i-TED

Status report

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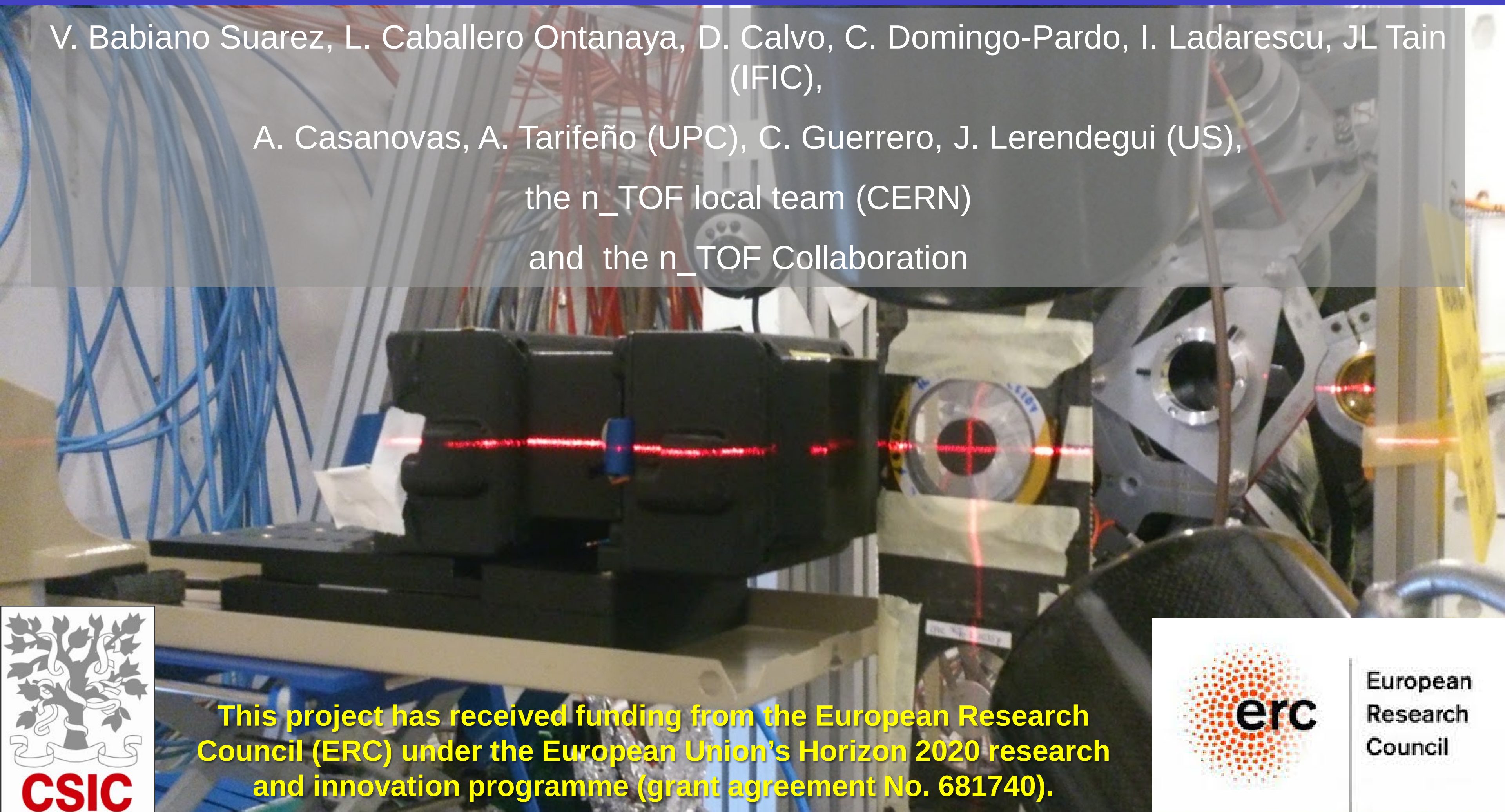
A. Casanovas, A. Tarifeño (UPC), C. Guerrero, J. Lerendegui (US),

the n_TOF local team (CERN)

and the n_TOF Collaboration



CSIC

This project has received funding from the European Research Council (ERC) under the European Union’s Horizon 2020 research and innovation programme (grant agreement No. 681740).

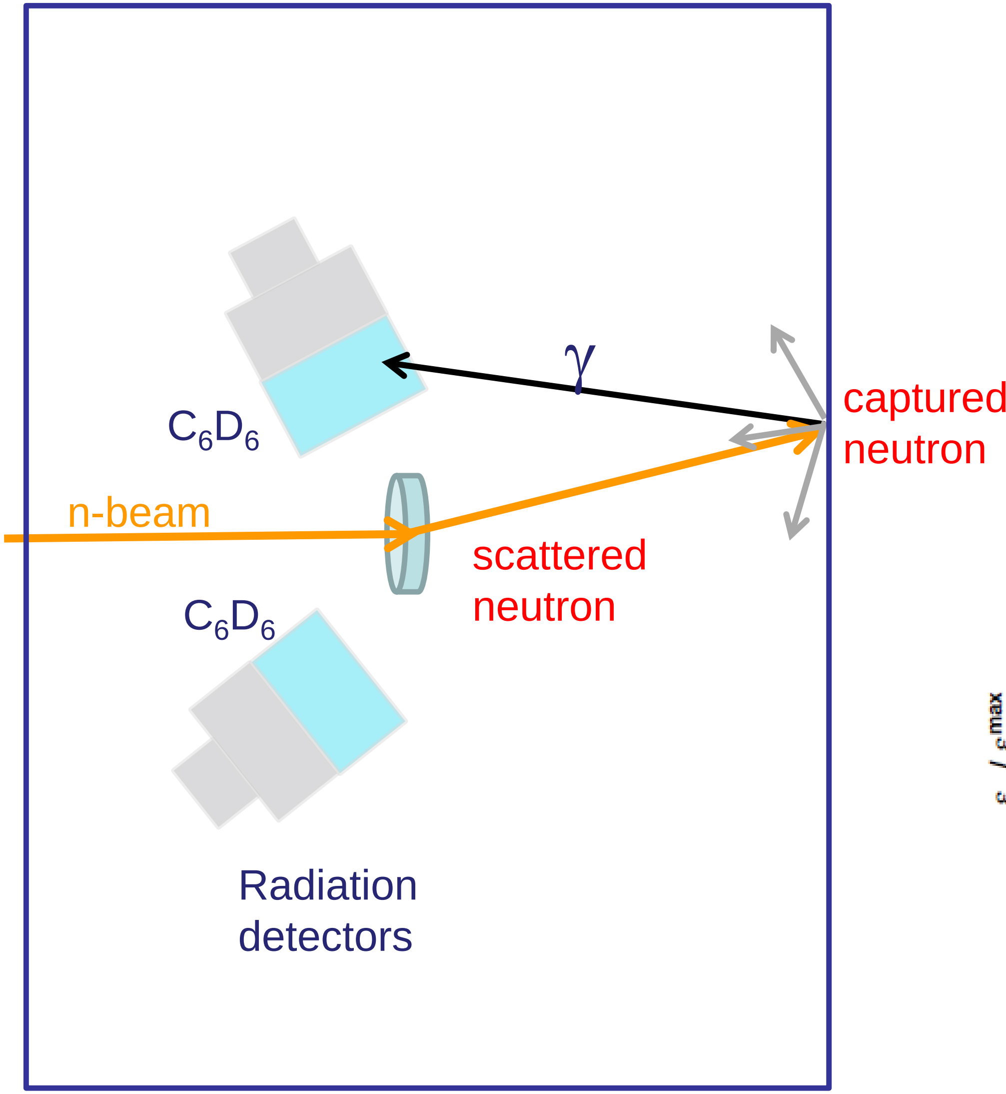
erc European Research Council

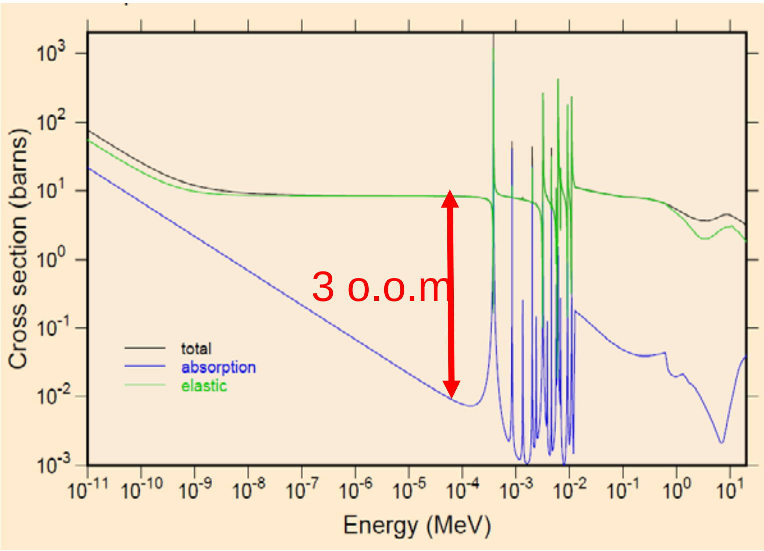
Outline

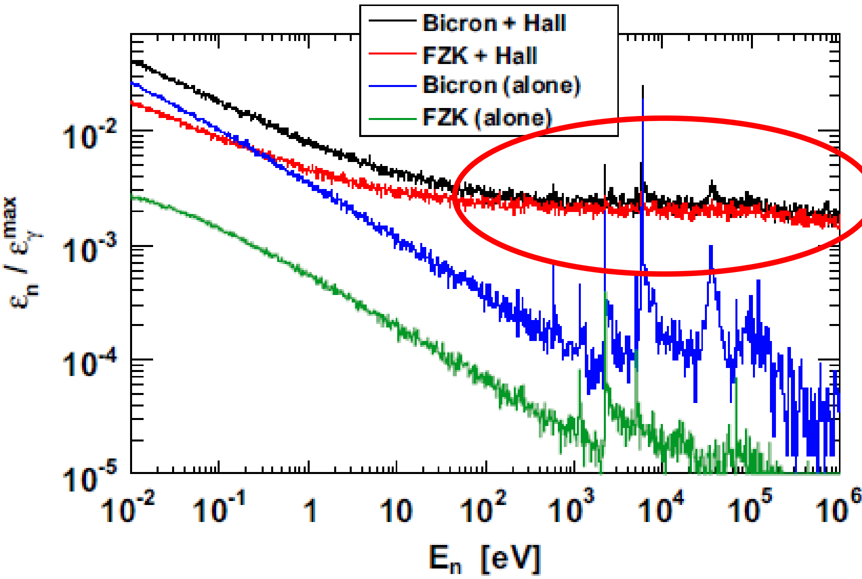
- i-TED concept review
- Apparatus & methodology
- i-TED tests @ n_TOF in September' 2017 // Preamp tests Massimo & N. Patronis
- i-TED tests @ n_TOF in November' 2017 // Tests 16OChamber (Sebastian)
- Outlook and next steps

The i-TED concept

→ Reduce “extrinsic” neutron sensitivity background







Nucl. Instr. Meth. A 760 (2014) P.Zugec et al.

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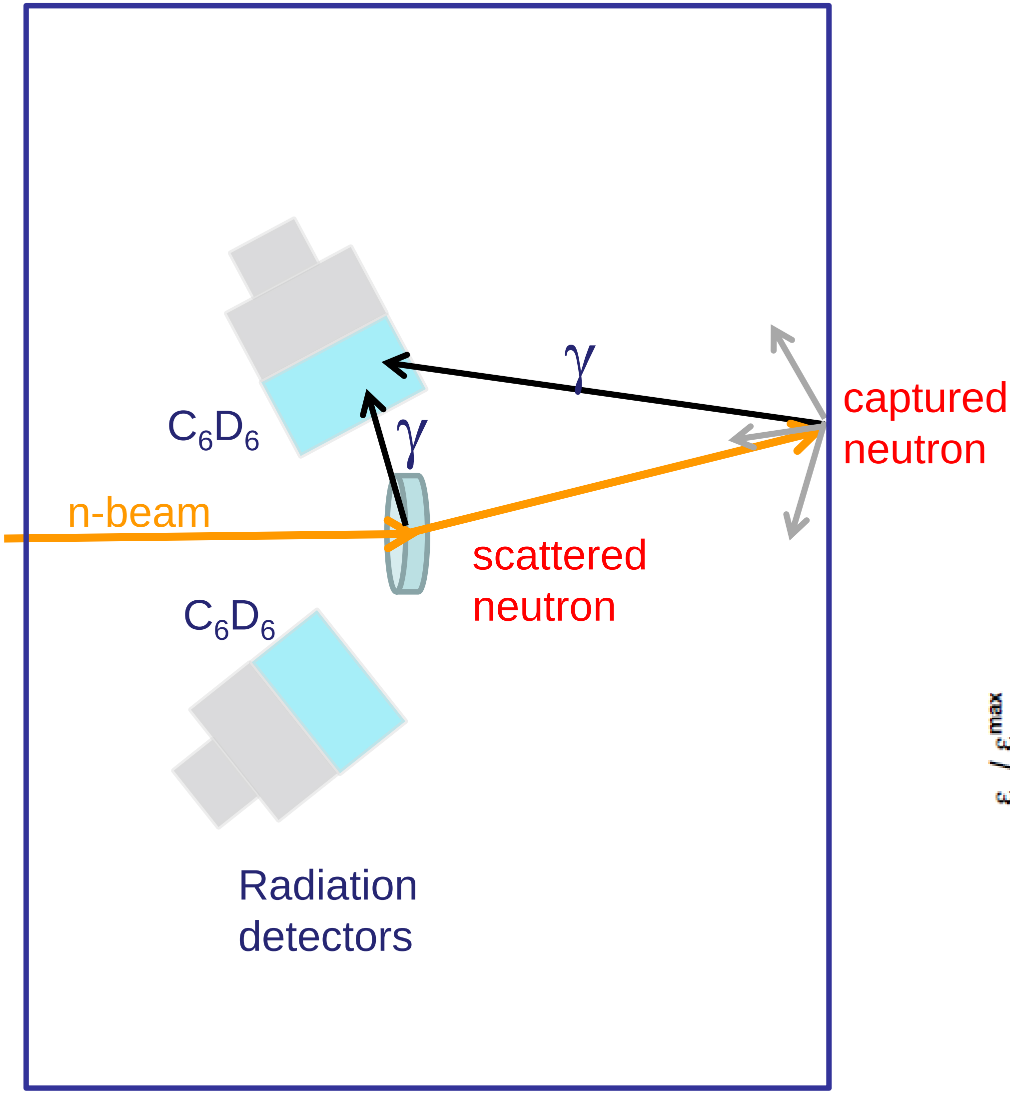

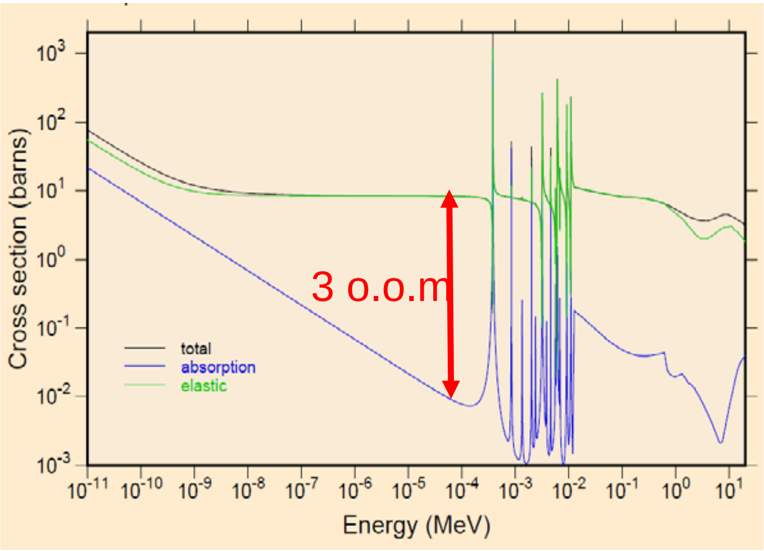

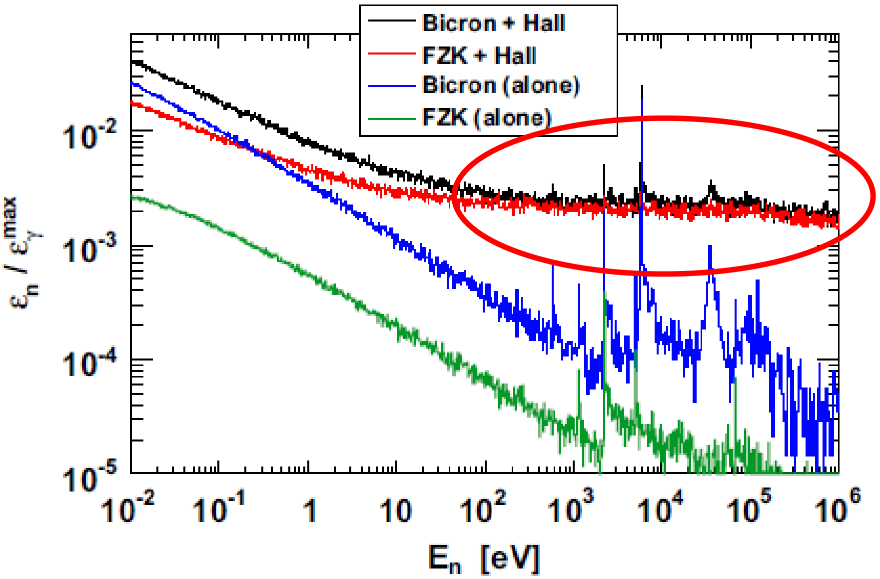

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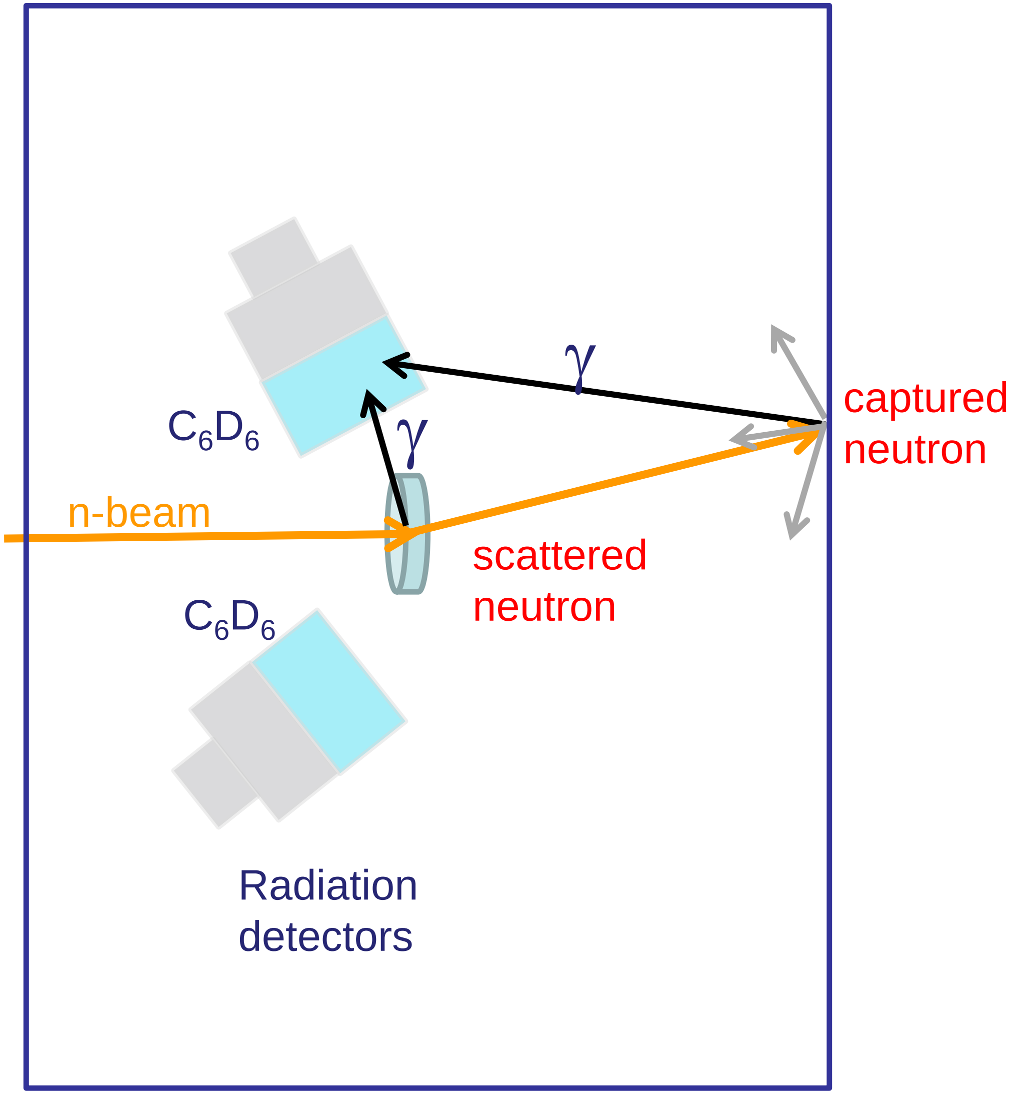
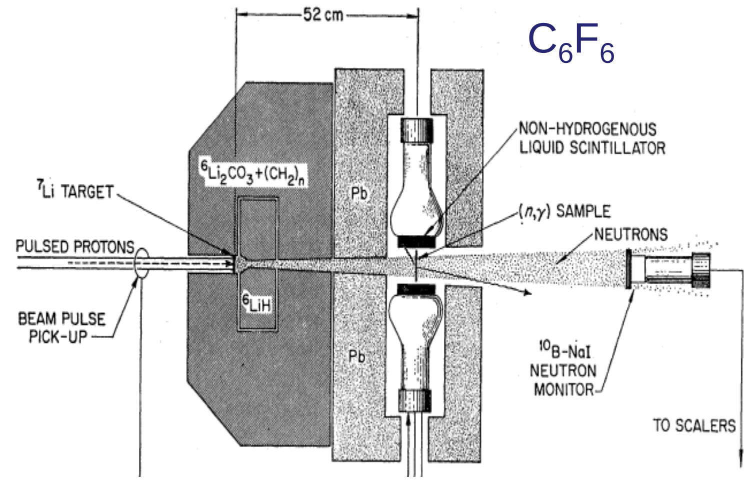
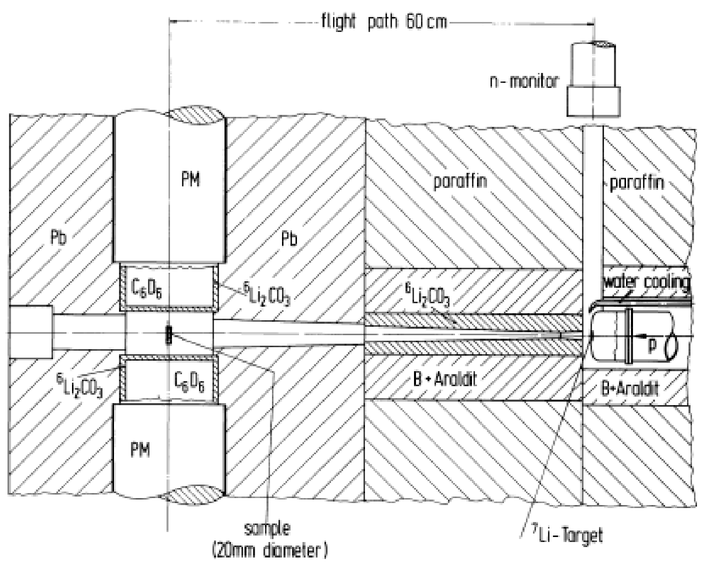




Macklin & Gibbons, ORNL, **1967**



G. Walter *et al.*, Astron. Astrophys. **167**, 186 (1986)

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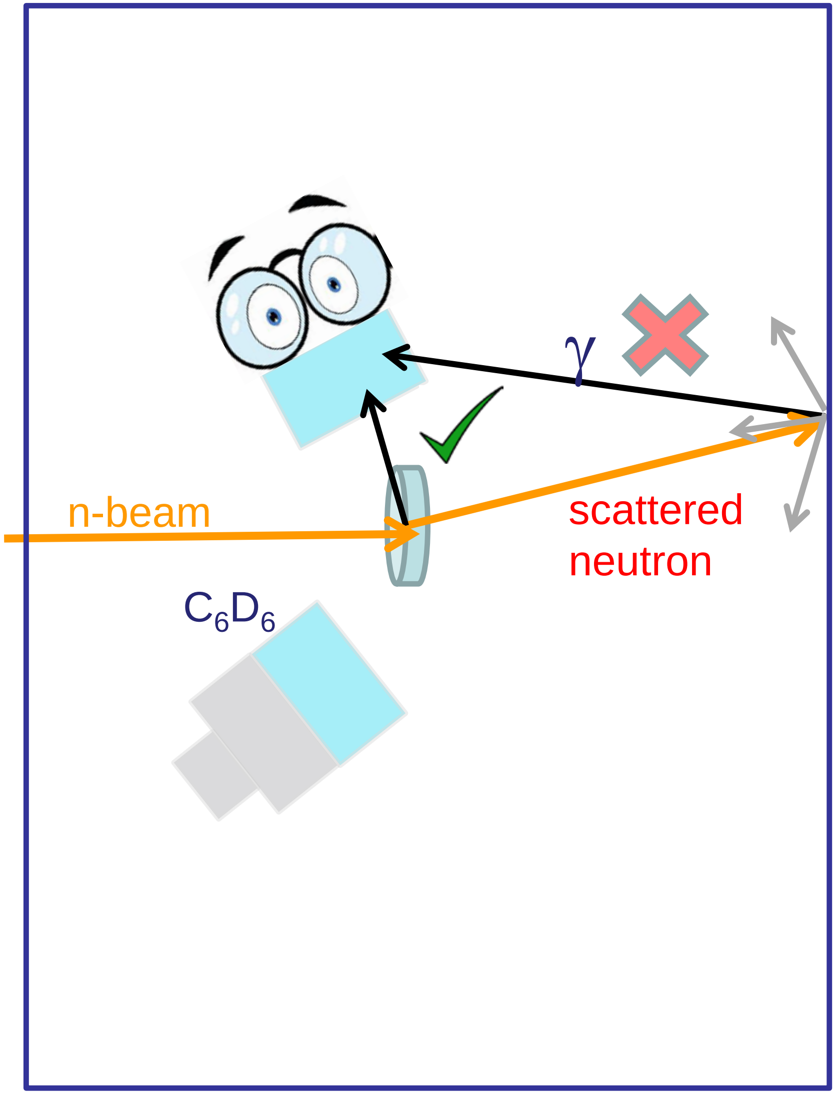

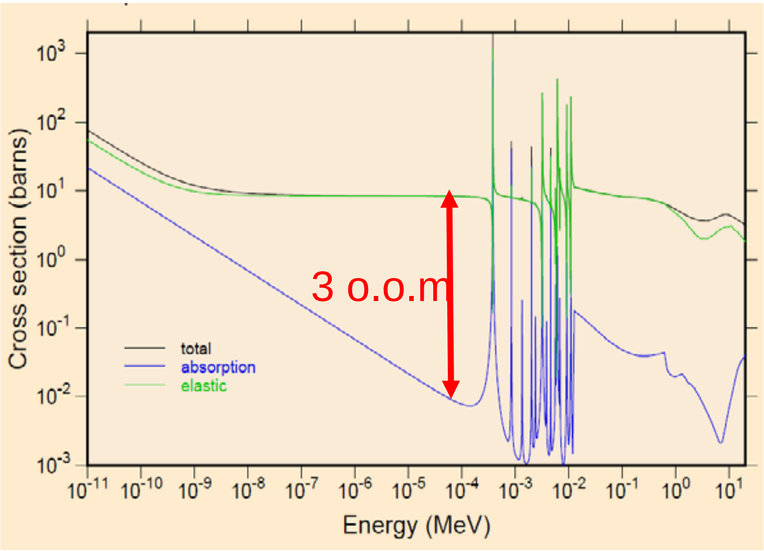

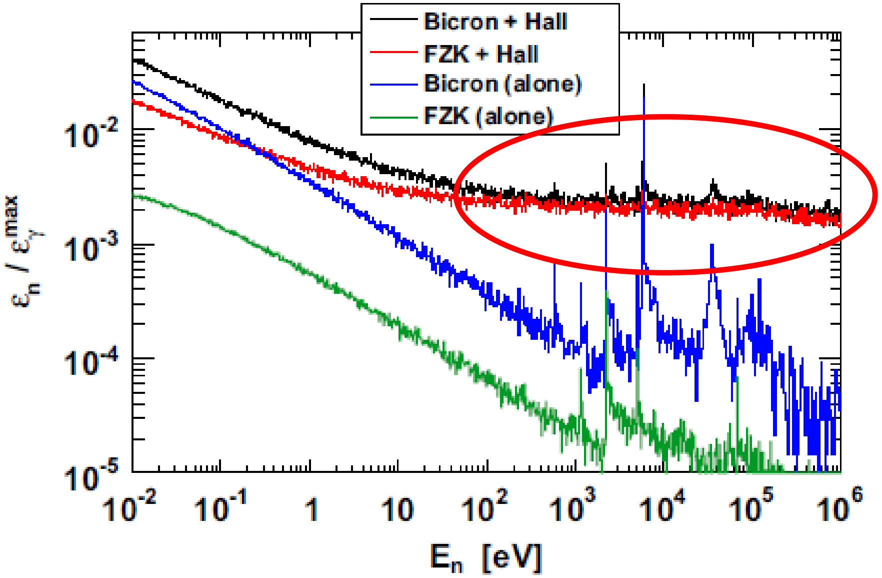

Nucl. Instr. Meth. A 825 (2016), CDP

Nucl. Instr. Meth. A 760 (2014) P.Zugec et al.

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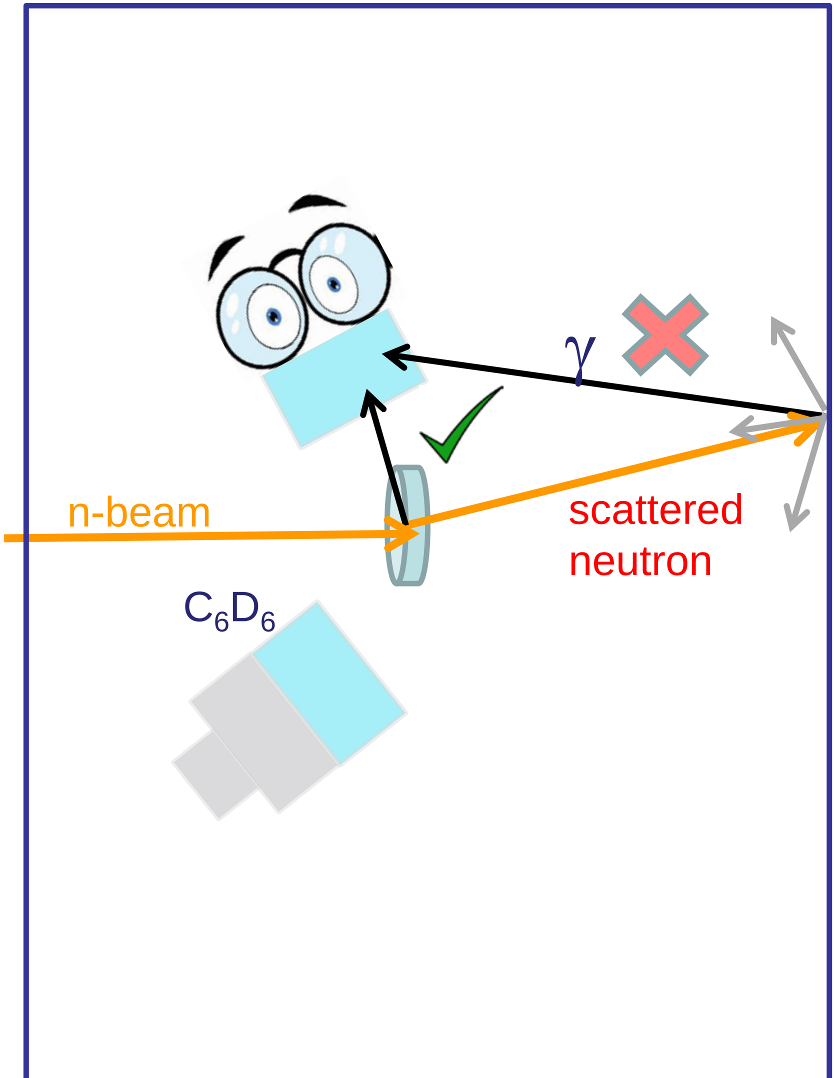
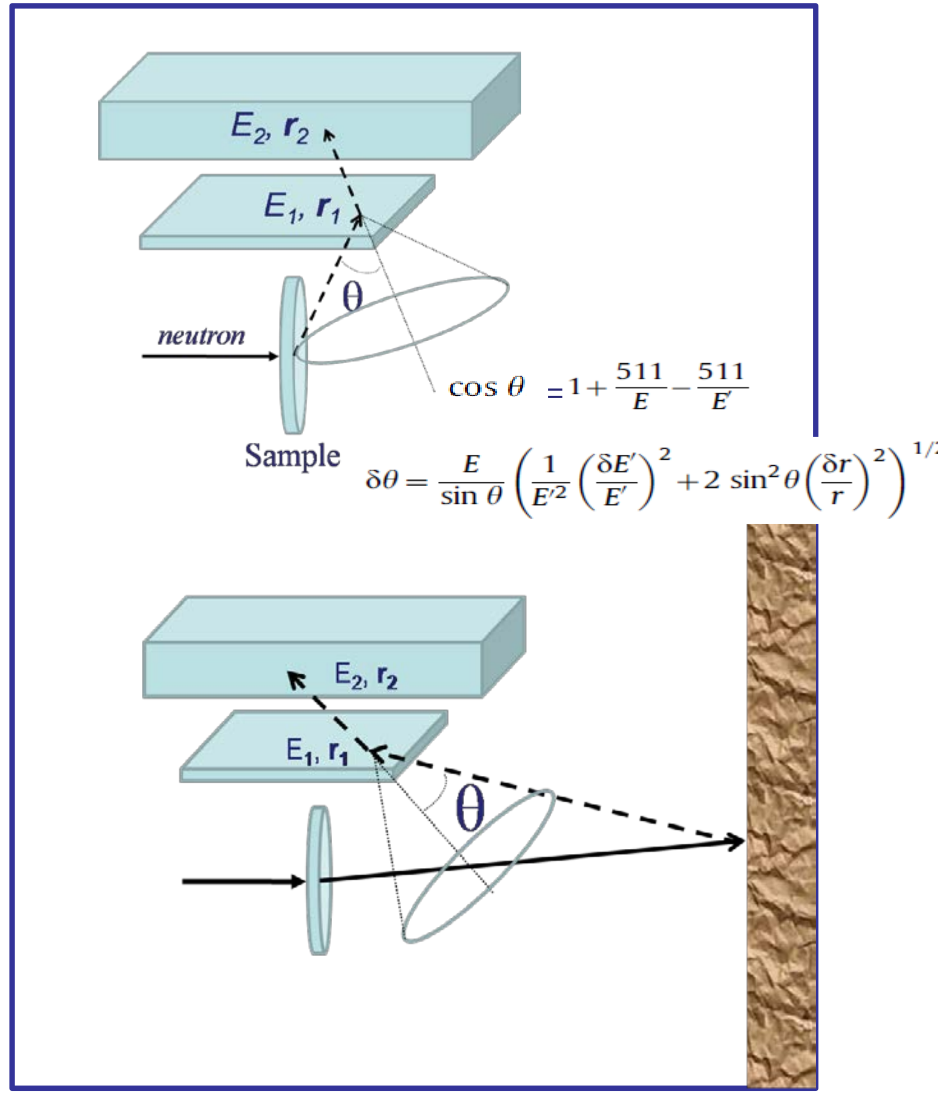


γ-Imaging → Better sensitivity

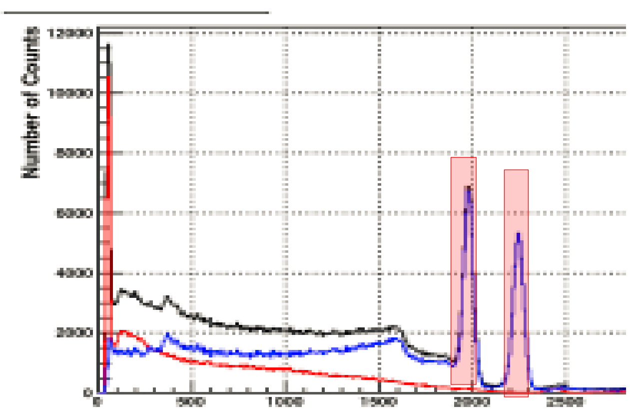


Nucl. Instr. Meth. A 825 (2016), CDP

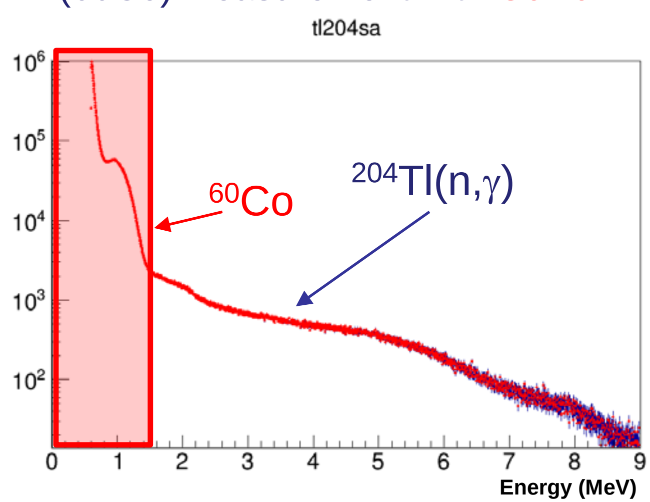
The i-TED concept

High E-resolution → Better selectivity

60Co measurement with **LaCl3 (i-TED)**



204Tl(60Co) measurement with **C6D6**



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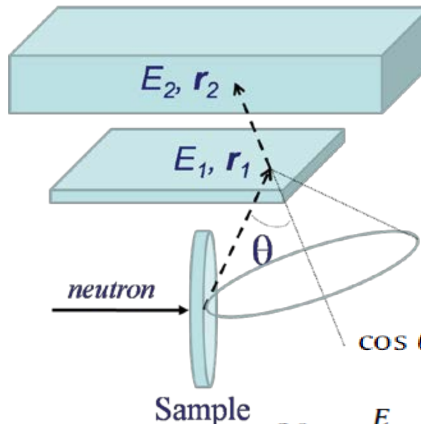
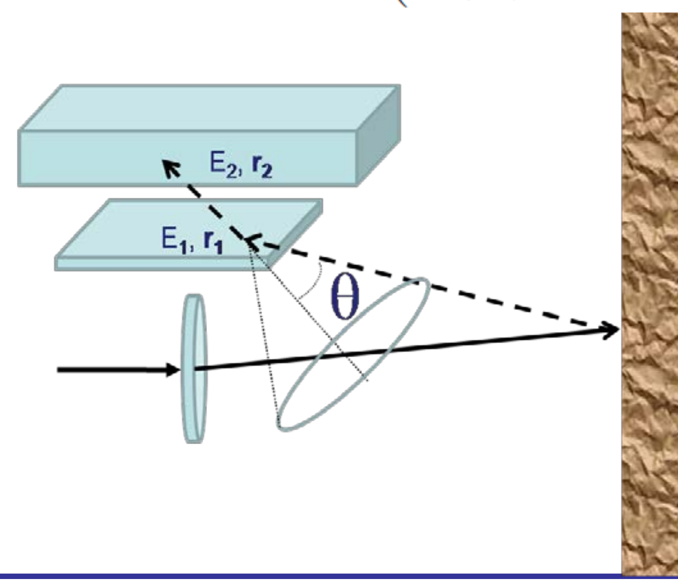


$$\cos\theta = 1 + \frac{511}{E} - \frac{511}{E'}$$

$$\delta\theta = \frac{E}{\sin\theta}\left(\frac{1}{E'^2}\left(\frac{\delta E'}{E'}\right)^2 + 2\sin^2\theta\left(\frac{\delta r}{r}\right)^2\right)^{1/2}$$

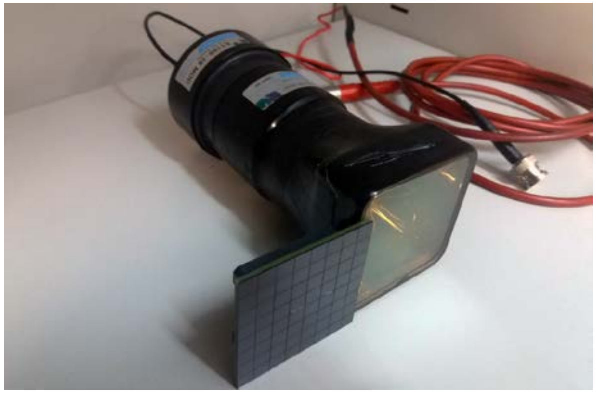


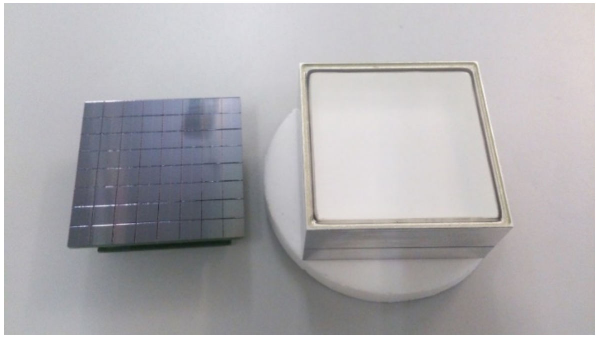
i-TED implies developments:

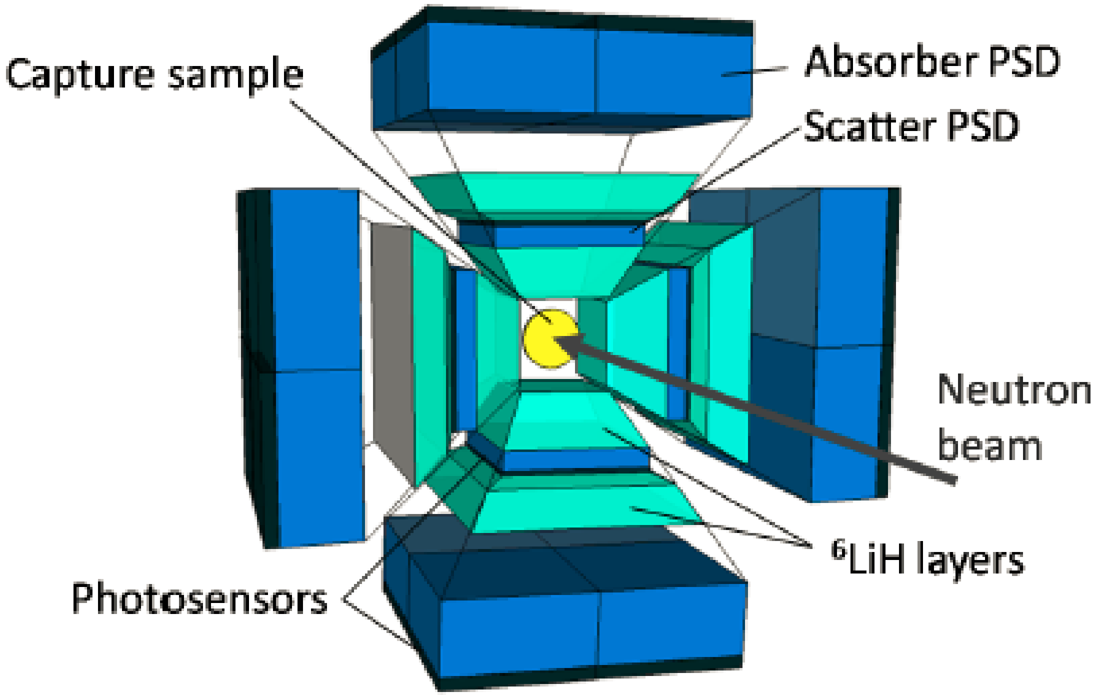
→ SiPMs instead of PS-PMTs:

→ High E-Resolution with SiPM albeit large dead-space between pixels

→ Scalable system (very low efficiency → large solid angle → many channels) → Compact electronics → Question on spectroscopic/timing performance ?







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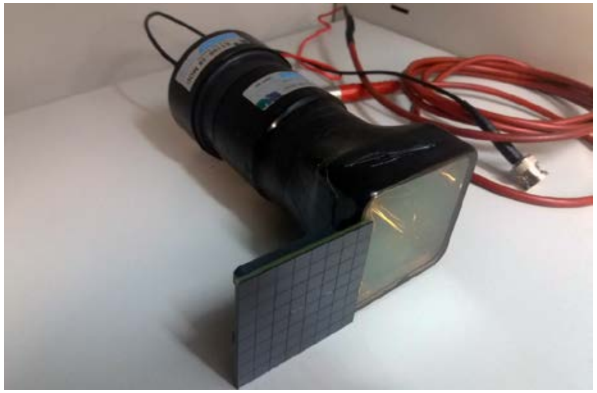
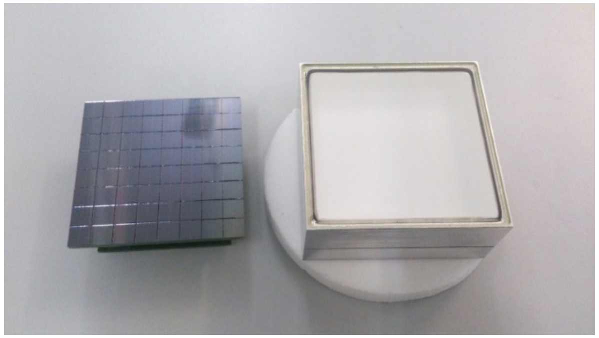
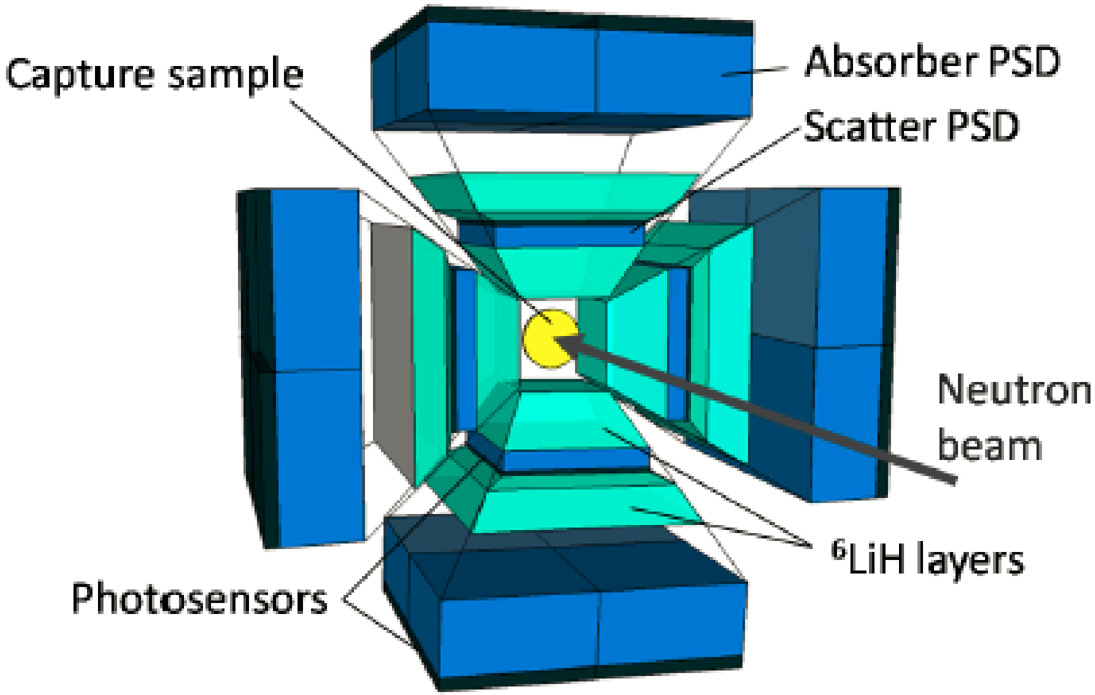
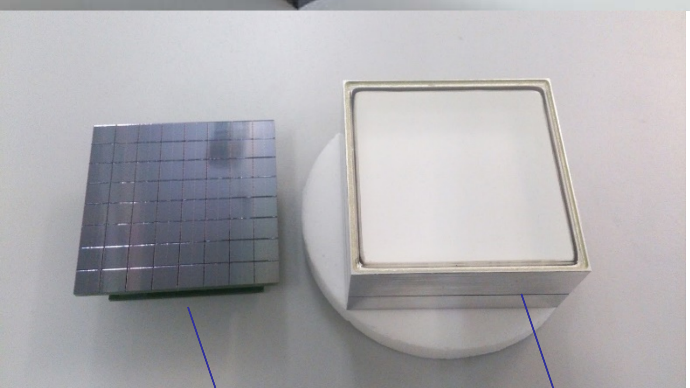






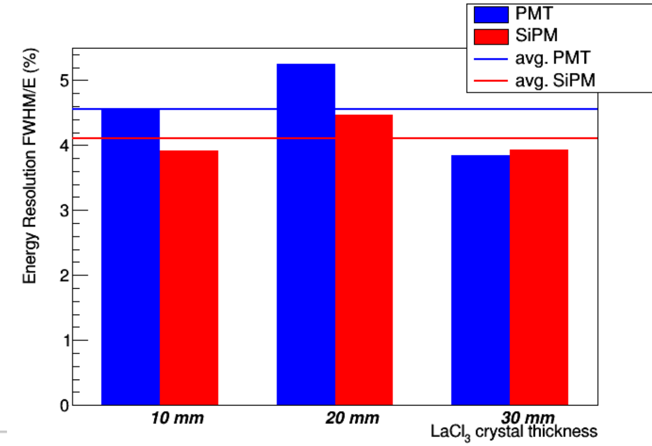
i-TED pre-requisites:
high energy resolution+ good timing resolution

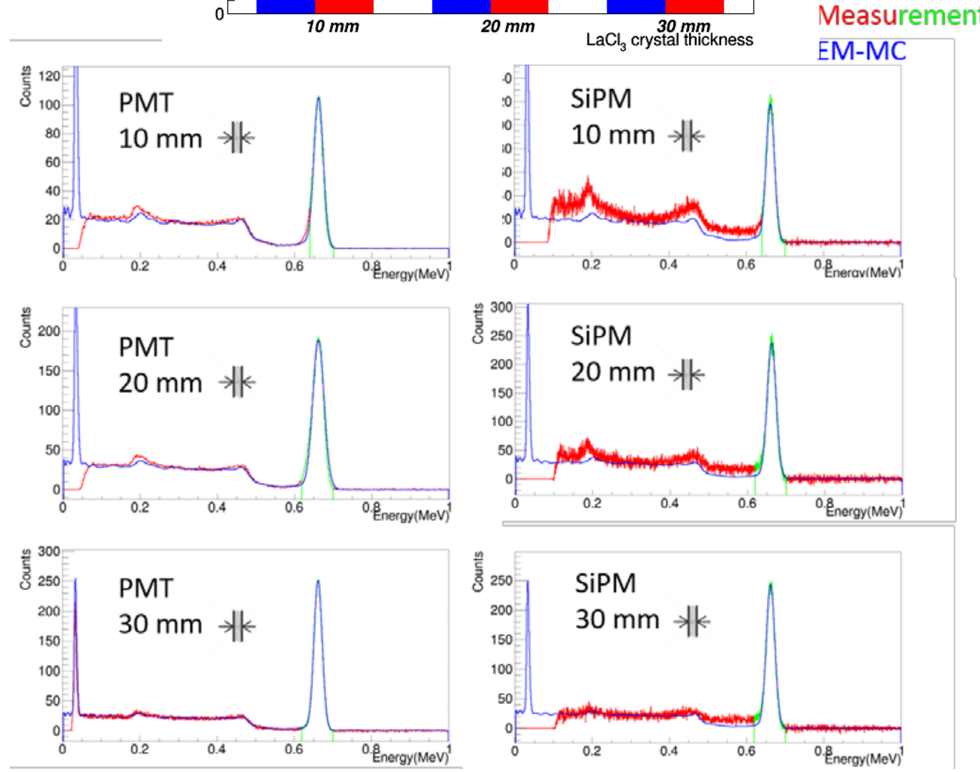


sensL SiPM ArrayJ
30035-64P-PCB

LaCl3

10/20/30mm





P.Olleros, Master Thesis, IFIC, 2017

i-TED implies developments:

→ SiPMs instead of PS-PMTs:

→Demonstrate High E-Resolution with SiPM albeit large dead-space between pixels

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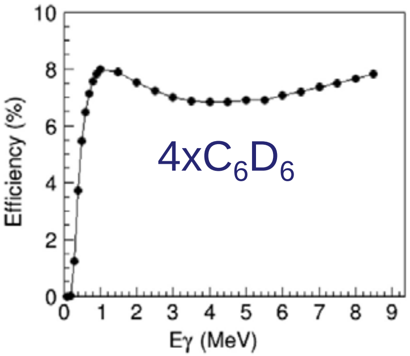
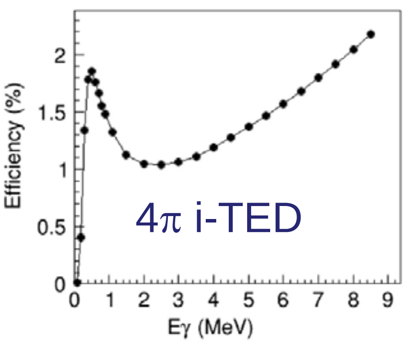
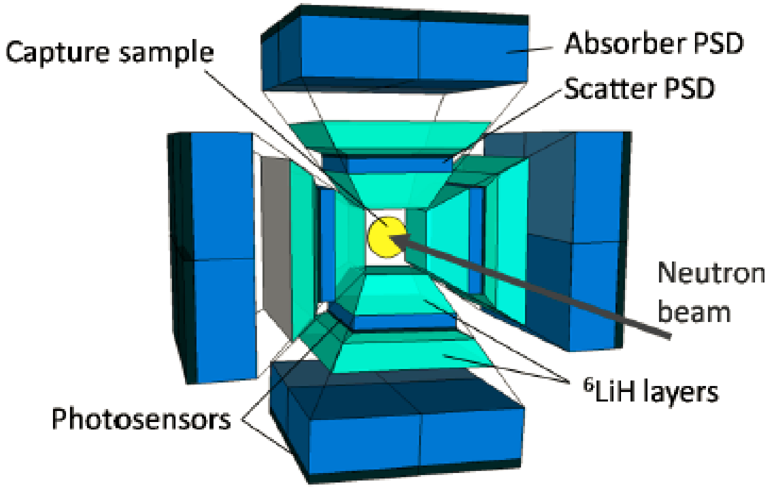
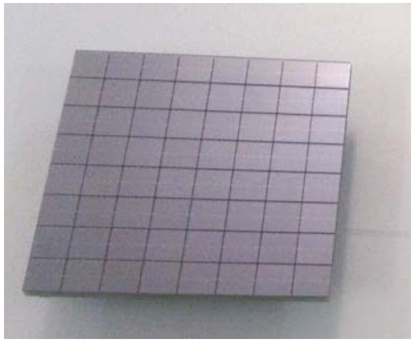








→1xScatter = 5x5 cm^2

→ 1xAbsorber = 10x10 cm^2

→Full i-TED = 4S+4A= 500 cm^2

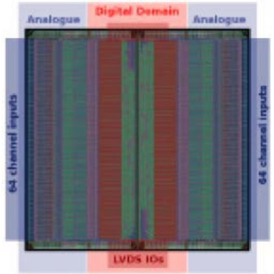
→ # pixels= 8x8y = 64 ch → **1280 channels!**

→ pixel size **= 6x6 mm^2**

→ area = 5x5 cm^2 = 25 cm^2

i-TED: readout electronics (PETsys) Test Sept.2017

PETsys Electronics S.A.

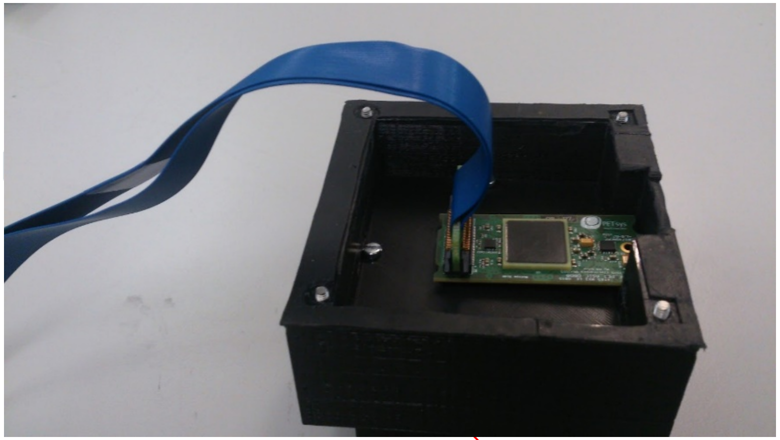


→128 channels (or pixels from SiPM)

→ 25 ps intrinsic t-resolution / 32 ps SiPM+ASIC/ **200 ps** Crystal + SiPM + ASIC

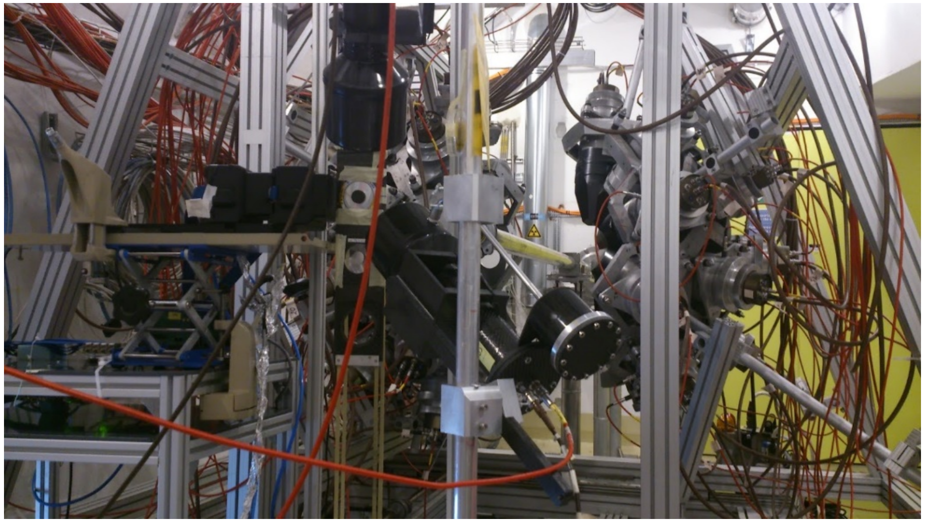
→max. rate 160 kEvents/ch or 12 Mevents/board

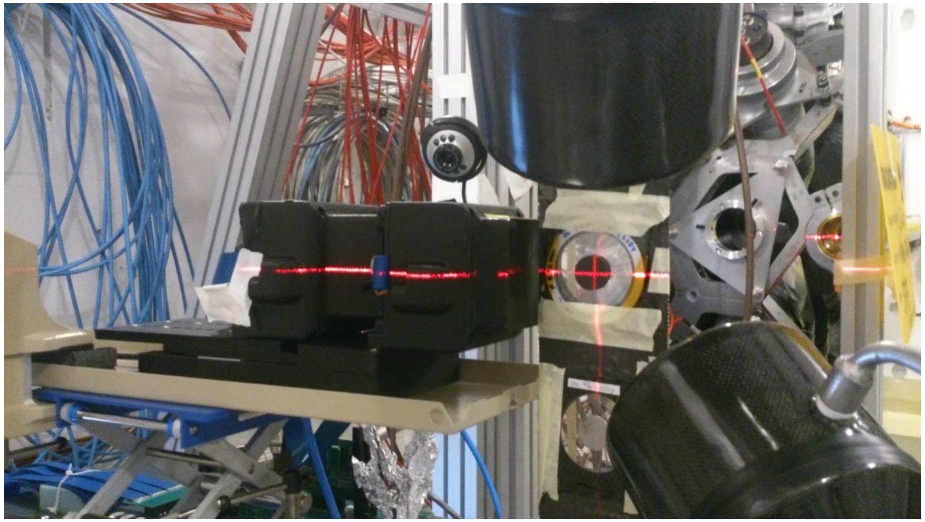
→ energy via qdc for each channel

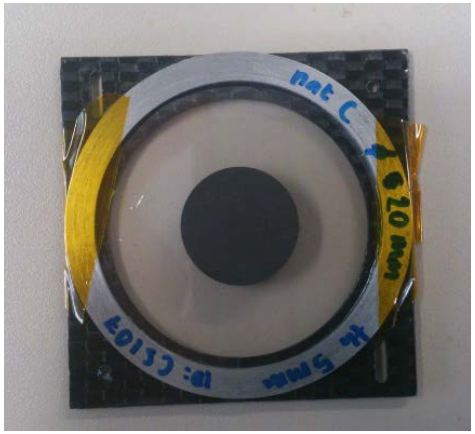


i-TED @ EAR1:

i-TED prototype: September tests







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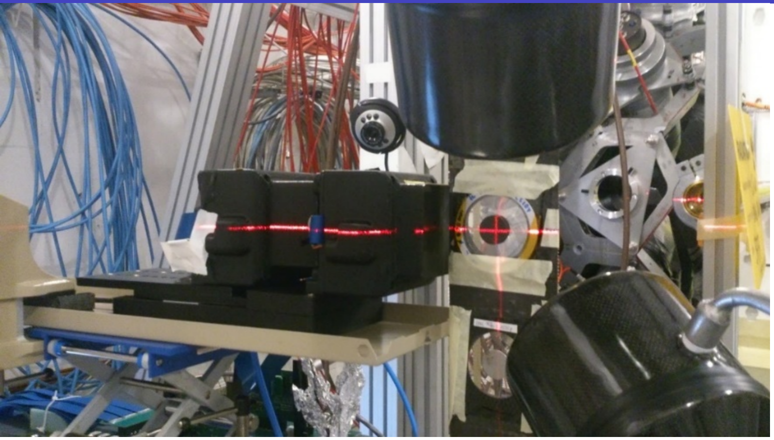
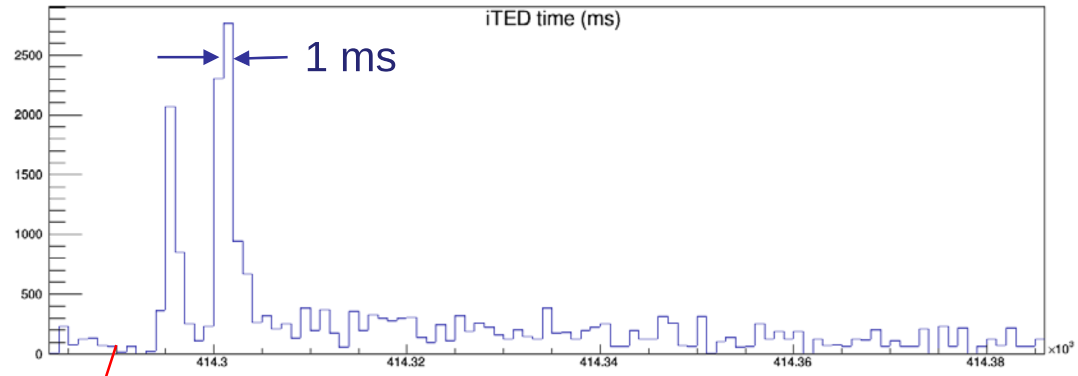
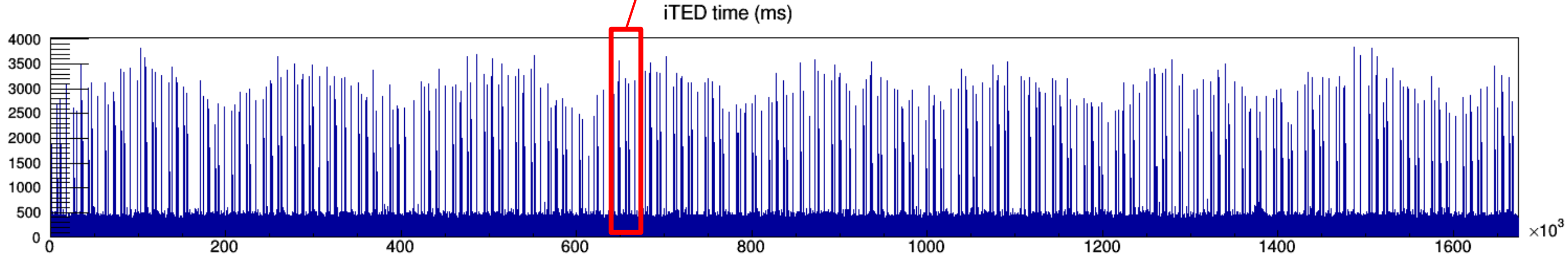


→ Difficult to identify the t_o of each bunch



^{197}Au(n,γ) RUNS:

i-TED time-stamps:



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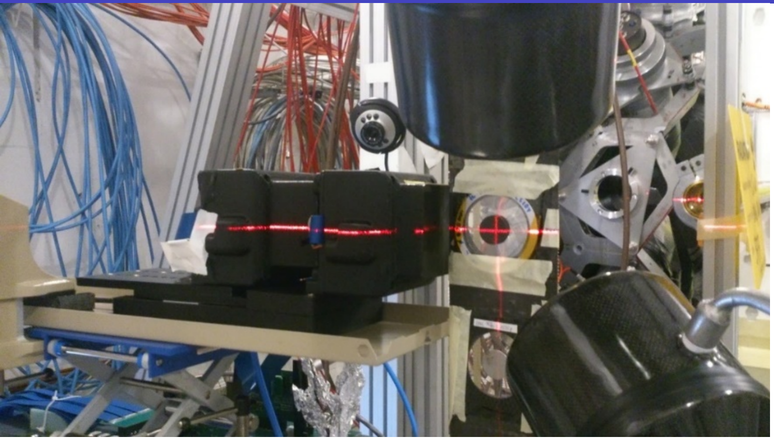

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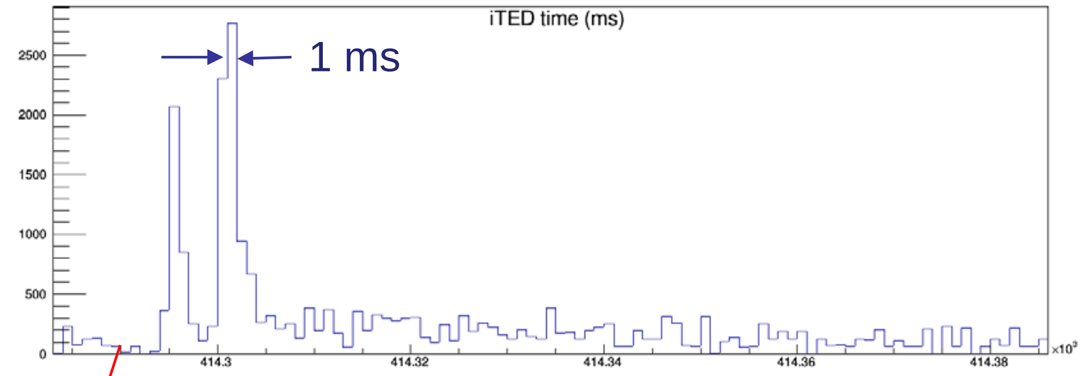

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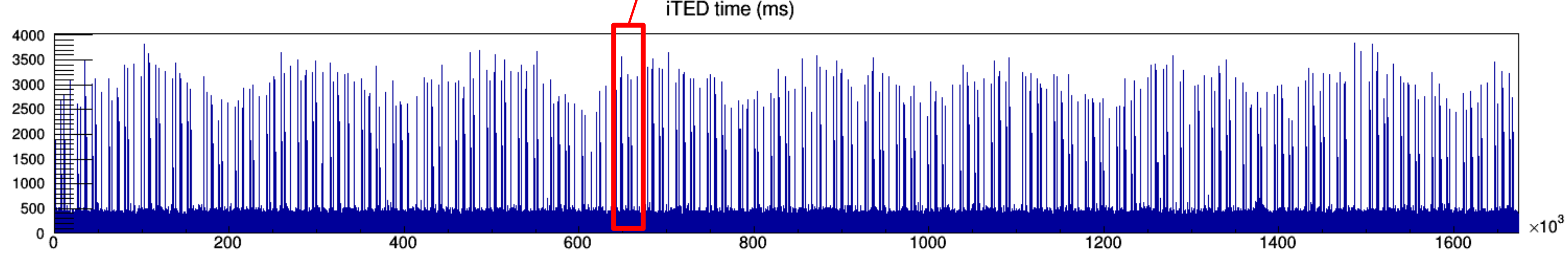
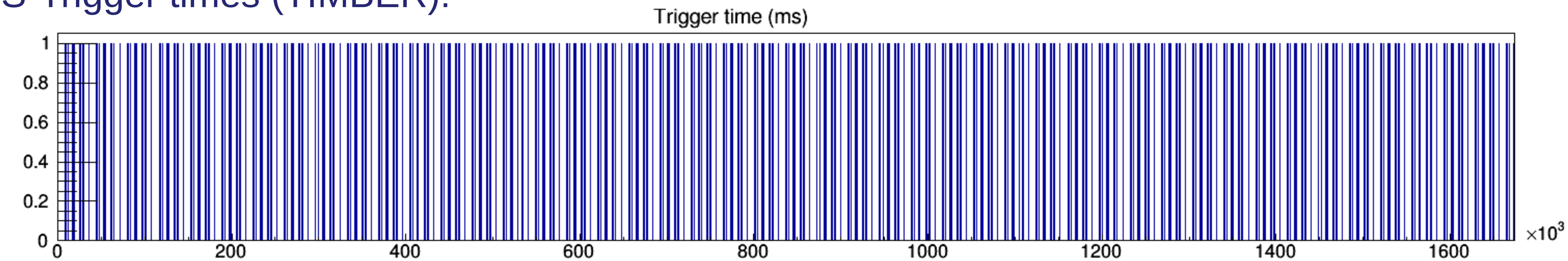


PS-Trigger times (TIMBER):



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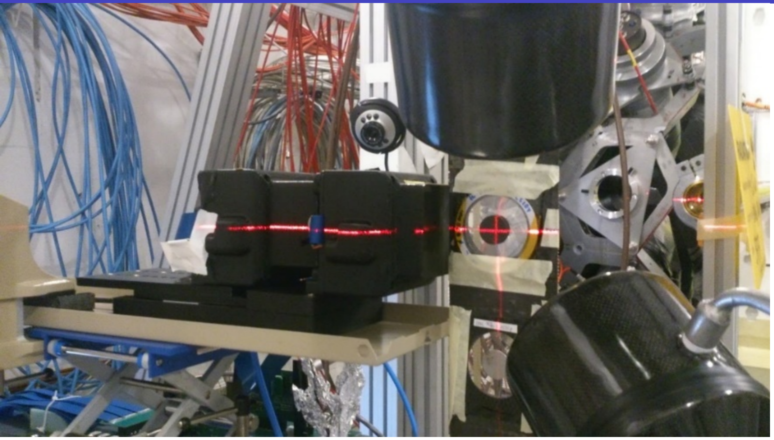

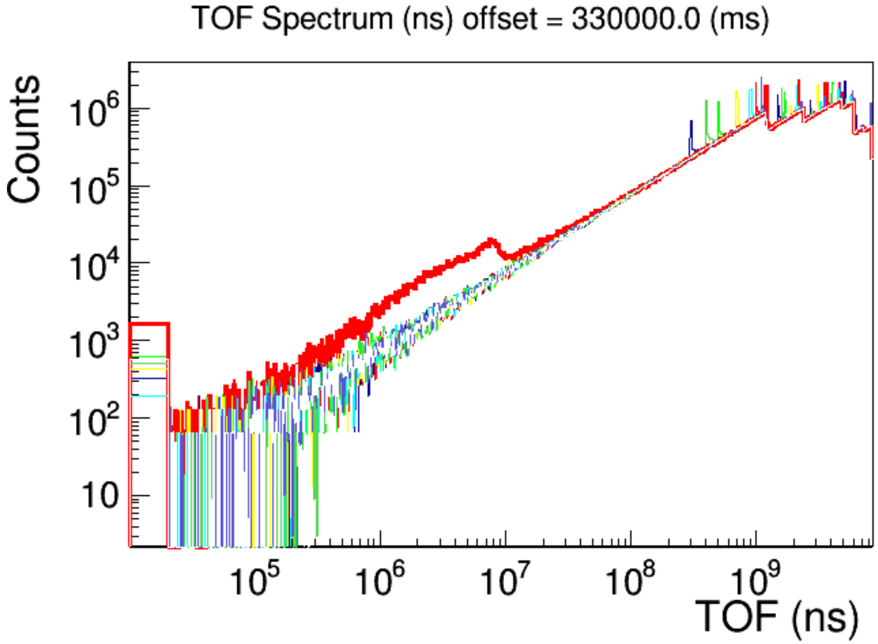

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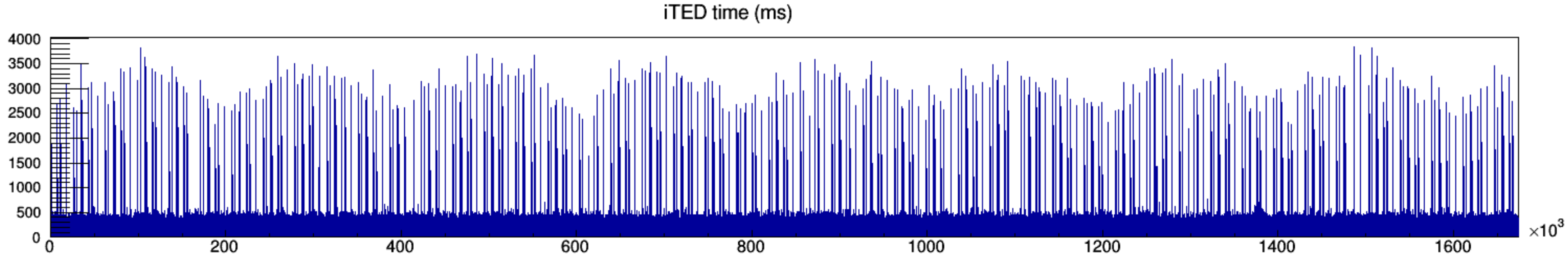

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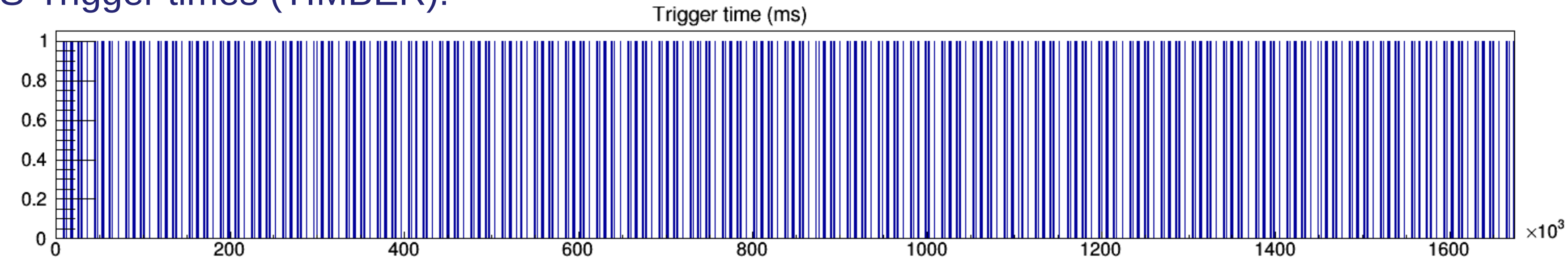

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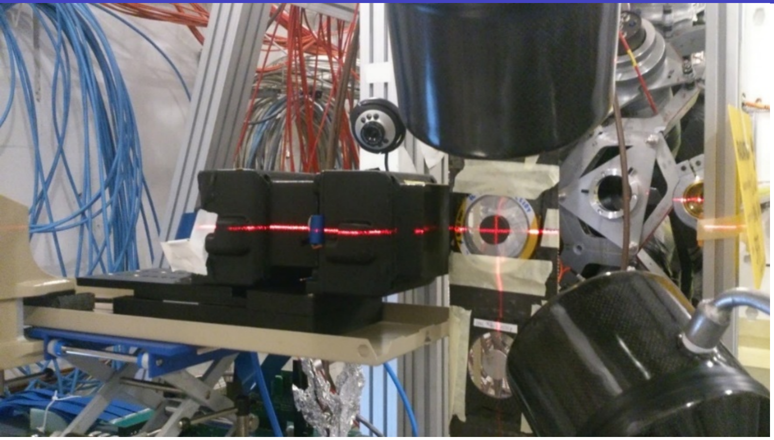

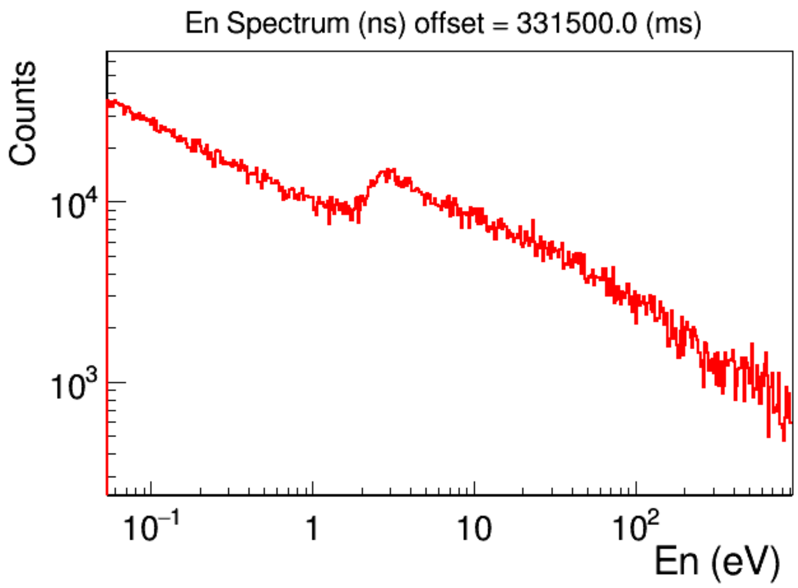

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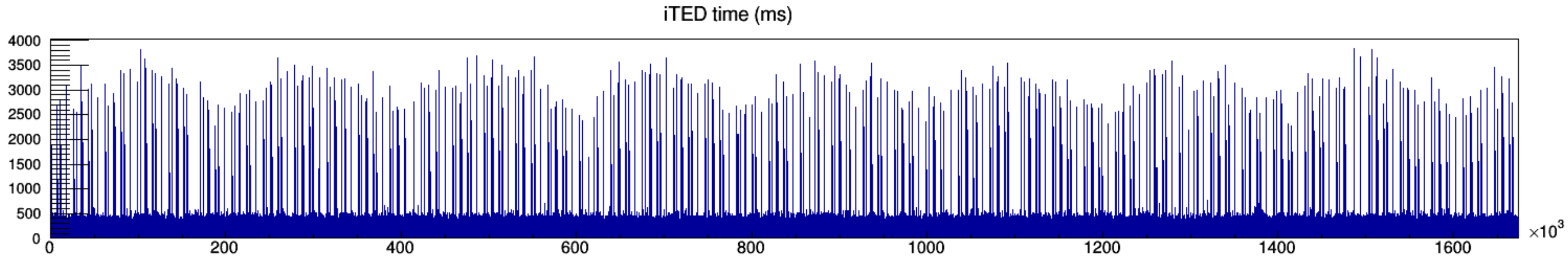

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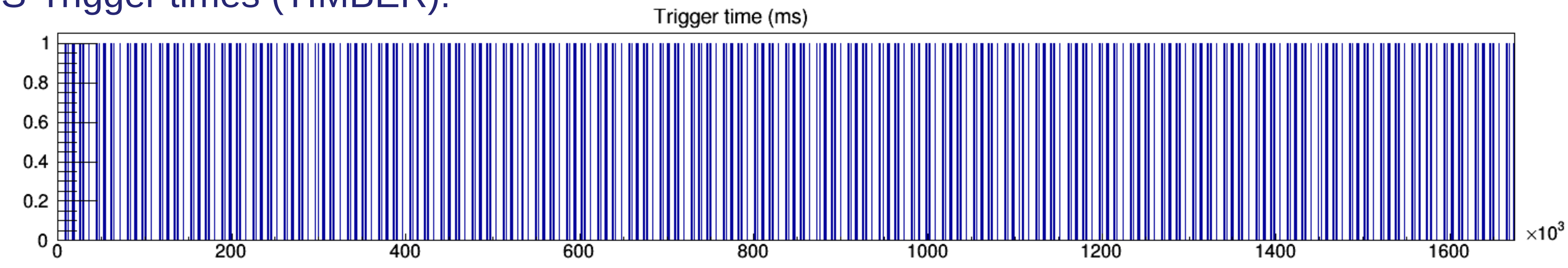

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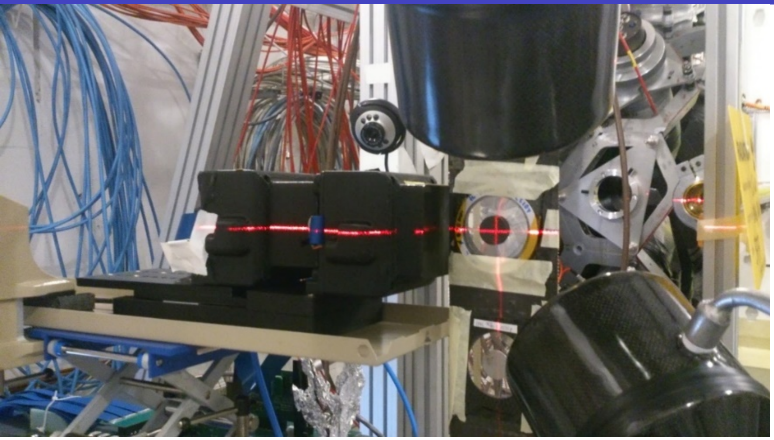
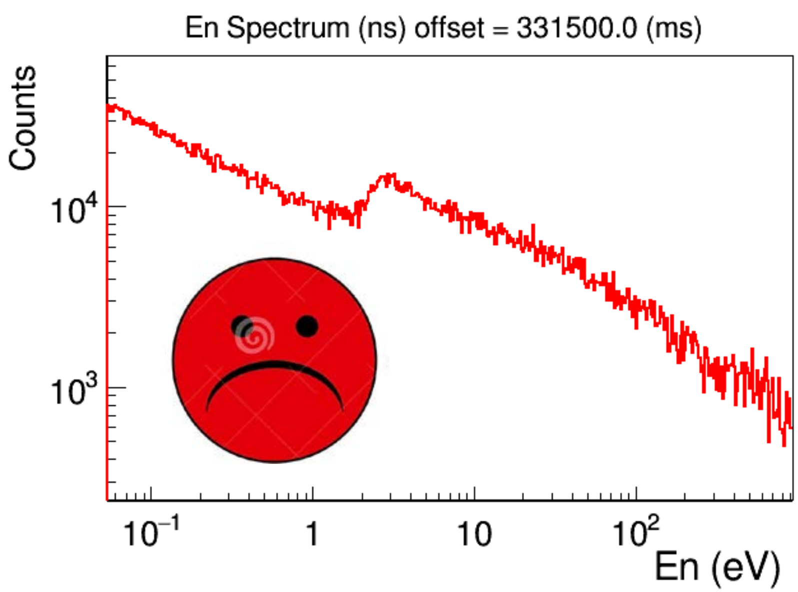
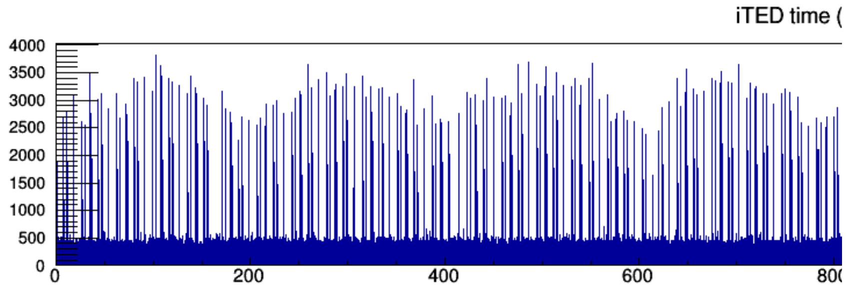




→ Need an external trigger signal!!

i-TED time-stamps:



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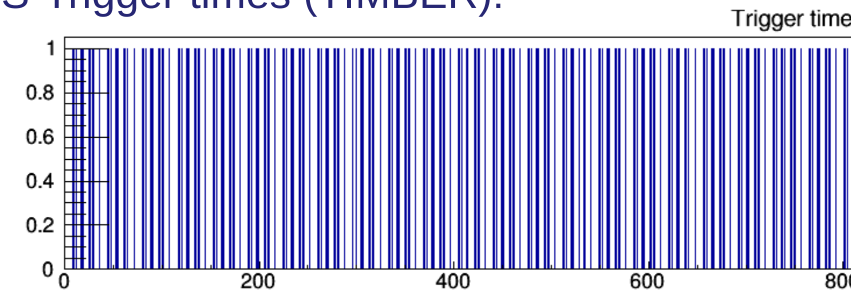

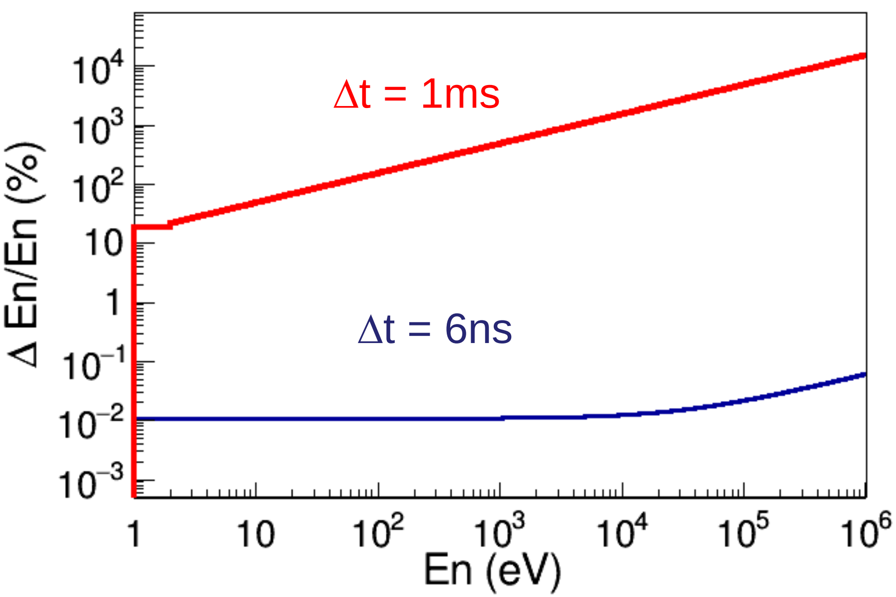

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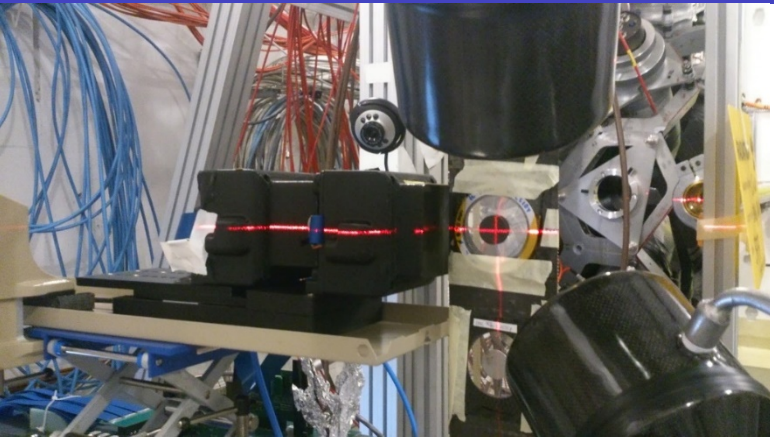

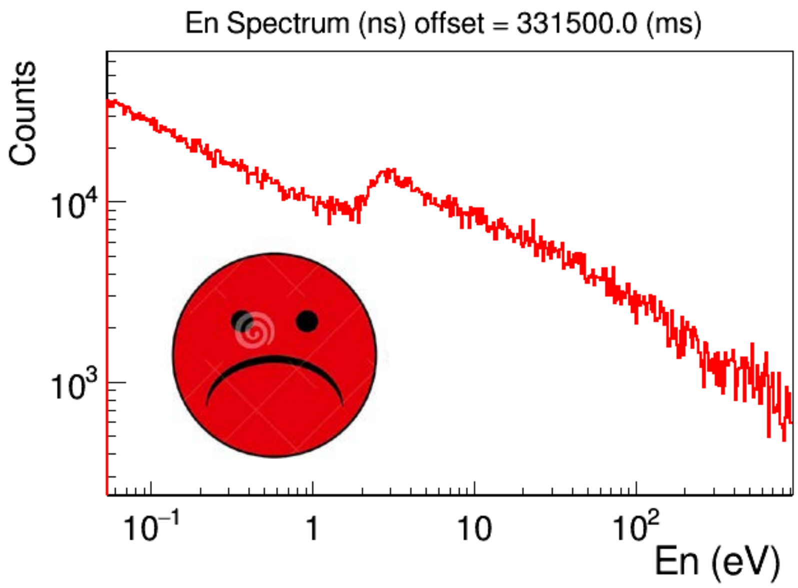

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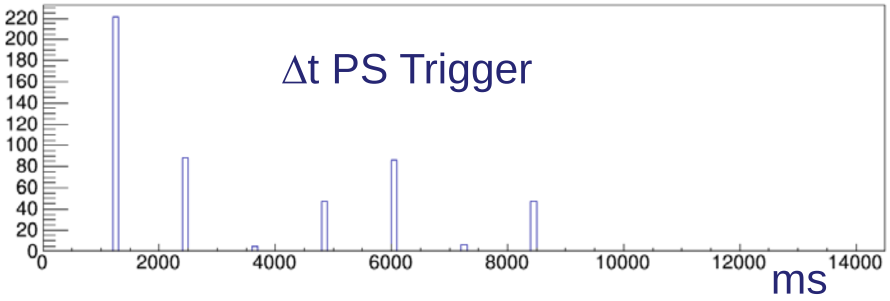
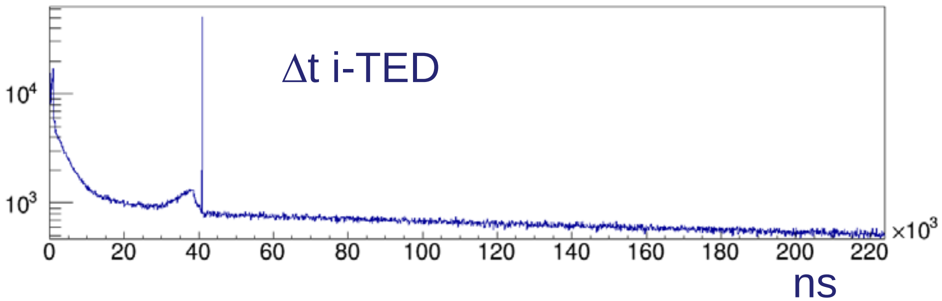
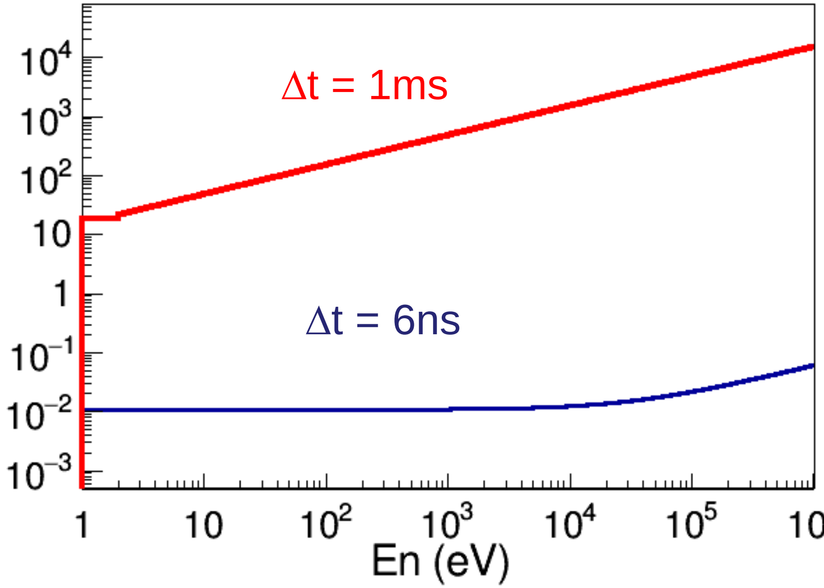
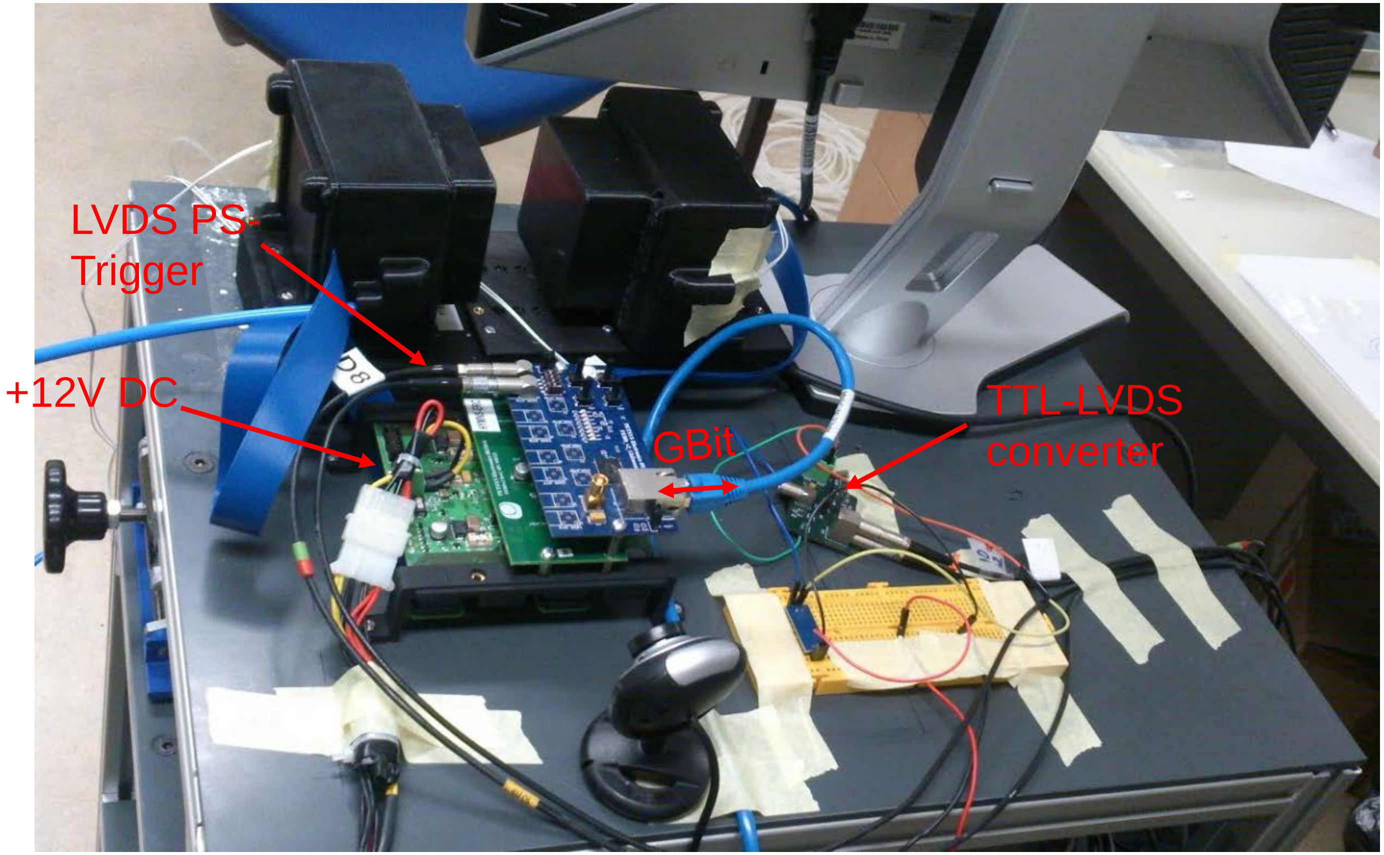


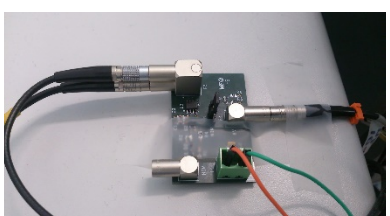




i-TED: new readout electronics (November test)

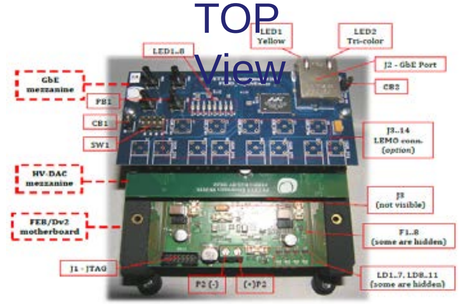


TTL-to-LVDS Converter:

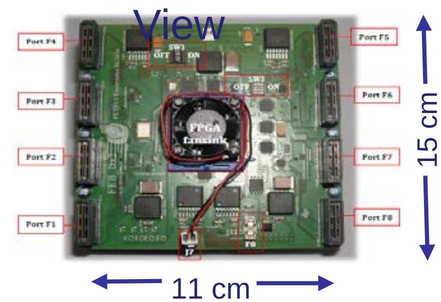


→ **PS-Trigger input into our dacq**

TOP View



Bottom View

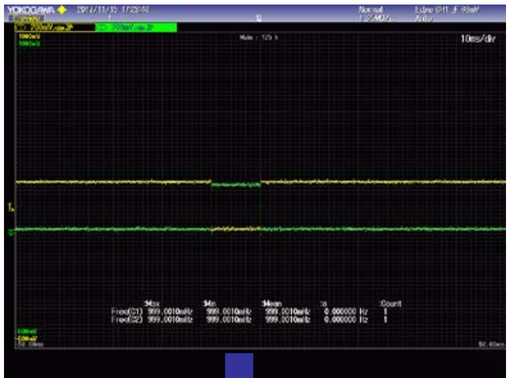


PETsys Electronics

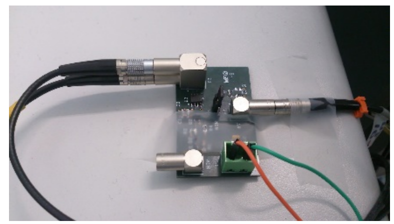
High performance TOFPET2 ASIC

i-TED external trigger tested in the lab

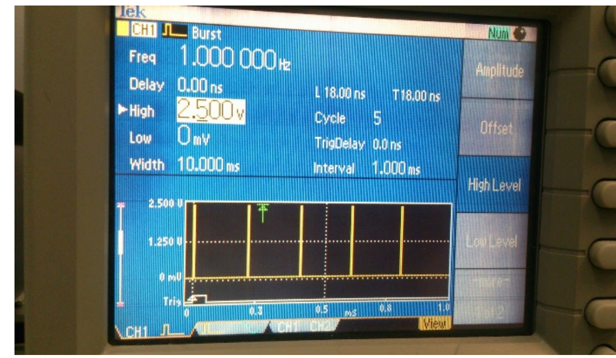
Oscilloscope: LVDS OK

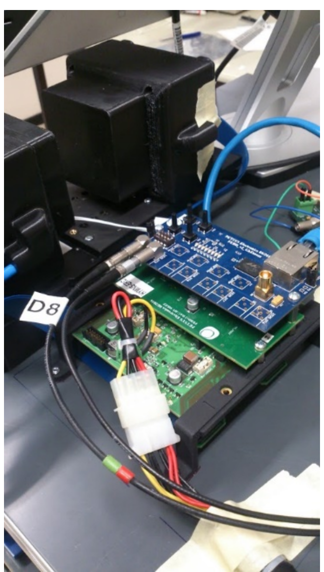


TTL-to-LVDS Converter:

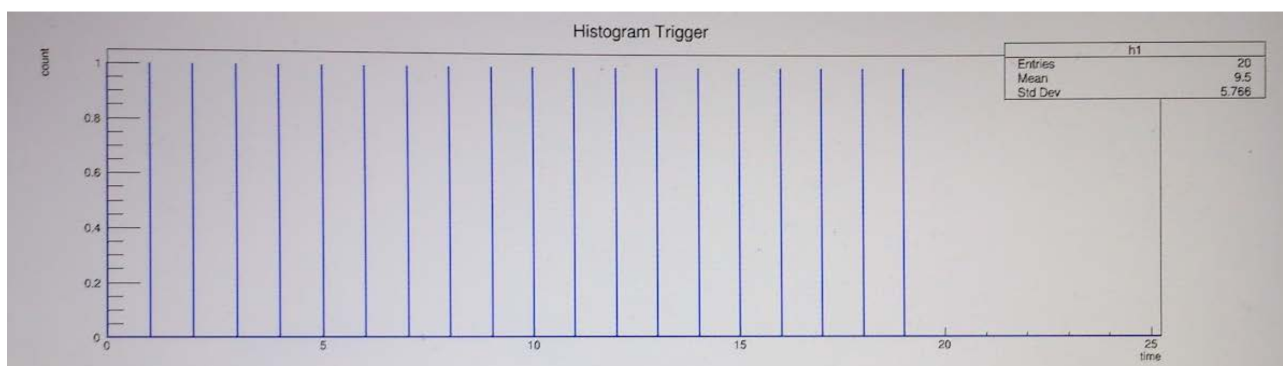


Pulse generator: n_TOF like trigger

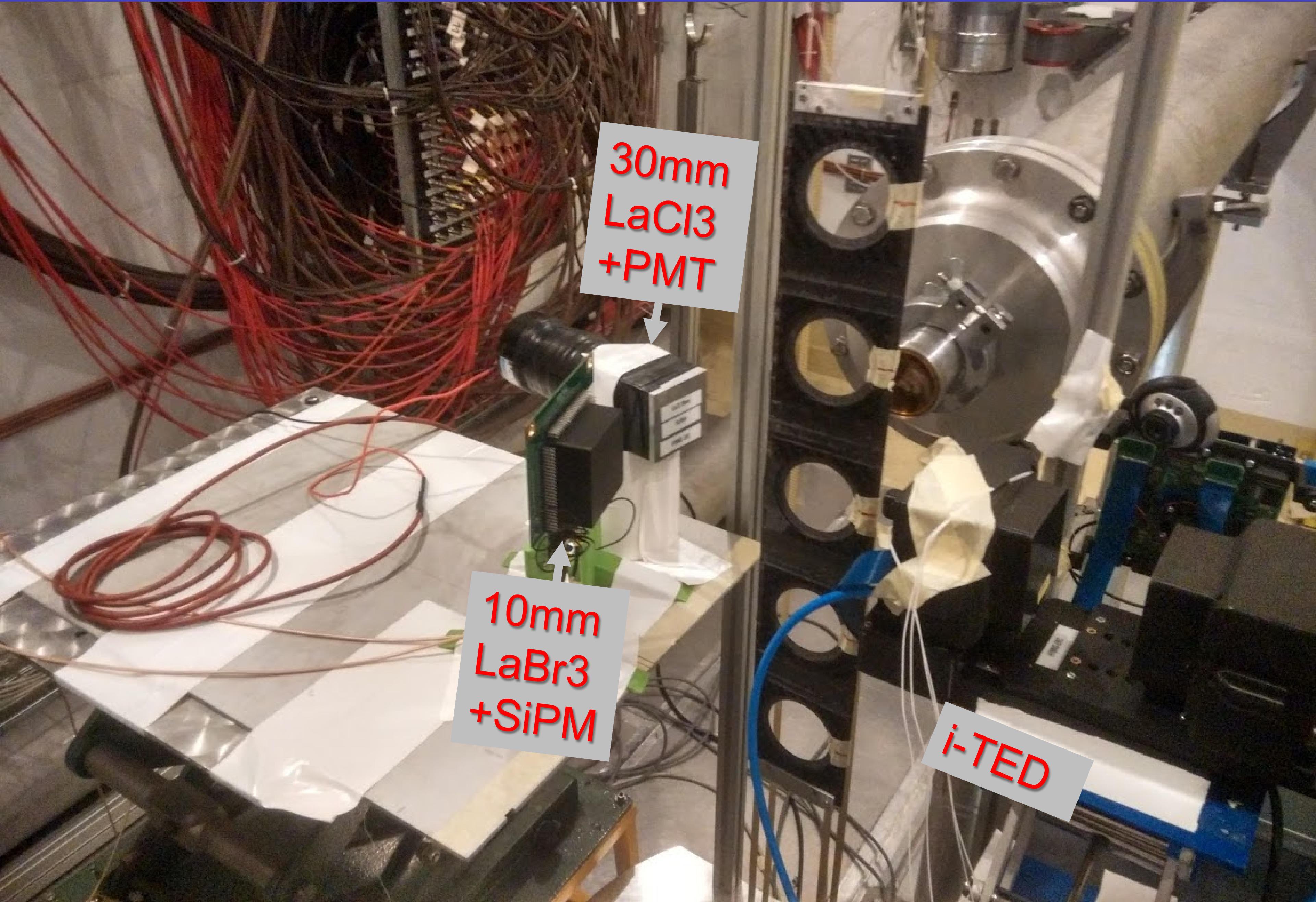




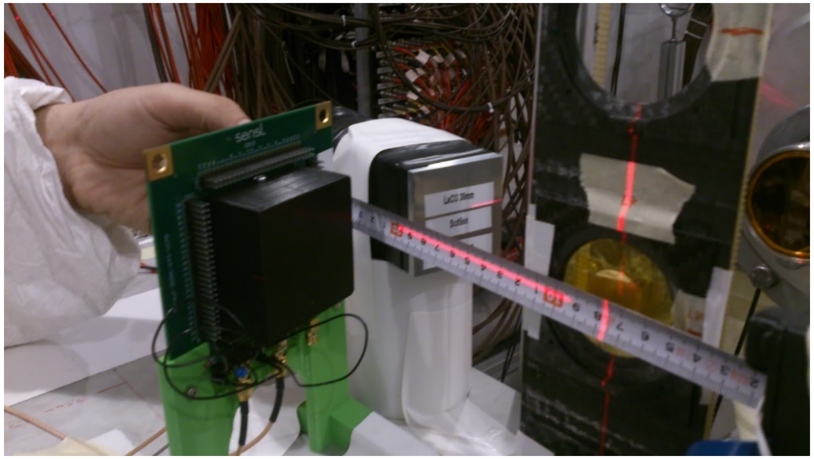
i-TED (PETSYS) DACQ:



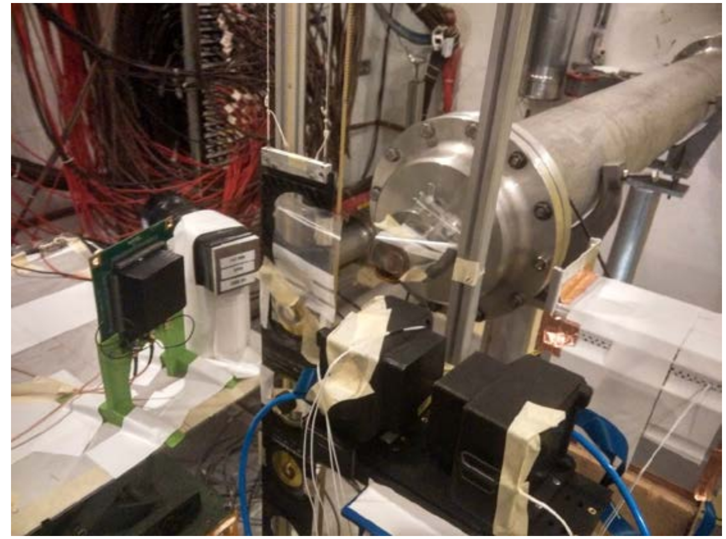
i-TED: new readout electronics (November test)

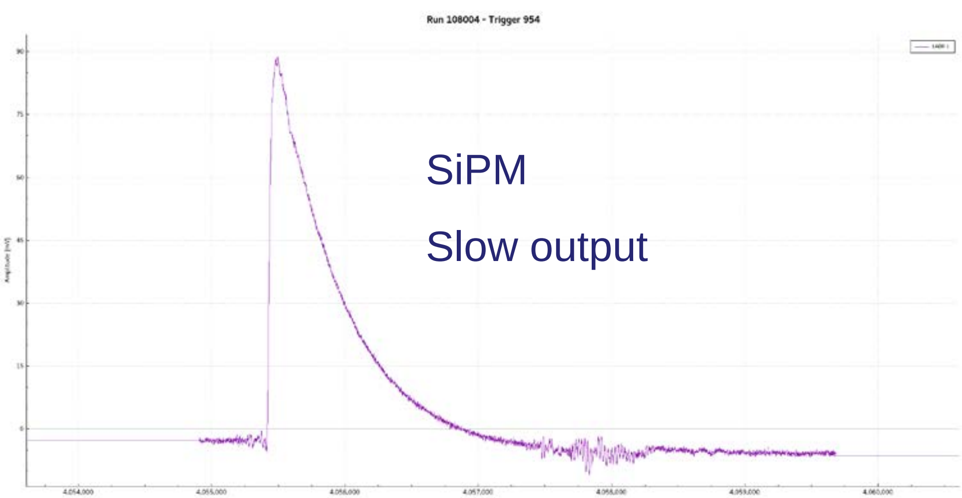


i-TED prototype: November tests



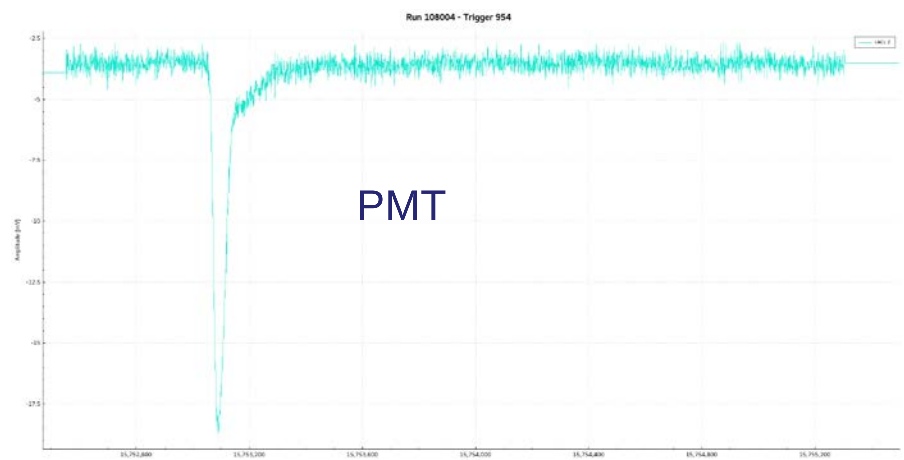
With n_TOF DACQ (signal displayer)





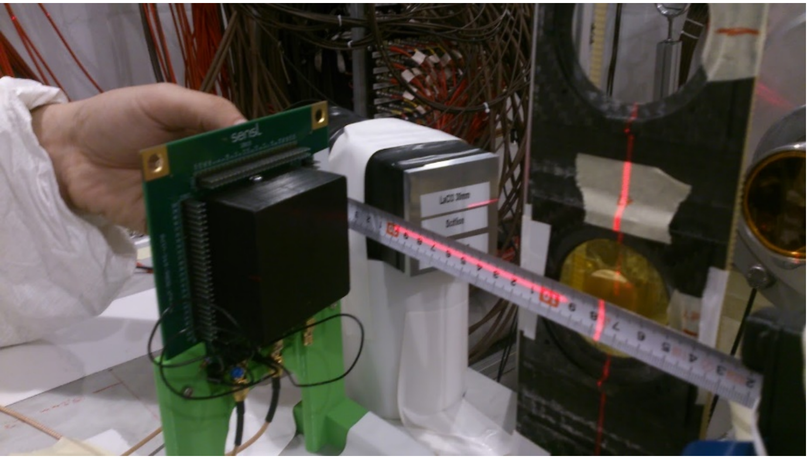
SiPM

Slow output

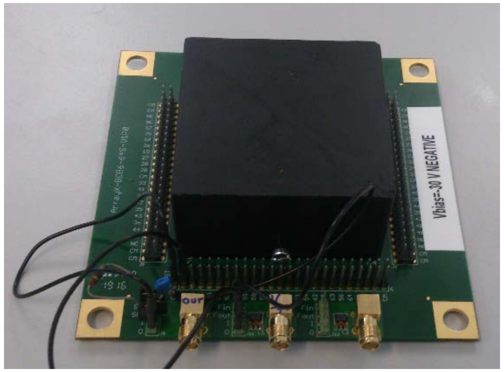


PMT

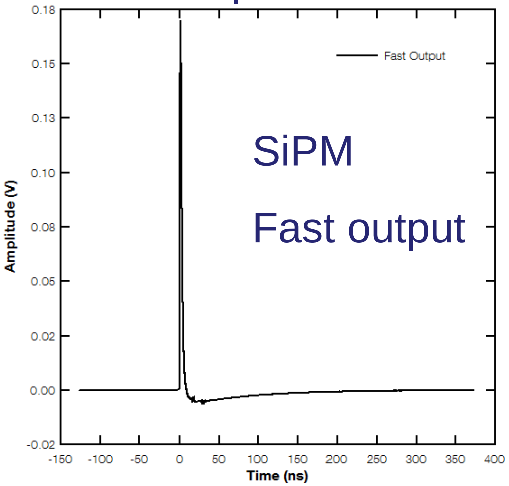
i-TED prototype: September tests

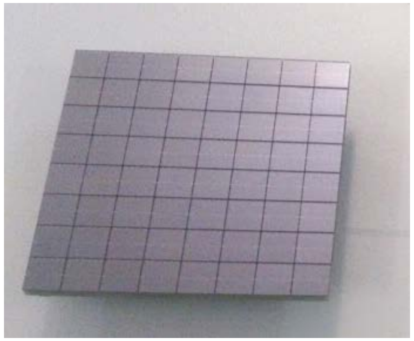


PCB Sum-board: only handles SLOW SiPM summed-outputs



C=200pF → t=3ns





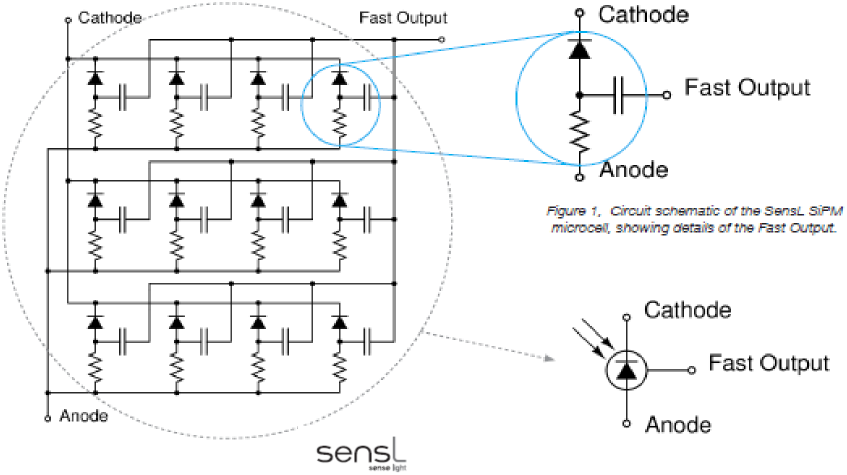
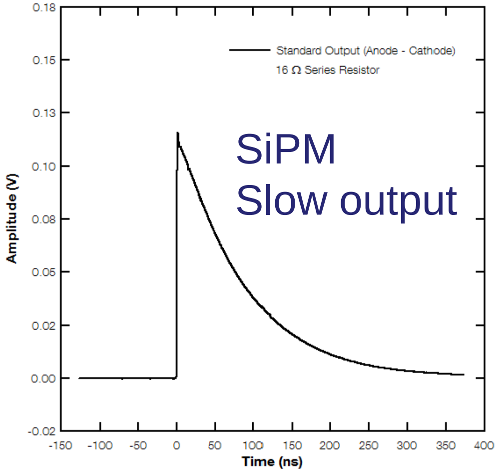
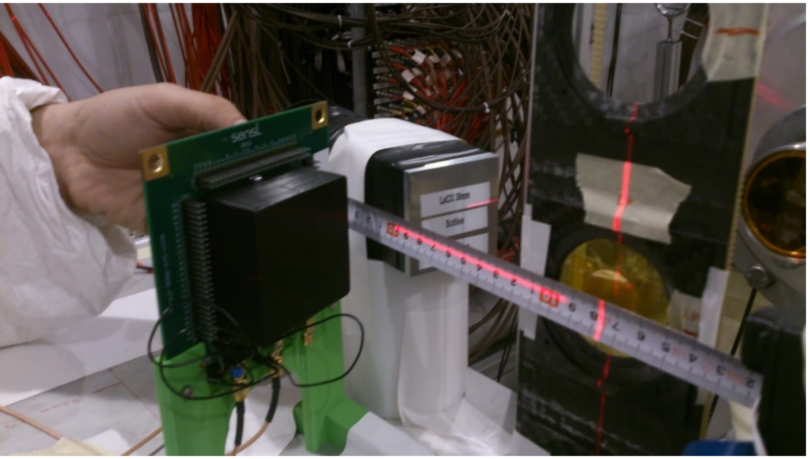


Figure 1, Circuit schematic of the SensL SiPM microcell, showing details of the Fast Output.

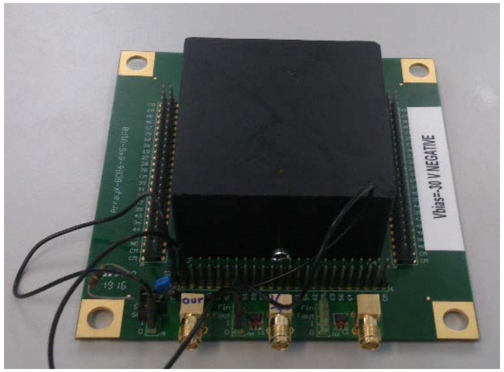
C=4nF → t=100ns



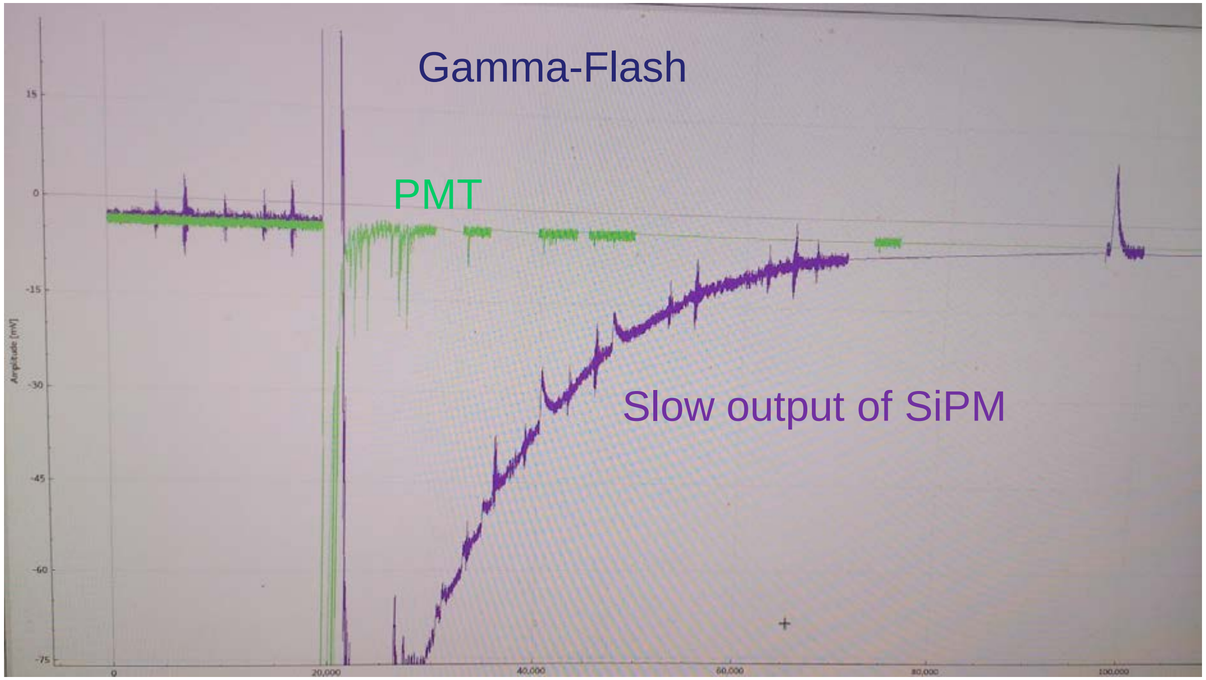
i-TED prototype: September tests



PCB Sum-board:

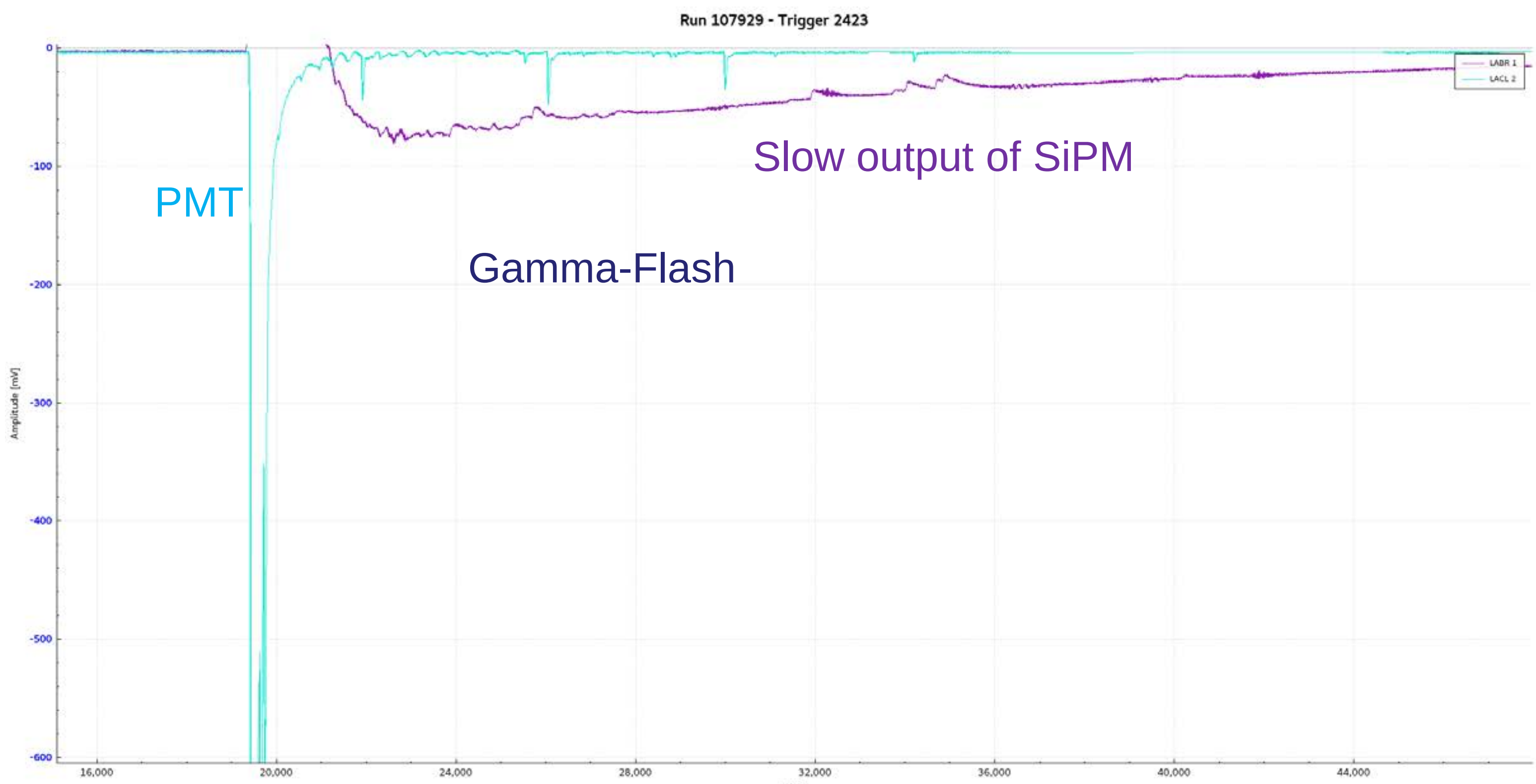


With n_TOF DACQ (signal displayer)

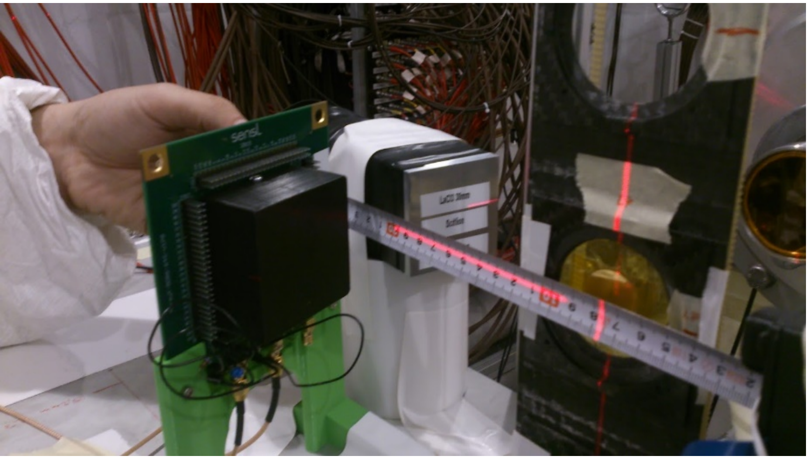


i-TED prototype: November tests

With n_TOF DACQ

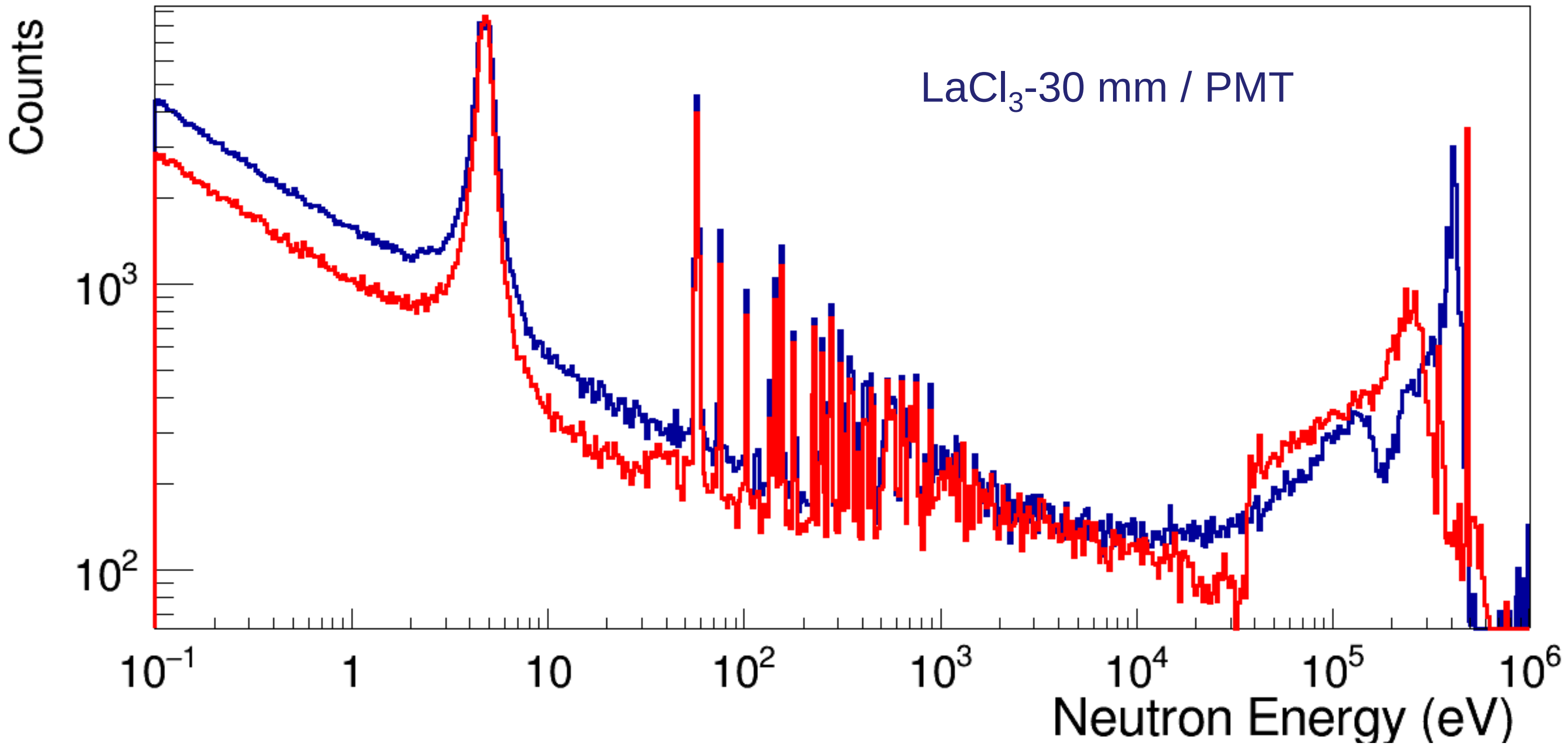


i-TED prototype: November tests

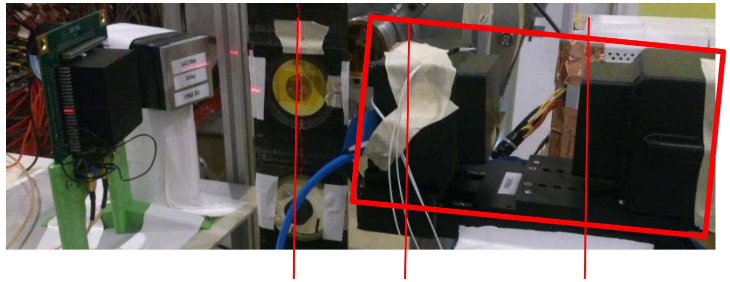


- Response OK for TOF
- HE part probably affected by unoptimized PSA
- Effect of the crystal radioactivity (alphas) in the large crystal

With n_TOF DACQ



i-TED prototype: November tests

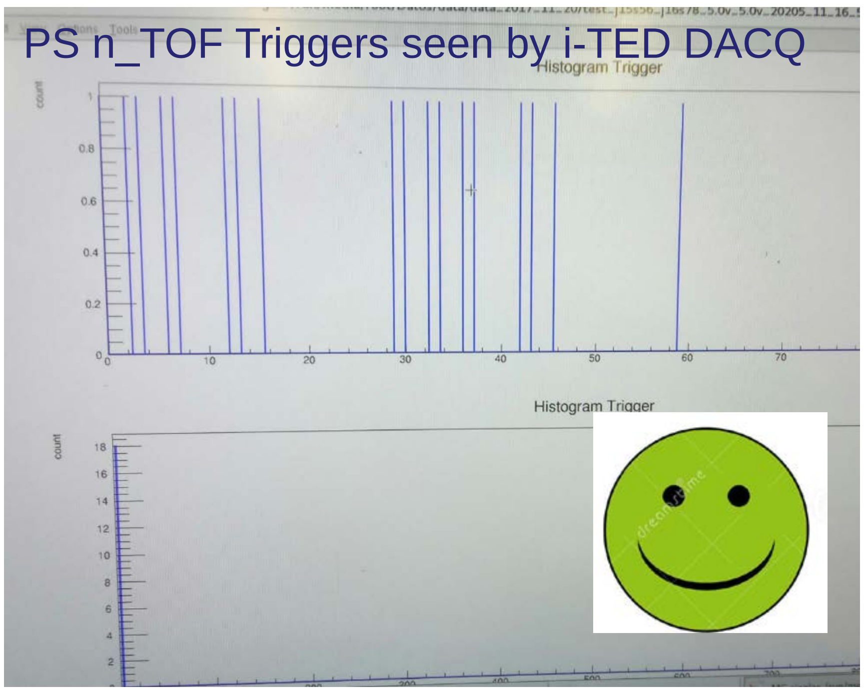


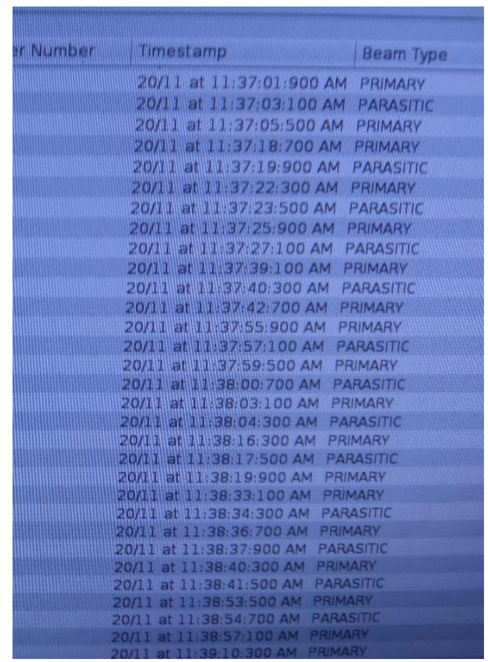
dsample = 8 cm   dSA=30 mm   SETUP 1

dsample = 5 cm   dSA=15 mm   SETUP 2

With i-TED (PETSYS) DACQ:

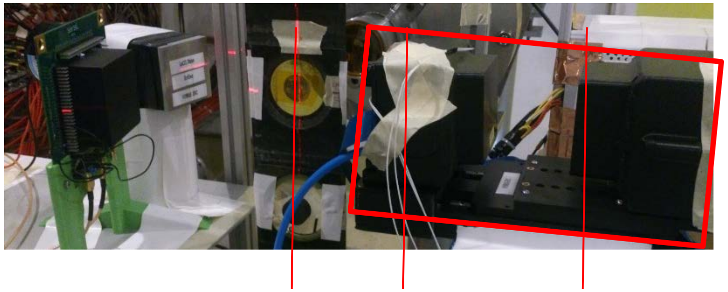
PS n_TOF Triggers seen by i-TED DACQ





...r Number	Timestamp	Beam Type
	20/11 at 11:37:01:900 AM	PRIMARY
	20/11 at 11:37:03:100 AM	PARASITIC
	20/11 at 11:37:05:500 AM	PRIMARY
	20/11 at 11:37:18:700 AM	PRIMARY
	20/11 at 11:37:19:900 AM	PARASITIC
	20/11 at 11:37:22:300 AM	PRIMARY
	20/11 at 11:37:23:500 AM	PARASITIC
	20/11 at 11:37:25:900 AM	PRIMARY
	20/11 at 11:37:27:100 AM	PARASITIC
	20/11 at 11:37:39:100 AM	PRIMARY
	20/11 at 11:37:40:300 AM	PARASITIC
	20/11 at 11:37:42:700 AM	PRIMARY
	20/11 at 11:37:55:900 AM	PRIMARY
	20/11 at 11:37:57:100 AM	PARASITIC
	20/11 at 11:37:59:500 AM	PRIMARY
	20/11 at 11:38:00:700 AM	PARASITIC
	20/11 at 11:38:03:100 AM	PRIMARY
	20/11 at 11:38:04:300 AM	PARASITIC
	20/11 at 11:38:16:300 AM	PRIMARY
	20/11 at 11:38:17:500 AM	PARASITIC
	20/11 at 11:38:19:900 AM	PRIMARY
	20/11 at 11:38:33:100 AM	PRIMARY
	20/11 at 11:38:34:300 AM	PARASITIC
	20/11 at 11:38:36:700 AM	PRIMARY
	20/11 at 11:38:37:900 AM	PARASITIC
	20/11 at 11:38:40:300 AM	PRIMARY
	20/11 at 11:38:41:500 AM	PARASITIC
	20/11 at 11:38:53:500 AM	PRIMARY
	20/11 at 11:38:54:700 AM	PARASITIC
	20/11 at 11:38:57:100 AM	PRIMARY
	20/11 at 11:39:10:300 AM	PRIMARY

i-TED prototype: November tests

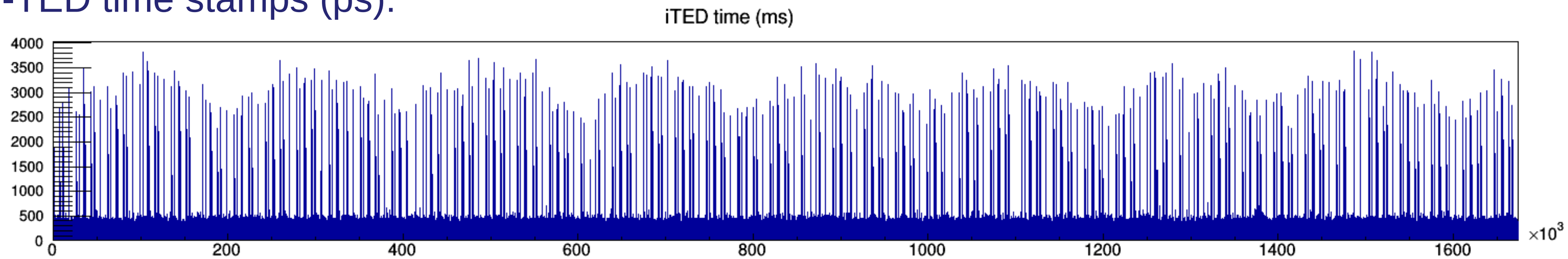


dsample = 8 cm   dSA=30 mm   SETUP 1

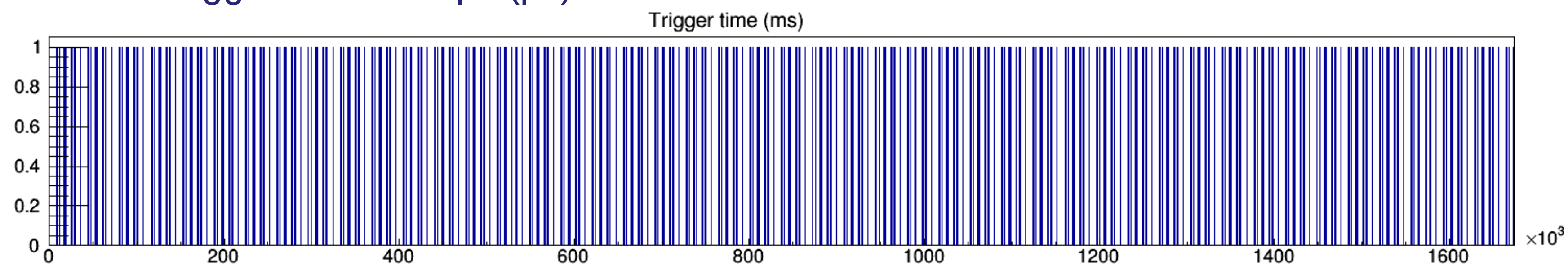
dsample = 5 cm   dSA=15 mm   SETUP 2

With i-TED (PETSYS) DACQ:

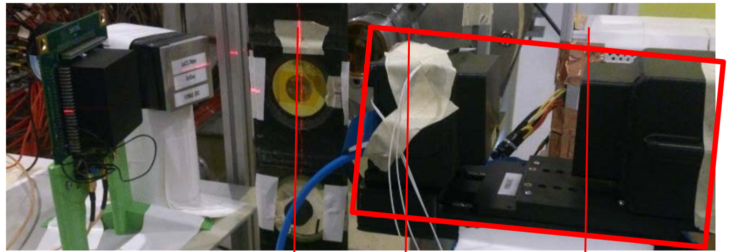
i-TED time stamps (ps):



i-TED PS Trigger time stamps (ps):



i-TED prototype: November tests

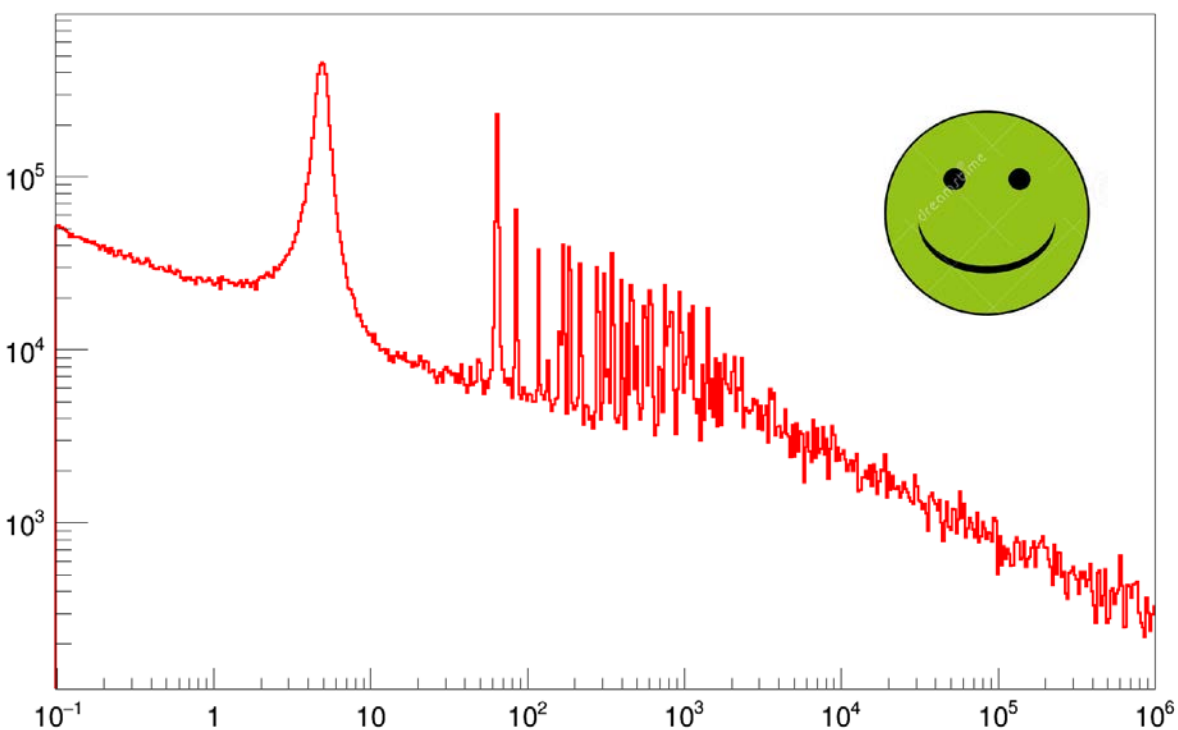


dsample = 8 cm   dSA=30 mm   SETUP 1

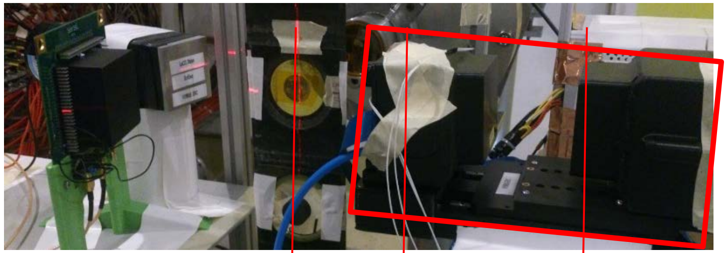
dsample = 5 cm   dSA=15 mm   SETUP 2

With i-TED (PETSYS) DACQ:

i-TED [S-detector] En Spectrum / All Files



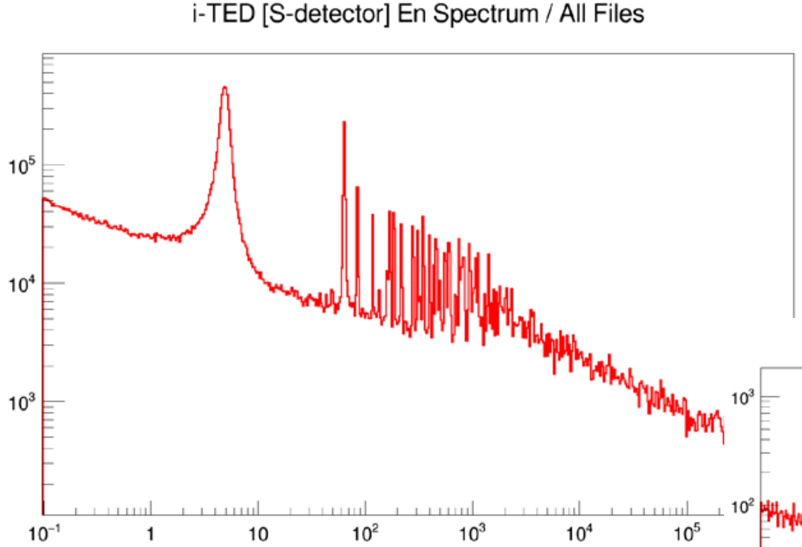
i-TED prototype: November tests

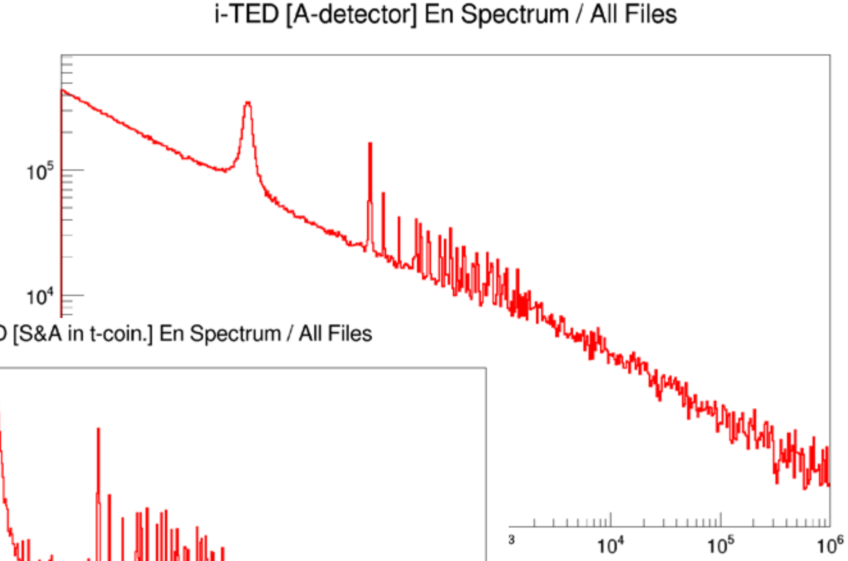


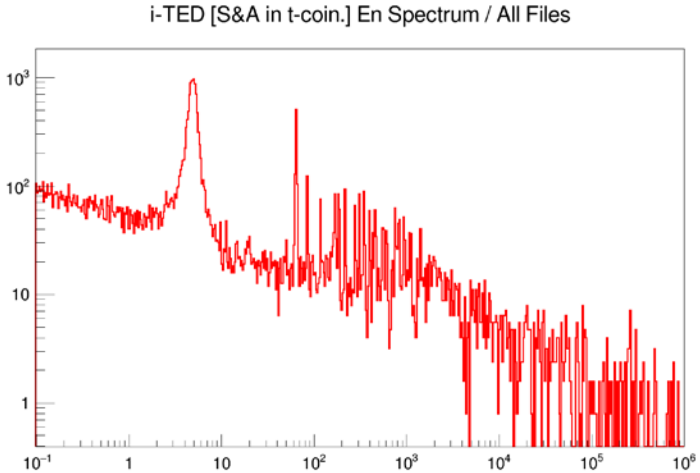
dsample = 8 cm   dSA=30 mm   SETUP 1

dsample = 5 cm   dSA=15 mm   SETUP 2

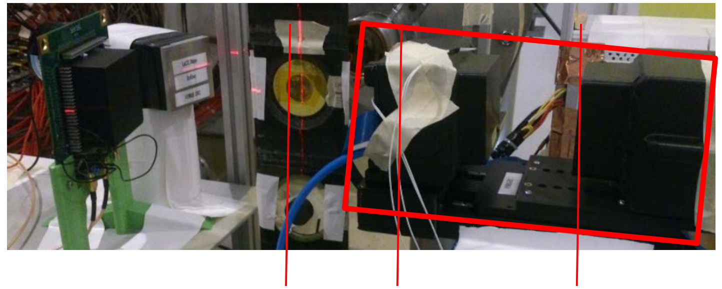
With i-TED (PETSYS) DACQ:







i-TED prototype: November tests

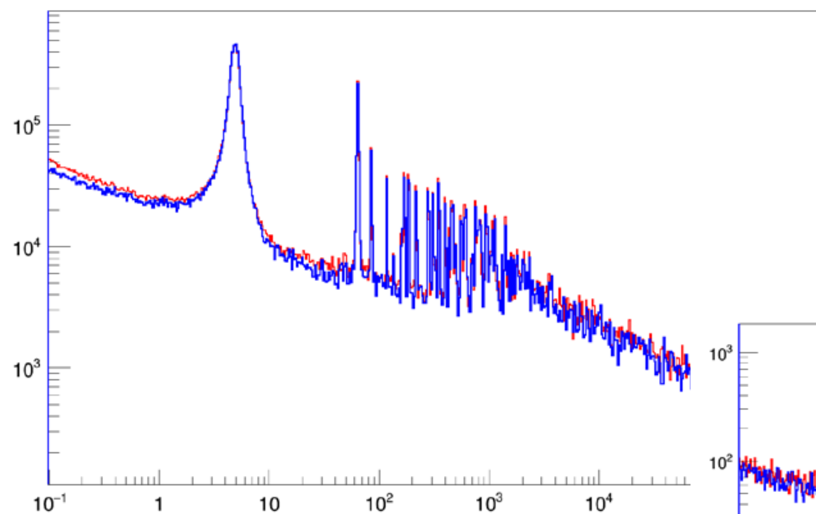


dsample = 8 cm dSA=30 mm SETUP 1

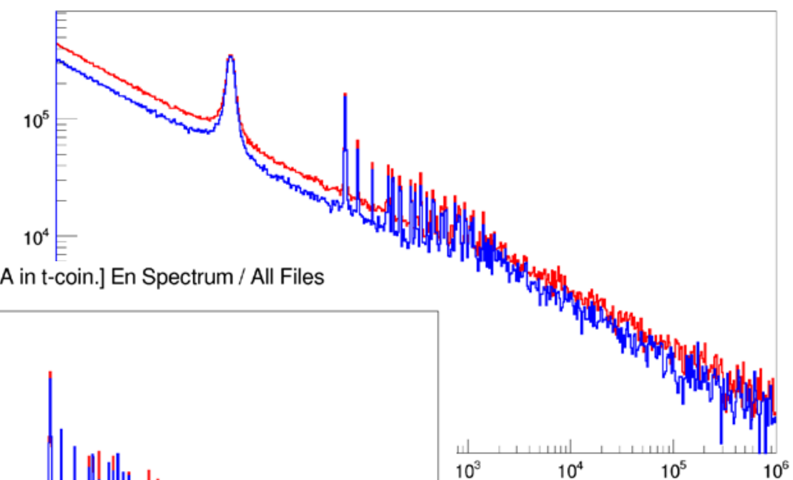
dsample = 5 cm dSA=15 mm SETUP 2

With i-TED (PETSYS) DACQ:

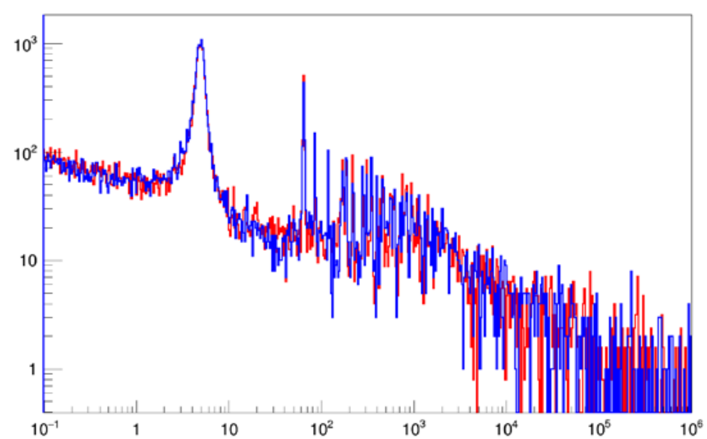
i-TED [S-detector] En Spectrum / All Files



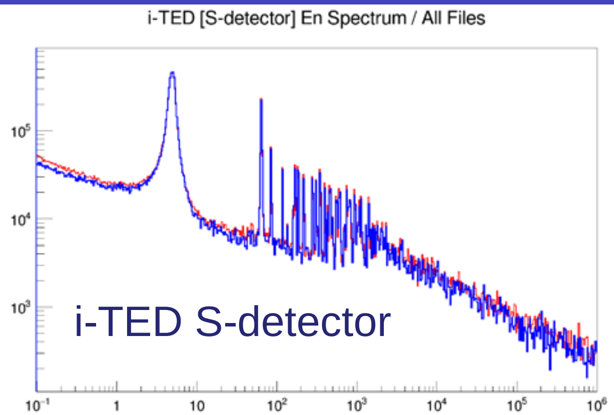
i-TED [A-detector] En Spectrum / All Files

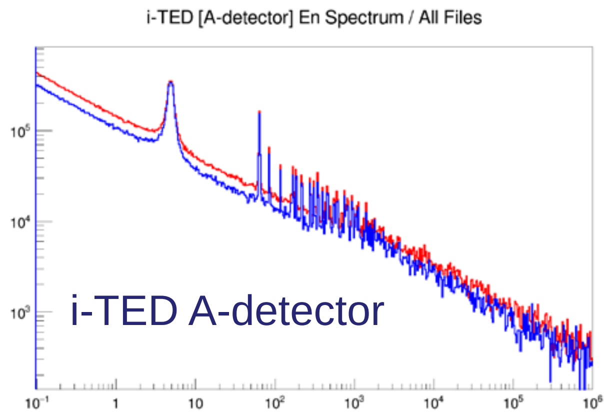


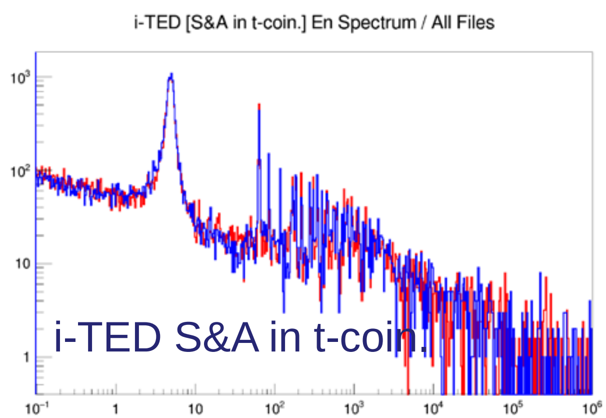
i-TED [S&A in t-coin.] En Spectrum / All Files



i-TED prototype: November tests







9 h run

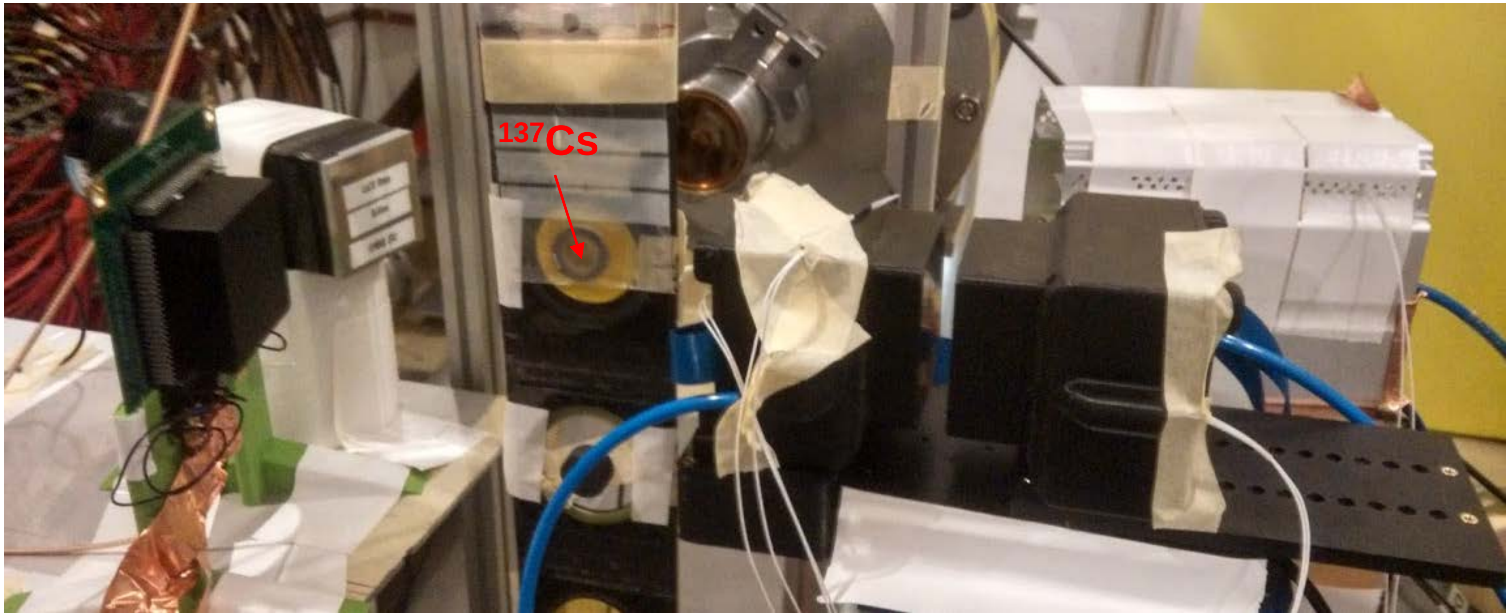
About 9k Bunches

4.7×10^{16} protons

	S	A	i-TED (S&A)
S/B Setup 1	57	11	57
S/B Setup 2	59	14	56

	S	A	i-TED (S&A)
Rel Eff. (%) Setup 1	100%	64%	0.15%
Rel. Eff. (%) Setup 2	100%	70%	0.2%

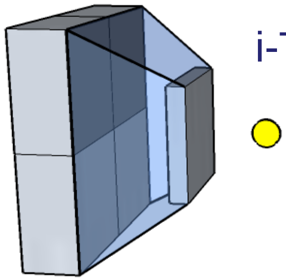
i-TED prototype: November tests



i-TED: Summary & Outlook

• Main technical commissioning of i-TED, both in terms of detectors (crystals, SiPMs, etc), readout electronics (PETSYS mod. Version) and processing software has been accomplished successfully.

• With the developed i-TED prototype, we have not found any major drawback in terms of performance, it seems also that with i-TED we can come much closer to the sample than in these tests (to enhance efficiency). To be tested.



• We have to complete the analysis, including:

  • C6D6 runs from september as a benchmark

  • Imaging in our i-TED runs of November

• For 2018 we are preparing the i-TED Demonstrator (i-TED2), which features 5 detectors (instead of 2), 1 detector for the S & 4 detectors for the A-detector.

• We need to perform a few additional technical detector-tests early 2018 and a dedicated performance commissioning in 2018 (more tomorrow).

THANKS FOR YOUR ATTENTION

Project HYMNS funded by the ERC under Grant Agreement Nr. 681740

European Research Council

Backup slides

Remaining technical i-TED tests / 2018 (with parasitic neutron beam/n_TOF detector test):

- Effect of sample-detector distance, how close we can come with i-TED (its S-detector) to the sample → Efficiency / high En
- Possibility to use a veto time-gate to go higher in neutron energy, for the case that the detector is affected by the gamma-flash
- Combined capture & gamma-source measurement to develop sample-activity rejection algorithms
- Effect of the LiH moderator for reducing intrinsic neutron sensitivity
- i-TED response tests at EAR2
- Explore dynamic range of i-TED, how high we can go in g-ray energy
- Combined i-TED & TAC “matriuska-like” set-up, to enhance efficiency at high gamma-ray energy (see next slide).

i-TED + TAC (?):

→ Enhance efficiency for high-enery part of the capture cascade (Triple-coincidences S&A&TAC)

40 ch. TAC →

1 port of PETSYS FEB/D_v2