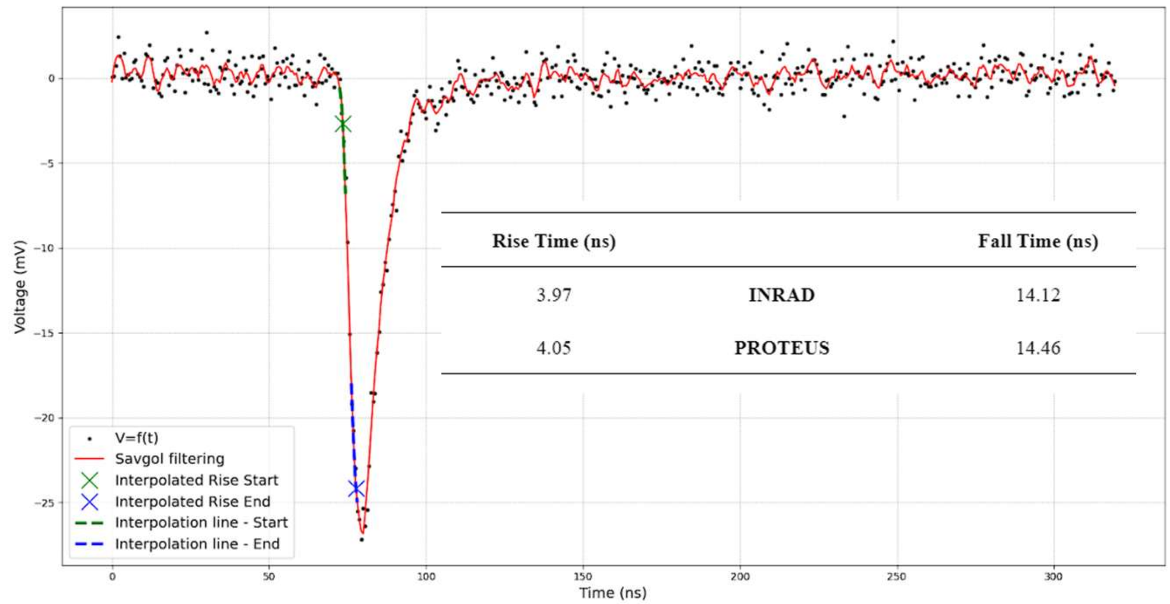
Record creato 2024-04-08, modificato l'ultima volta il 2024-04-08

Record simili

Approved on 23/05/2024 by INTC@CERN
need for an eight detectors cluster

New stilbene crystals from PROTEUS: first tests October 2023





Rise Time (ns)		Fall Time (ns)
3.97	**INRAD**	14.12
4.05	**PROTEUS**	14.46

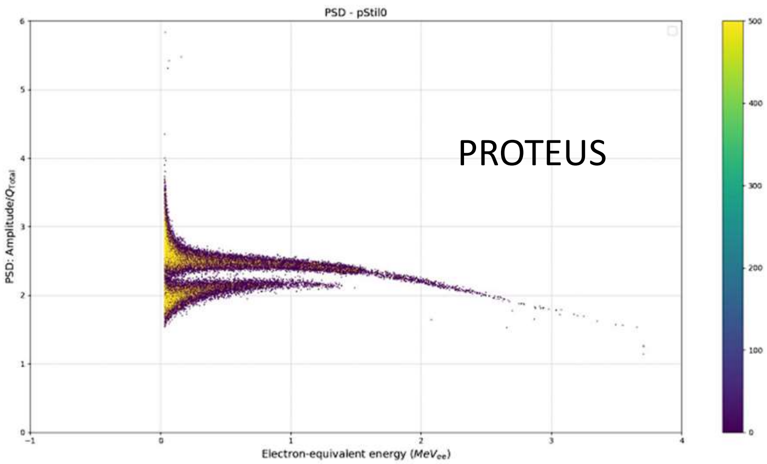
Analysis by Dimitris Papanikolaou

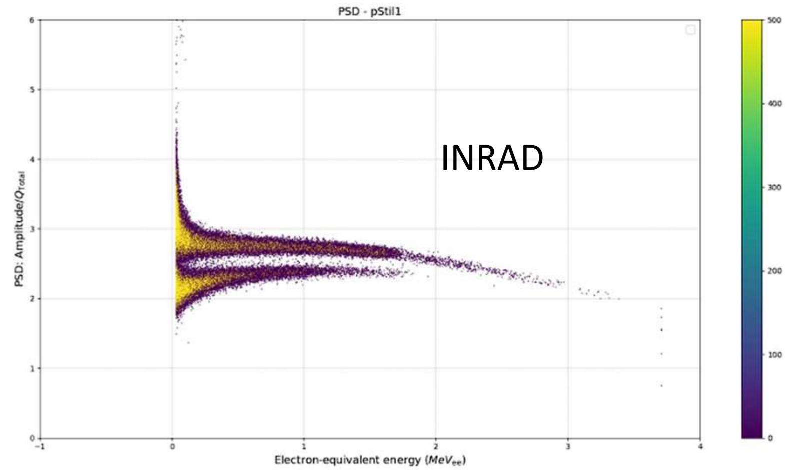
1"x 1" cylindrical ***INRAD*** p-stilbene detector
1"x 1" cylindrical ***PROTEUS*** p-stilbene detector
Carbon fiber housing
Aluminium cover in the front window

INFN CATANIA Università di Catania

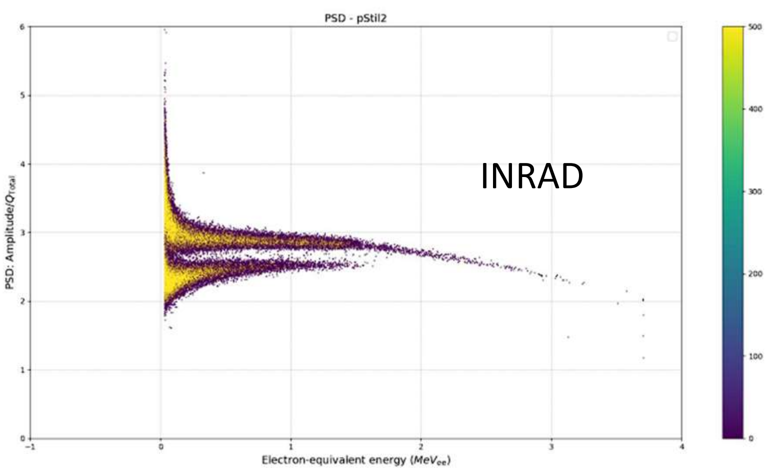
nTOF

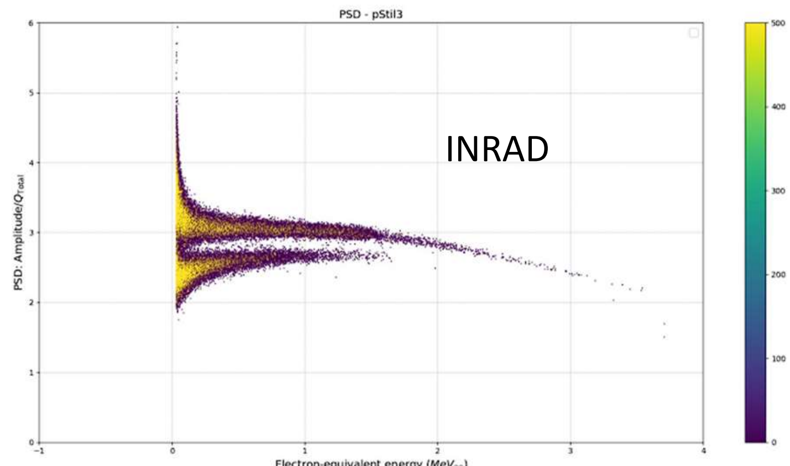
Pulse Shape Discrimination by *Am-Be n-γ* source (600 V HV)





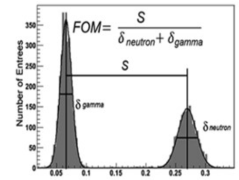
20 mV threshold

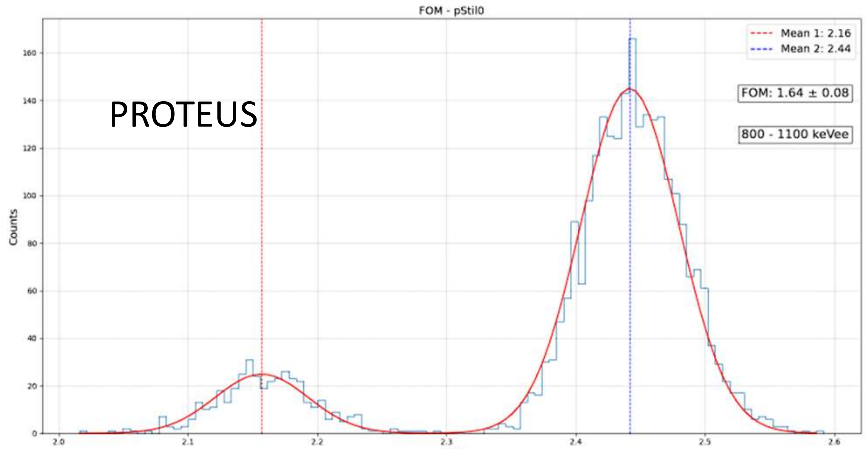


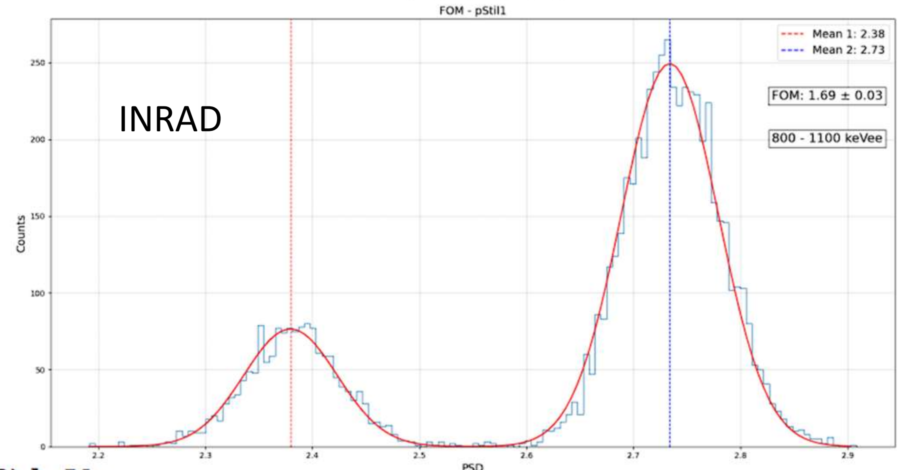


By D. Papanikolaou

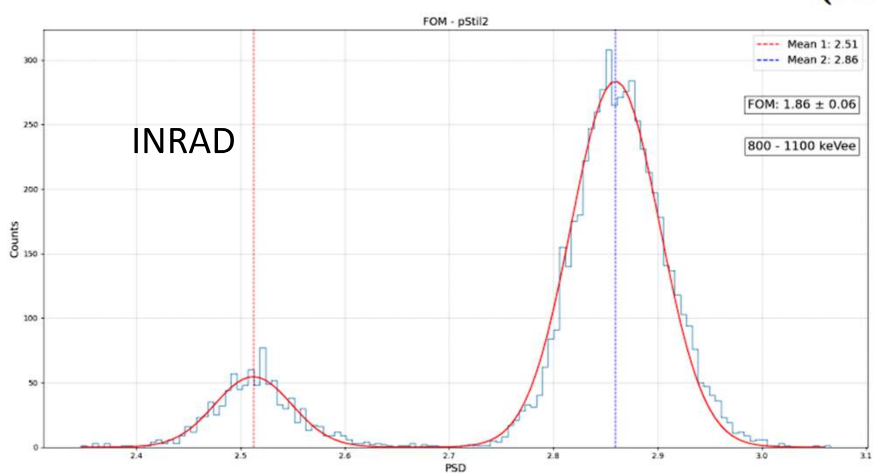
PSD (*Pulse Height/Q_{tot}*) – *FOM*

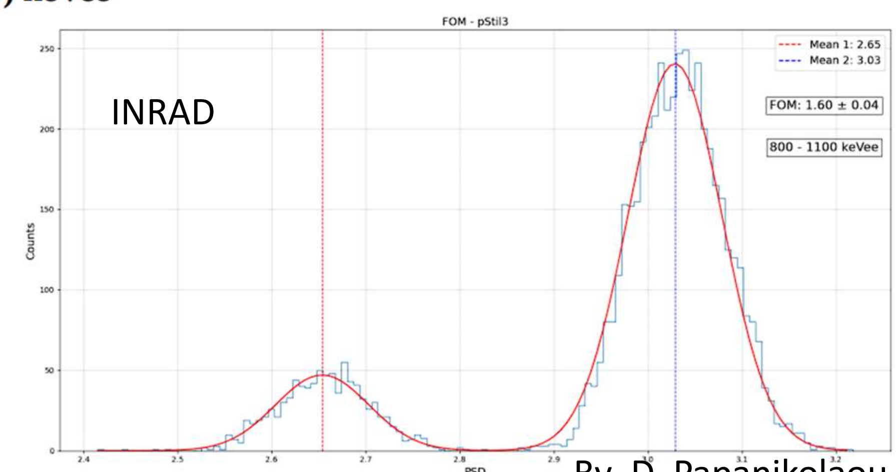






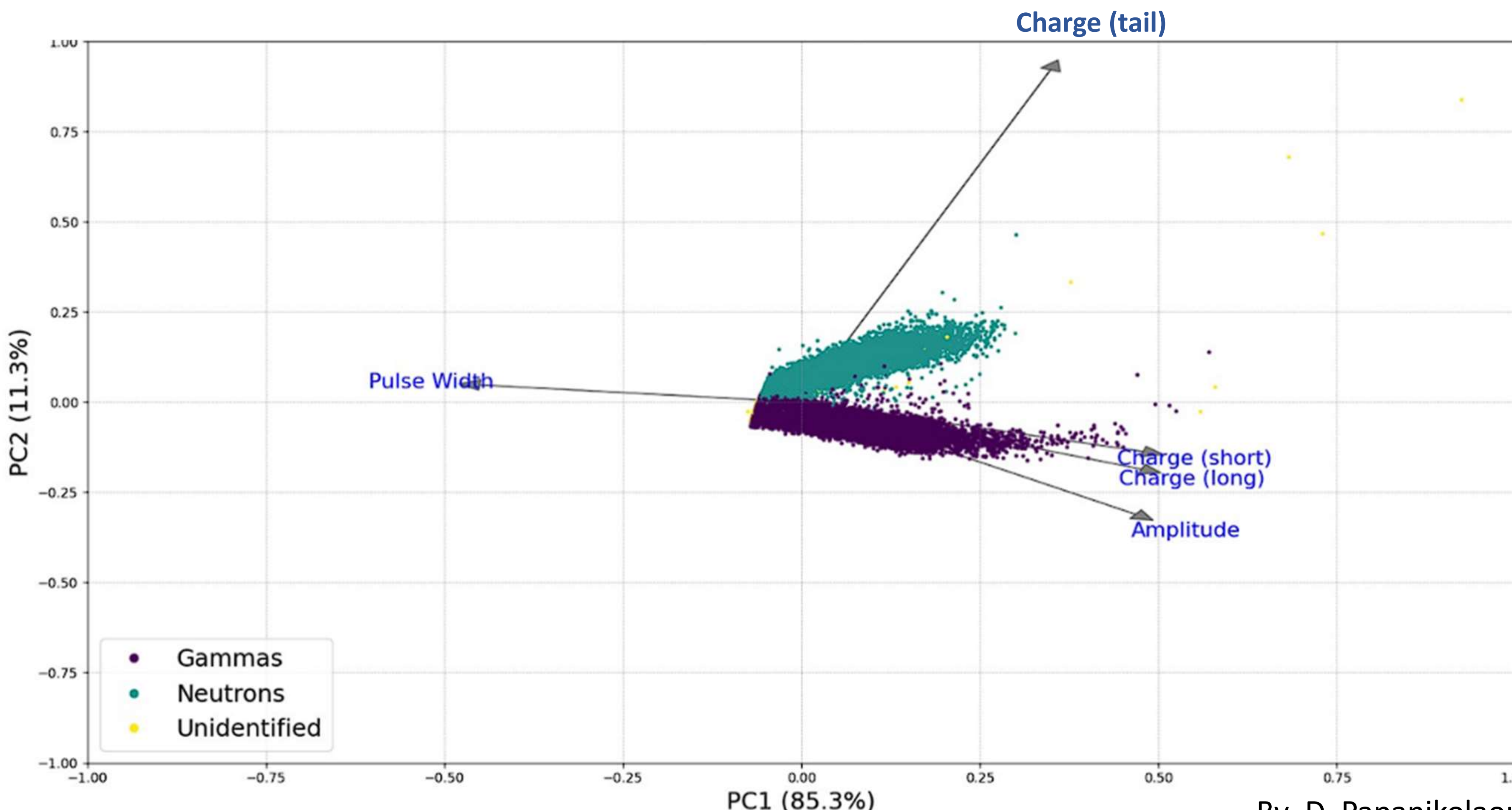
(800 – 1100) keVee





By D. Papanikolaou

Principal Component Analysis (*PCA*) by five signal parameters

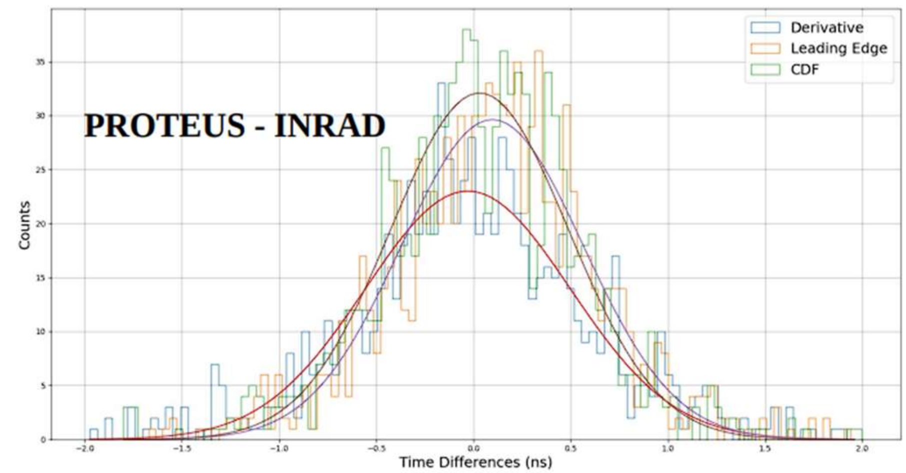


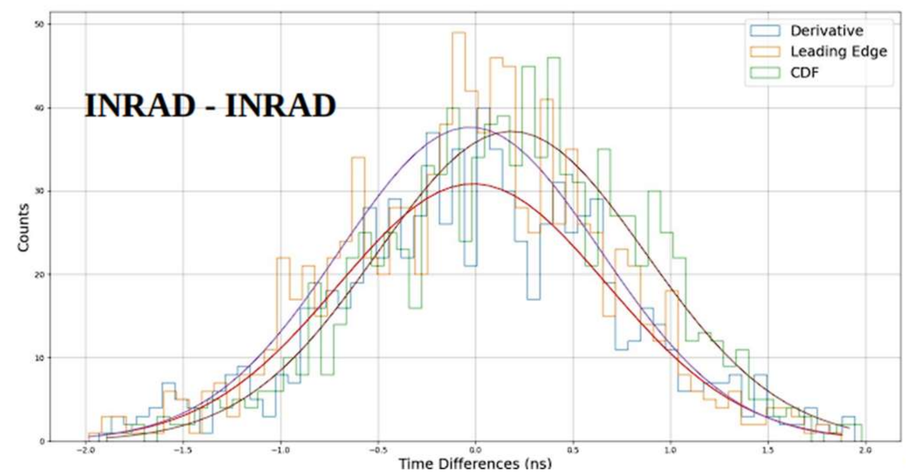
By D. Papanikolaou

Time resolution by 60-Co γ–γ coincidence (*preliminary*)

Time Resolution (ns)		
	PROTEUS - INRAD	INRAD - INRAD
Derivative	0.88 ± 0.03	1.15 ± 0.05
Leading Edge	0.78 ± 0.03	1.12 ± 0.05
CDF	0.76 ± 0.03	1.15 ± 0.04

By D. Papanikolaou



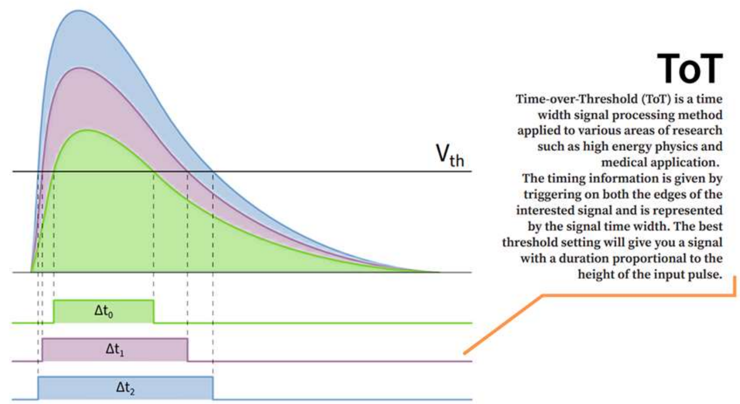


Fast counting in EAR 2 needs some new development….

TEDIEL S.R.L.

New ultrafast *DAQ* by *ToT*
SPIN-OFF of POLIMI

FELIX

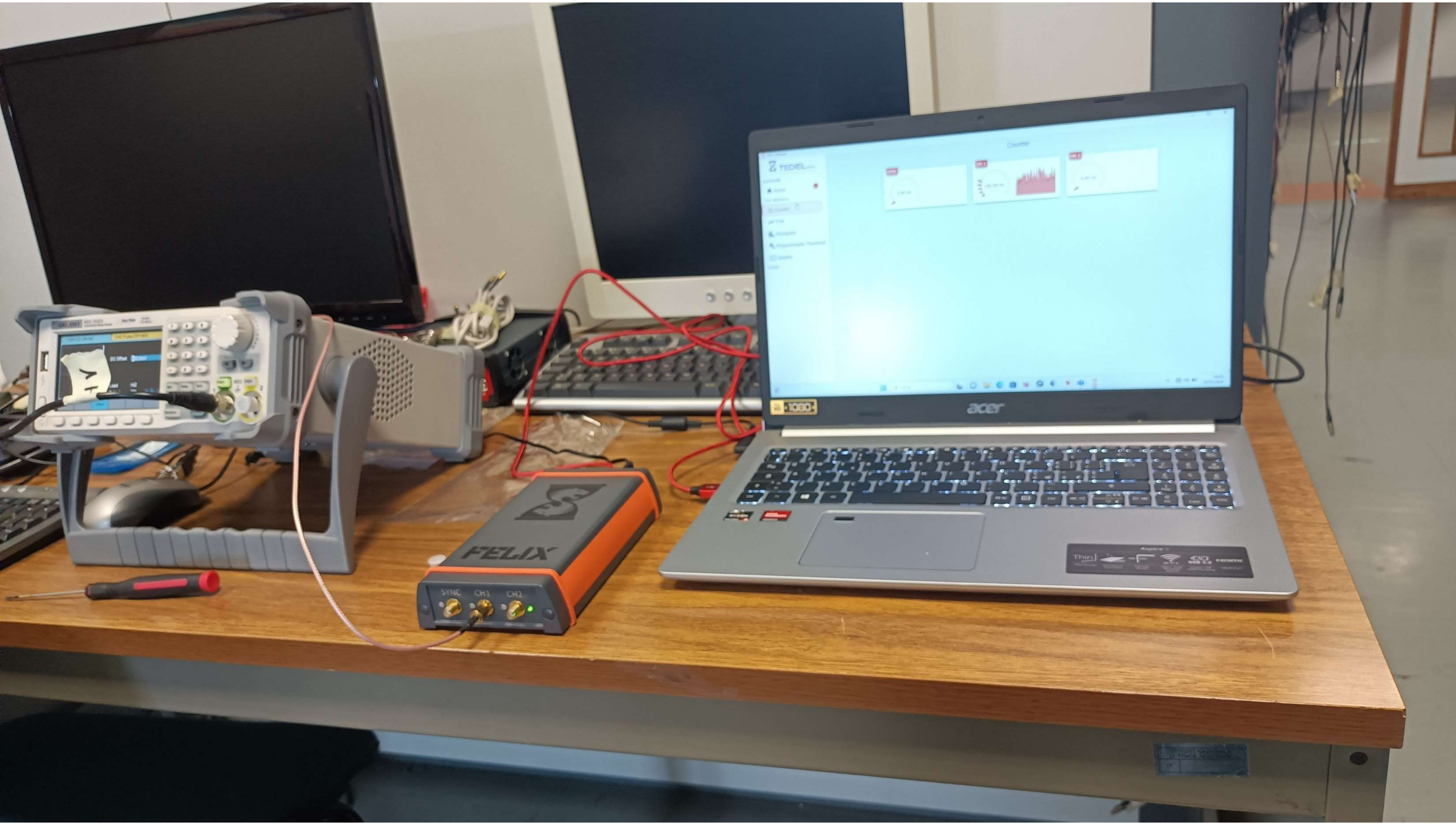


2+1 channels

16 channels module in progress

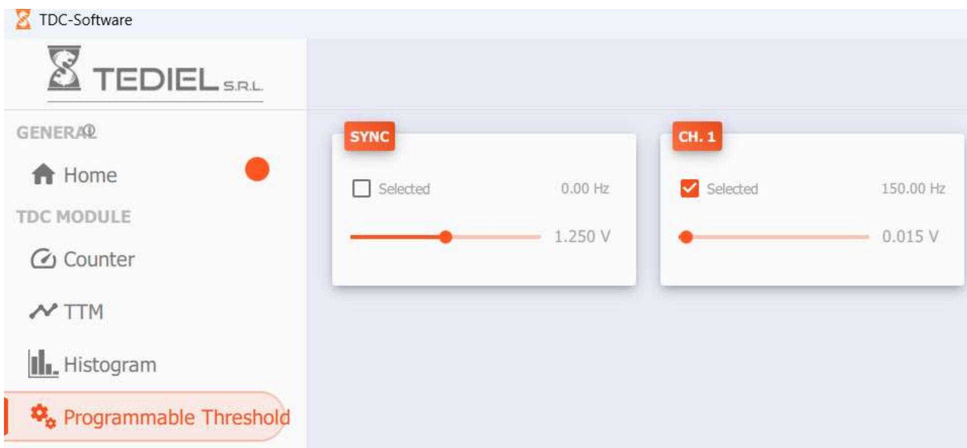
		EDU VERSION
Single-Shot Channel Precision	12 ps r.m.s.	< 1 ns r.m.s.
Resolution (LSB)	36.6 fs	600 ps
Dead-Time	12 ns	100 ns
Global Measurement Rate	140 Msps	20 Msps
Channel Measurement Rate	80 Msps	10 Msps
Maximum Sync Frequency	150 MHz	
Absolute INL	< 19 ps	
Absolute DNL	< 0.8 ps	

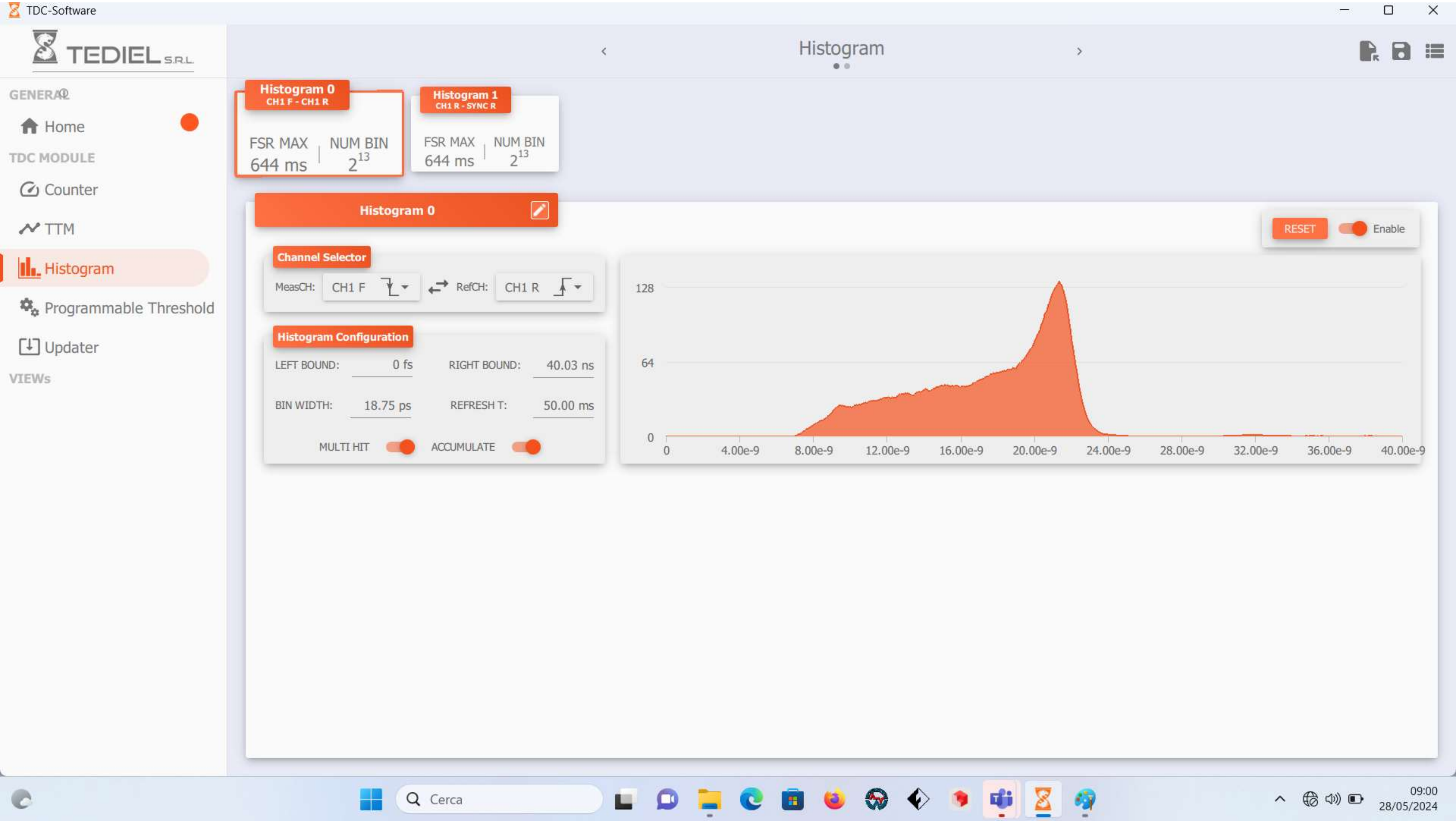
Input Channels	2 + SYNC
Input Impedance	50 Ω
Input Voltage Level	0 V - 3.3 V
Programmable Threshold Level	0 V - 2.5 V
Minimum Pulse Width	1.4 ns
Power Supply	5 V
Connector Type	USB-C
Size (L x W x H) [mm]	188 X 102 X 37


FELIX
SYNC
CH1
CH2
acer
1080

ToT by 137-Cs gamma source

PSTIL-1 (INRAD-STILBENE)





TDC-Software
TEDIEL S.R.L.
Histogram
GENERAL
Home
TDC MODULE
Counter
TTM
Histogram
Programmable Threshold
Updater
VIEWs
Histogram 0
CH1 F - CH1 R
FSR MAX
644 ms
NUM BIN
2^13
Histogram 1
CH1 R - SYNC R
FSR MAX
644 ms
NUM BIN
2^13
Histogram 0
RESET
Enable
Channel Selector
MeasCH:
CH1 F
RefCH:
CH1 R
Histogram Configuration
LEFT BOUND:
0 fs
RIGHT BOUND:
40.03 ns
BIN WIDTH:
18.75 ps
REFRESH T:
50.00 ms
MULTI HIT
ACCUMULATE
128
64
0
0
4.00e-9
8.00e-9
12.00e-9
16.00e-9
20.00e-9
24.00e-9
28.00e-9
32.00e-9
36.00e-9
40.00e-9
Cerca
09:00
28/05/2024

Fast scintillator crystal with dedicated PM

Try to achieve

2-3 ns signal length

100 MHz max rate

EJ-232 plastic scintillator is intended for very fast timing applications or when very high pulse pair resolution is required. Due to the small emission wavelength, the optical mean free path of this scintillator is approximately 10 cm. Therefore, to achieve the best light collection and to optimize the timing performance, EJ-232 should be used in a small size with the largest scintillator dimension less than 10 cm to minimize photon scattering effects. The use of light guides is best avoided.

EJ-232Q plastic scintillator is a quenched variant of EJ-232 specifically formulated for ultra-fast counting applications. The introduction of small amounts of benzophenone to EJ-232 significantly shortens the timing properties for purposes of achieving very high counting rates or improved coincidence timing. The quenching does not affect the emission spectrum but does reduce the scintillation efficiency (see table below). While it is recommended to keep the scintillator size and shape small in order to achieve the best timing performance, it is not recommended to use EJ-232Q in thin films (thicknesses ≤ 3 mm) due to the vapor pressure of benzophenone.

PROPERTIES	EJ-232	EJ-232Q (% BENZOPHENONE)				
		0.5	1.0	2.0	3.0	5.0
Light Output (% Anthracene)	55	19	11	5	4	3
Scintillation Efficiency (photons/1 MeV e^-)	8,400	2,900	1,700	770	610	460
Wavelength of Maximum Emission (nm)	370	370	370	370	370	370
Rise Time (ps)	350	110	105	100	100	100
Decay Time (ps)	1,600	700	700	700	700	700
Pulse Width, FWHM (ps)	1,300	360	290	260	240	220
H Atoms per cm³ ($\times 10^{22}$)	5.13	5.12	5.12	5.12	5.12	5.12
C Atoms per cm³ ($\times 10^{22}$)	4.66	4.66	4.66	4.66	4.66	4.66
Electrons per cm³ ($\times 10^{23}$)	3.30	3.38	3.38	3.38	3.38	3.38
Density (g/cm³)	1.023	1.023	1.023	1.023	1.023	1.023

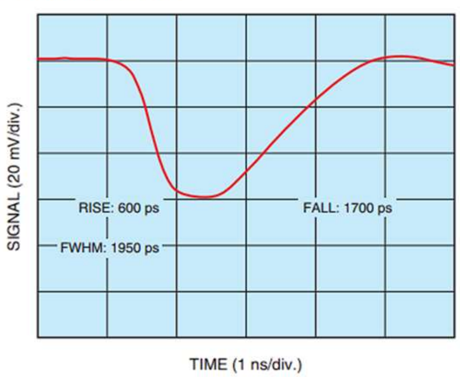
HAMAMATSU
PHOTON IS OUR BUSINESS

HIGH-SPEED RESPONSE PMT MODULES
FOR UNDERWATER OPTICAL COMMUNICATIONS

Photomultiplier already at INFN-CT scintillator

H14601-200

■H14600-100



Parameter			H14600 / H14601 series				Unit
Suffix			-100, -103	-200	-01, -04	-20	—
Input voltage			+4.5 to +5.5				V
Max. input voltage			5.5				V
Max. input current *1			3.5				mA
Max. average output signal current *2			100				μA
Max. control voltage			+1.0 (Input impedance 1 MΩ)				V
Recommended control voltage adjustment range			+0.5 to +1.0 (Input impedance 1 MΩ)				V
Effective area			φ8				mm
Peak sensitivity wavelength			400	400	400	630	nm
Cathode	Luminous sensitivity	Min.	80	100	100	350	μA/lm
		Typ.	105	135	200	500	
	Blue sensitivity index (Blue filter)	Typ.	13.5	15.5	—	—	—
	Red/White ratio	Typ.	—	—	0.25	0.45	—
	Radiant sensitivity *3	Typ.	110	130	77	78	mA/W
Anode	Luminous sensitivity *2	Min.	30	40	40	140	A/lm
		Typ.	105	135	200	500	
	Radiant sensitivity *2*3	Typ.	1.1×10^5	1.3×10^5	7.7×10^4	7.8×10^4	A/W
	Dark current *2*4	Typ.	0.5	0.5	1	10	nA
		Max.	5	5	10	100	
Rise time *2		Typ.	0.6				ns
Ripple noise *2*5 (peak to peak)		Max.	0.2				mV
Settling time *6		Max.	10				s
Operating ambient temperature *7			+5 to +50				°C
Storage temperature *7			-20 to +50				°C
Weight			32 (H14600 series), 40 (H14601 series)				g

Conclusions and perspectives

- A new array of Stilbene detectors has been characterized at CERN and INFN-CT
- The results look promising, facing the new demanding application before and after LS3@CERN
- The new setup shows very good performances for *n*-capture reactions
- Implementing n-γ discrimination makes the array suitable also for measuring n-n and n-γ coincidences.
- A new d-Stibene array by LLNL is in progress (Spanish collaborators)