CsI(Na) Wavelength-shifting fiber gamma camera using SiPMs

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LABORATÓRIO DE INSTRUMENTAÇÃO E FÍSICA EXPERIMENTAL DE PARTICULAS

LIP Lisboa Apr. 2012

IDPASC School on Digital Counting Photosensors for Extreme Low Light Levels

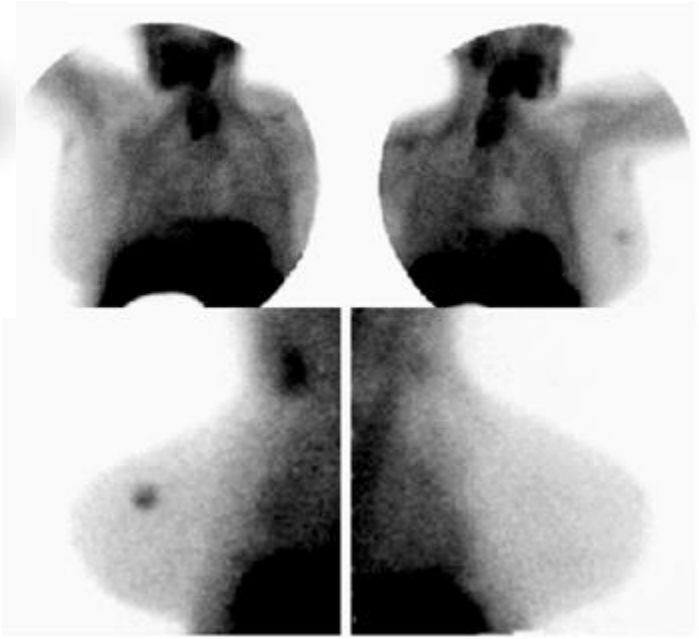
MOTIVATION

Improve sensitivity of scintigraphy exams

Typical radionuclide: ^{99m}Tc

(140 keV, $T_{1/2}$ = 6.02 h)

Mammoscintigraphy images with ^{99m}Tc-MIBI:



Bénard and Turcotte, *Breast Cancer Research* (2005)

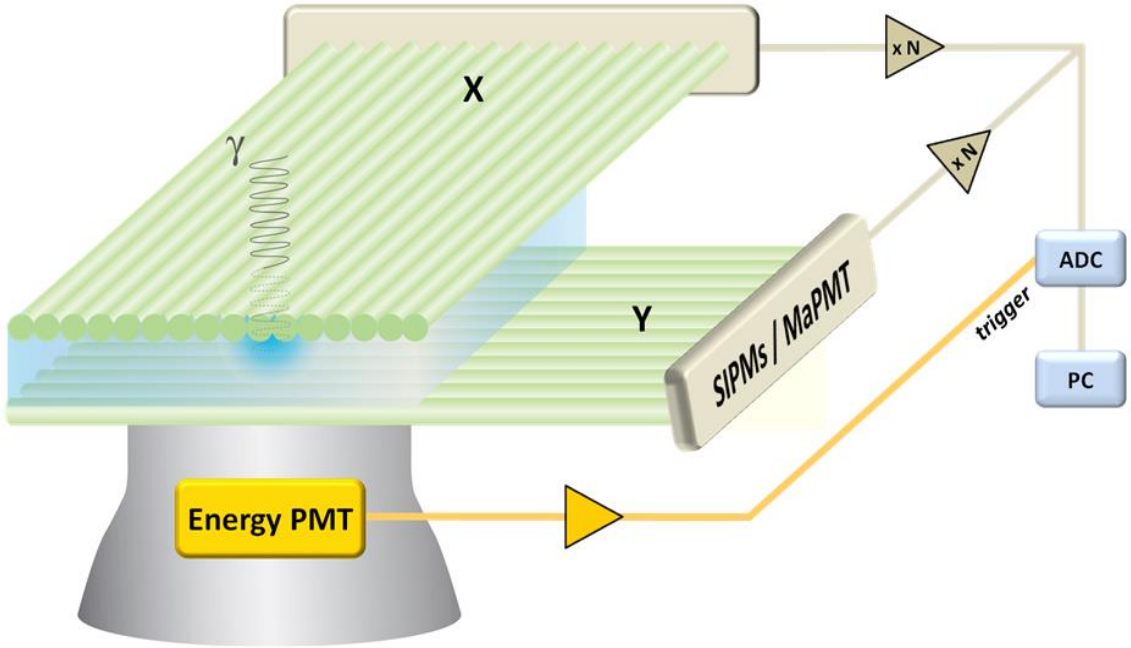
- Better spatial resolution
- Better positioning with compact portable app.-specific camera

- Earlier detection of smaller tumours
- Reduce rate of negative biopsies

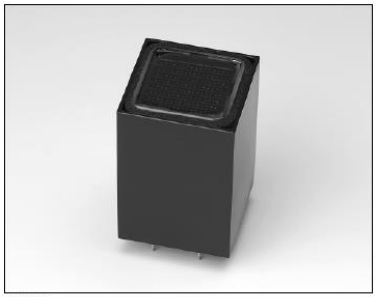
CsI(Na) WAVELENGTH-SHIFTING FIBER GAMMA CAMERA

Design

- λ-shifting fibers to read out γ-rays' position of interaction in the crystal
- SiPMs to detect light from optical fibers (also Ma-PMTs)
- E-PMT to provide energy signal and trigger for acquisition



Patent number WO2010080046-A2



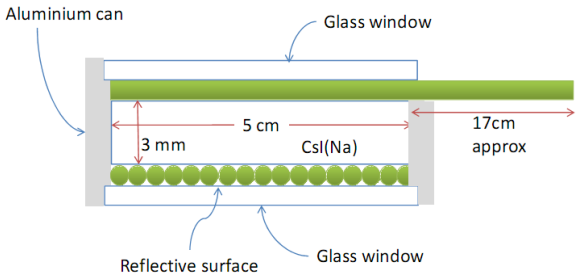
64 anode Hamamatsu Ma-PMT

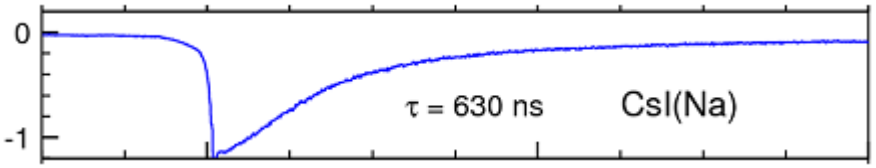
1x1 mm^2 Hamamatsu SiPM MPPC S10362-11-100U

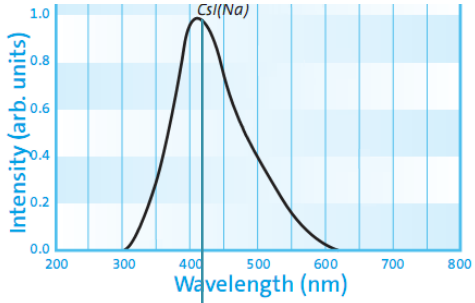
CsI(Na) WAVELENGTH-SHIFTING FIBER GAMMA CAMERA

Photon detection components and characteristics

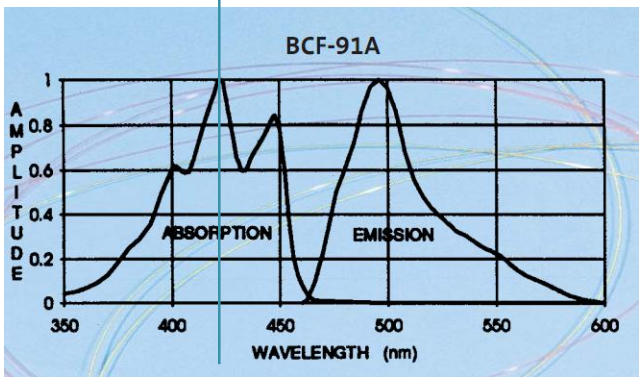
Crystal with embedded fibers:





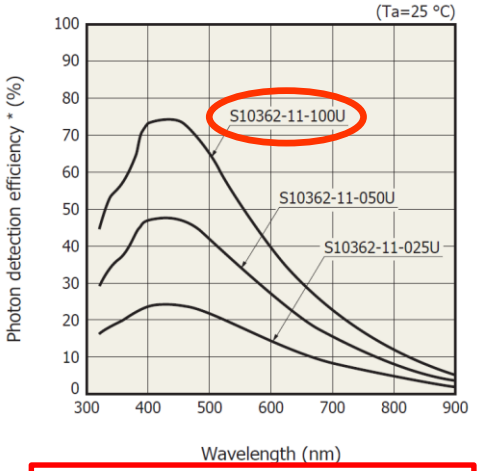


420 nm
to
494 nm



trapping efficiency > 5.6%

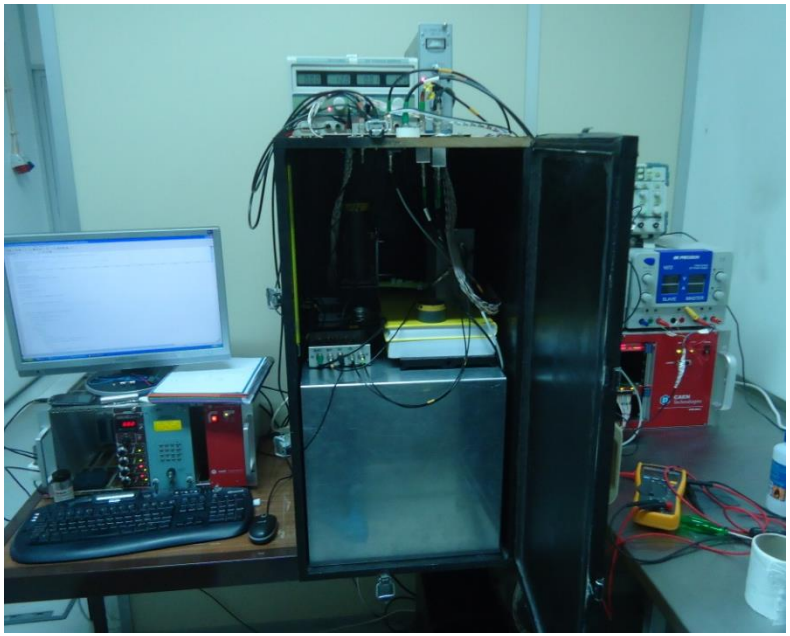
Photodetector efficiency:

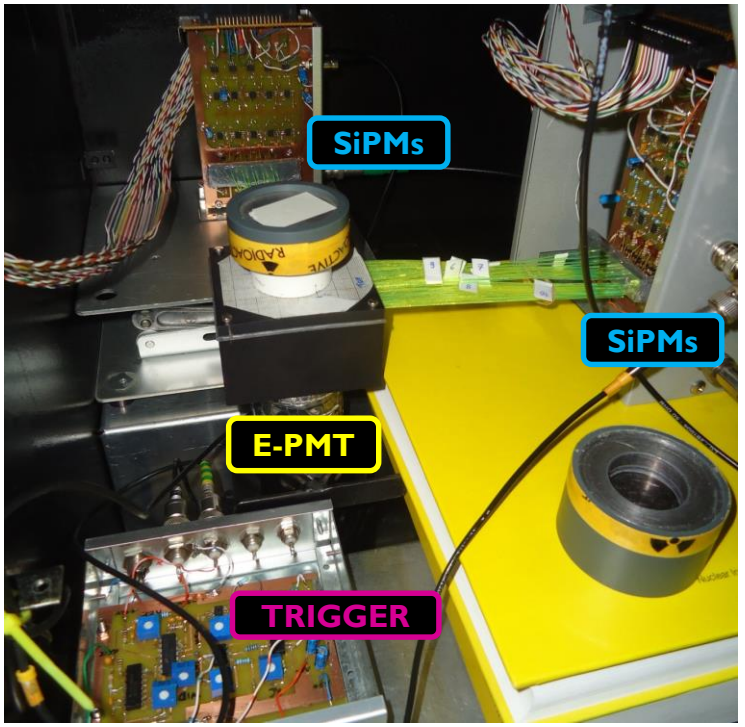


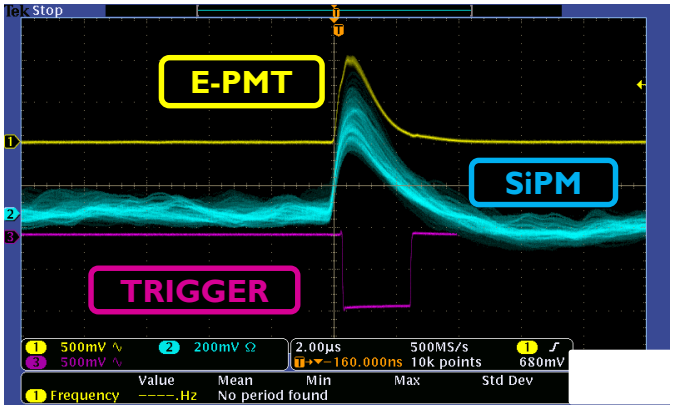
* Photon detection efficiency includes effects of crosstalk and afterpulses.

EXPERIMENTAL SETUP

Assembling and testing small prototype with 10x10 SiPMs (1cm^2)

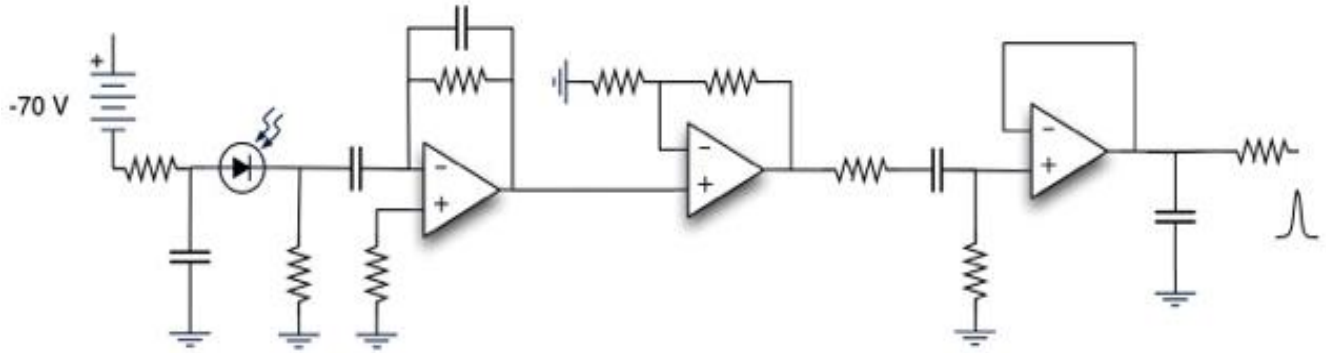




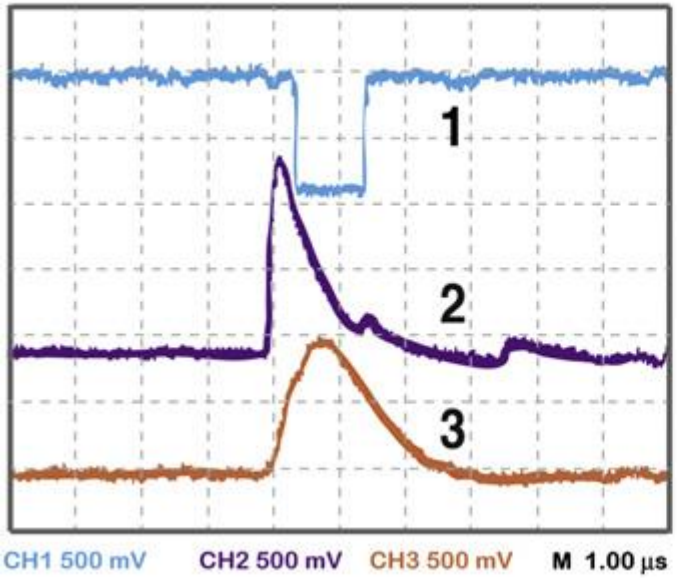


EXPERIMENTAL SETUP

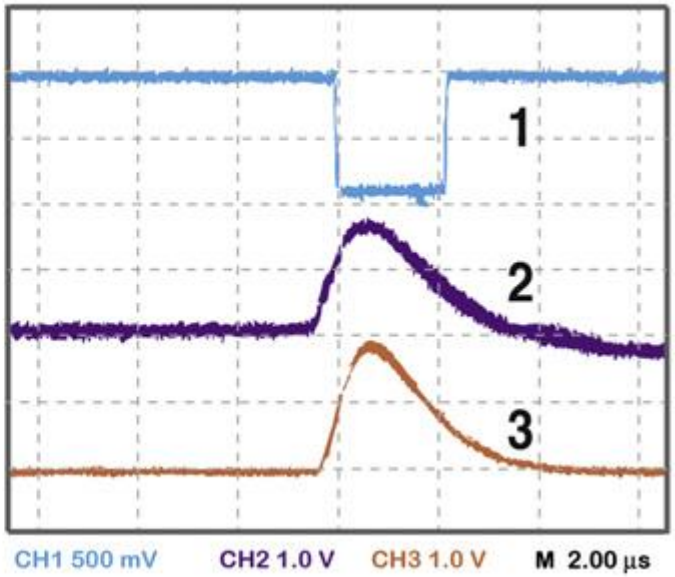
Readout electronics



With lower initial RC and no last stage

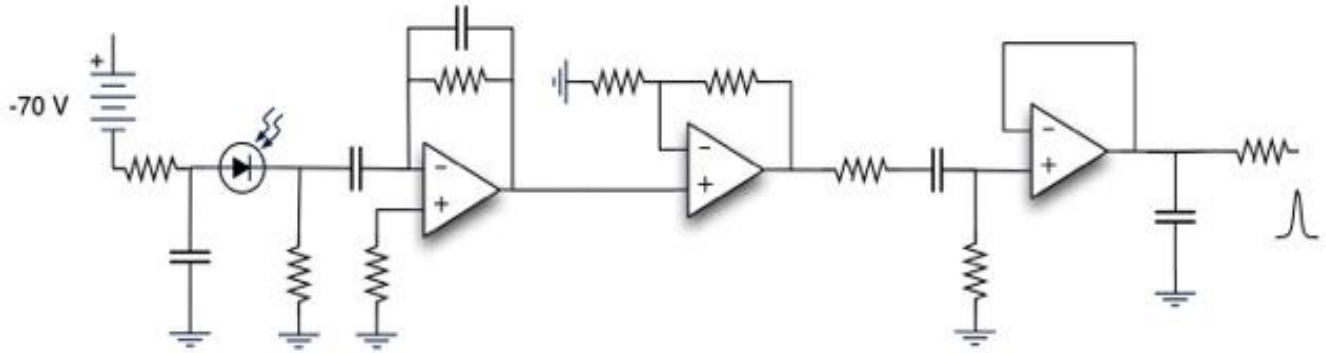


With larger initial RC and final CR–RC shaping

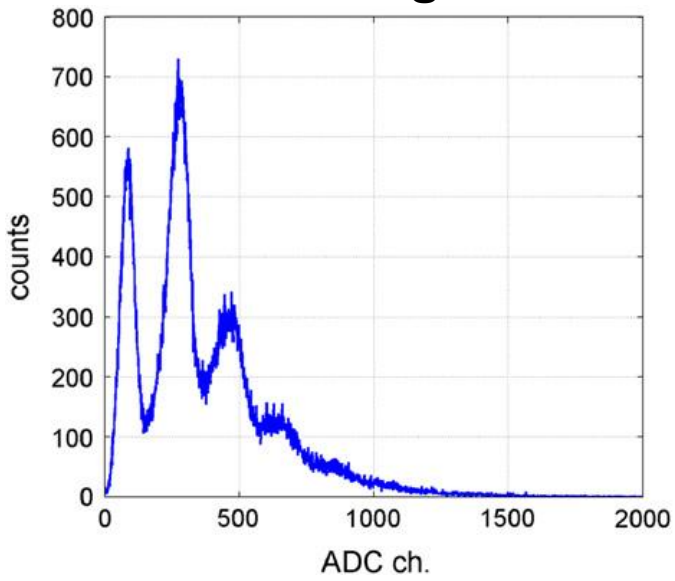


EXPERIMENTAL SETUP

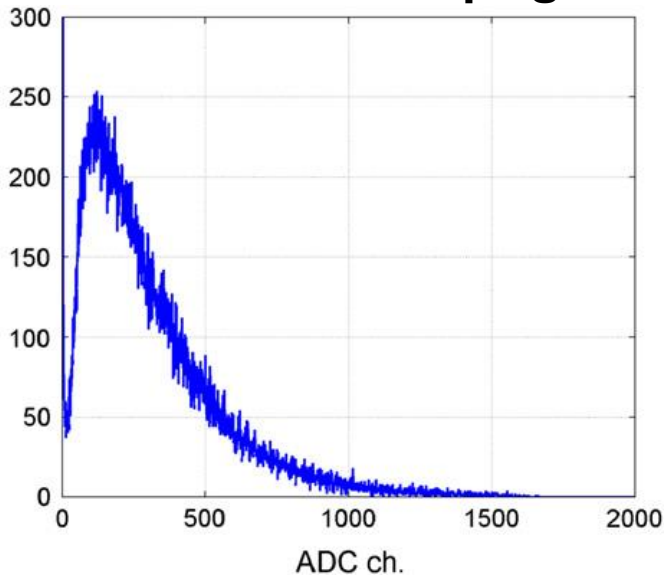
Readout electronics



With lower initial RC and no last stage

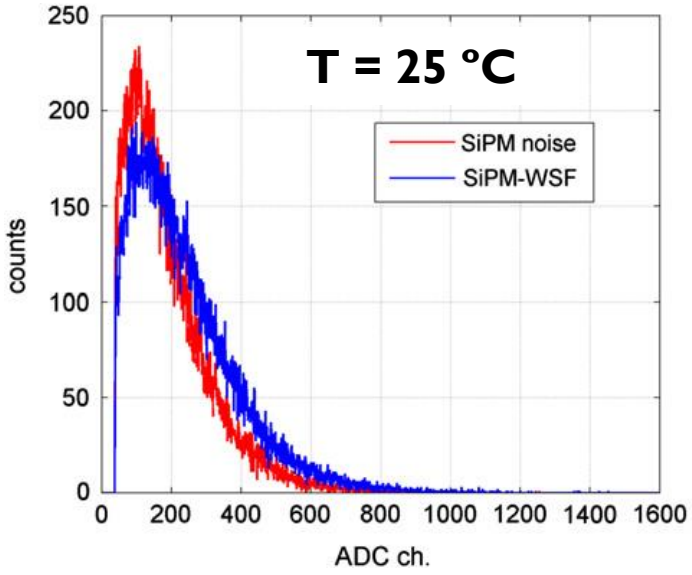


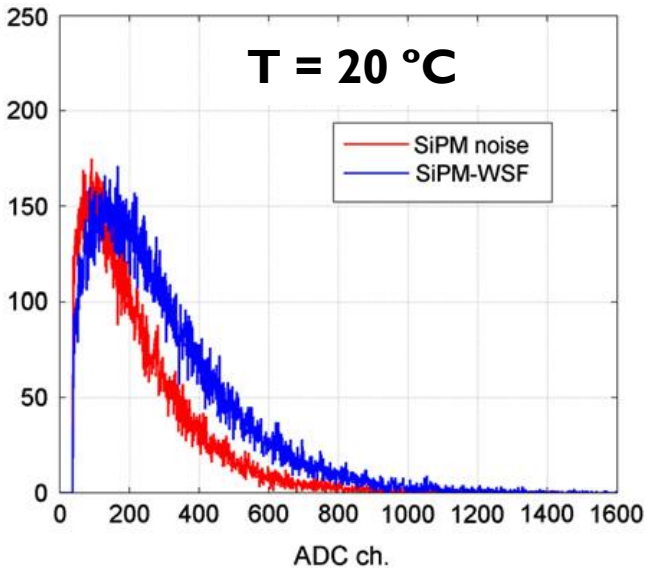
With larger initial RC and final CR–RC shaping

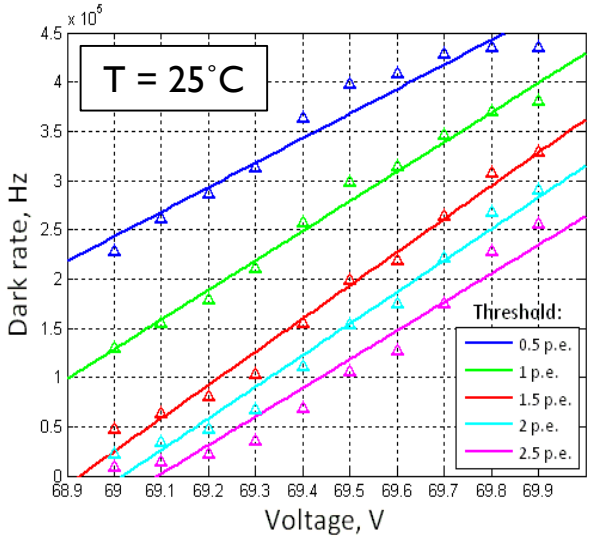


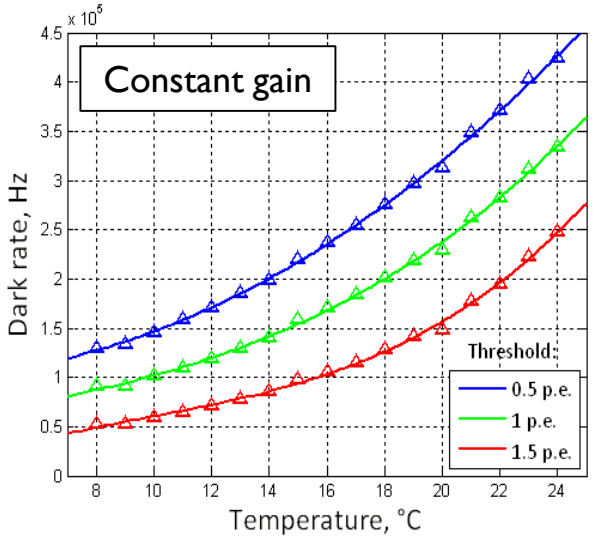
RESULTS

Temperature influence





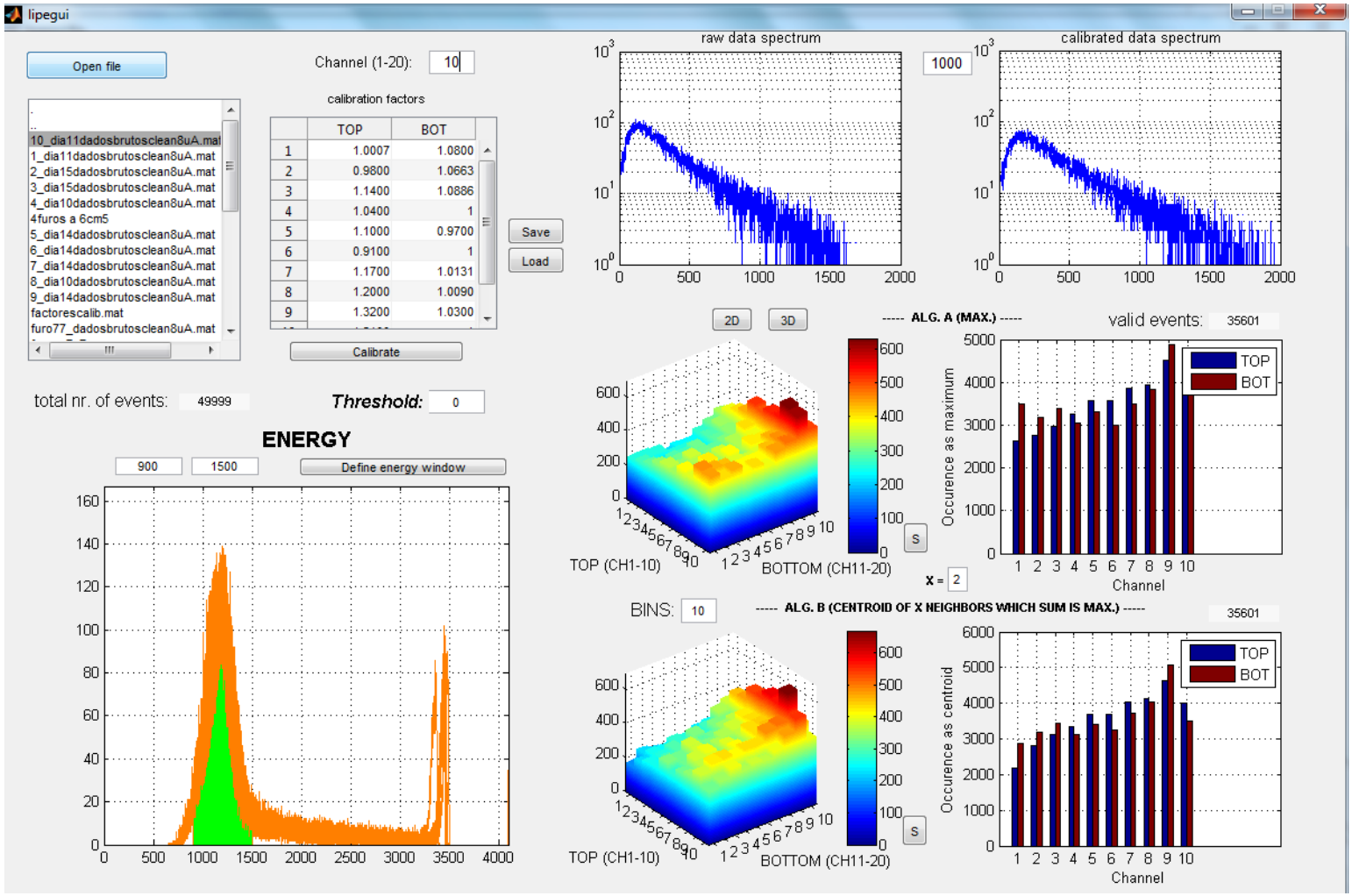




RESULTS – 10x10 SiPM PROOF-OF-CONCEPT PROTOTYPE

Imaging with ^{57}Co (122 keV)

(10, 10)

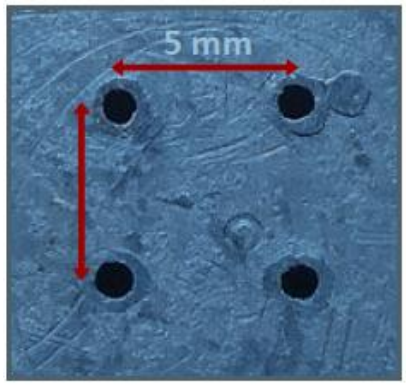


E_{res} ~ 23% FWHM

V_{bias} common to each 10 SiPM, T = 20°C

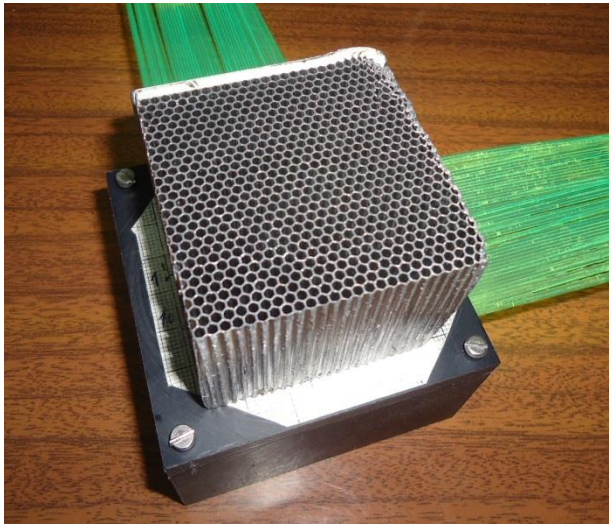
RESULTS – 10x10 SiPM PROOF-OF-CONCEPT PROTOTYPE

Imaging with ^{57}Co (122 keV) : 4-hole Pb collimator

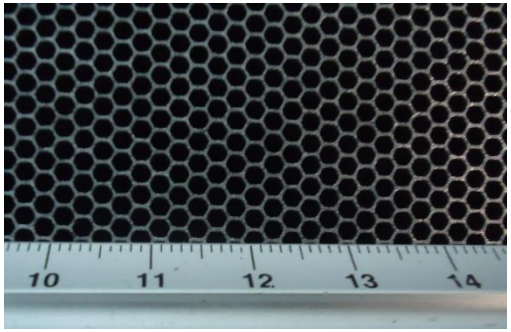


RESULTS – 10X10 SiPM PROOF-OF-CONCEPT PROTOTYPE

Imaging with ^{99m}Tc (140 keV)

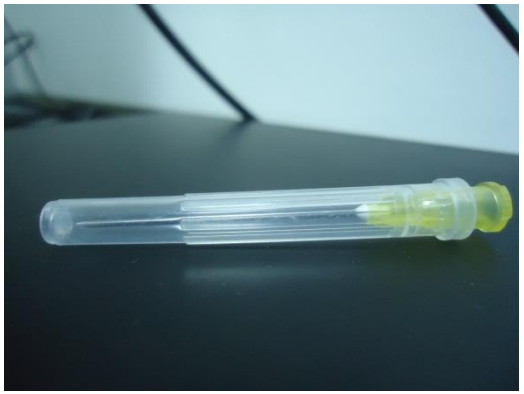


Parallel-hole collimator
from large FOV gamma camera



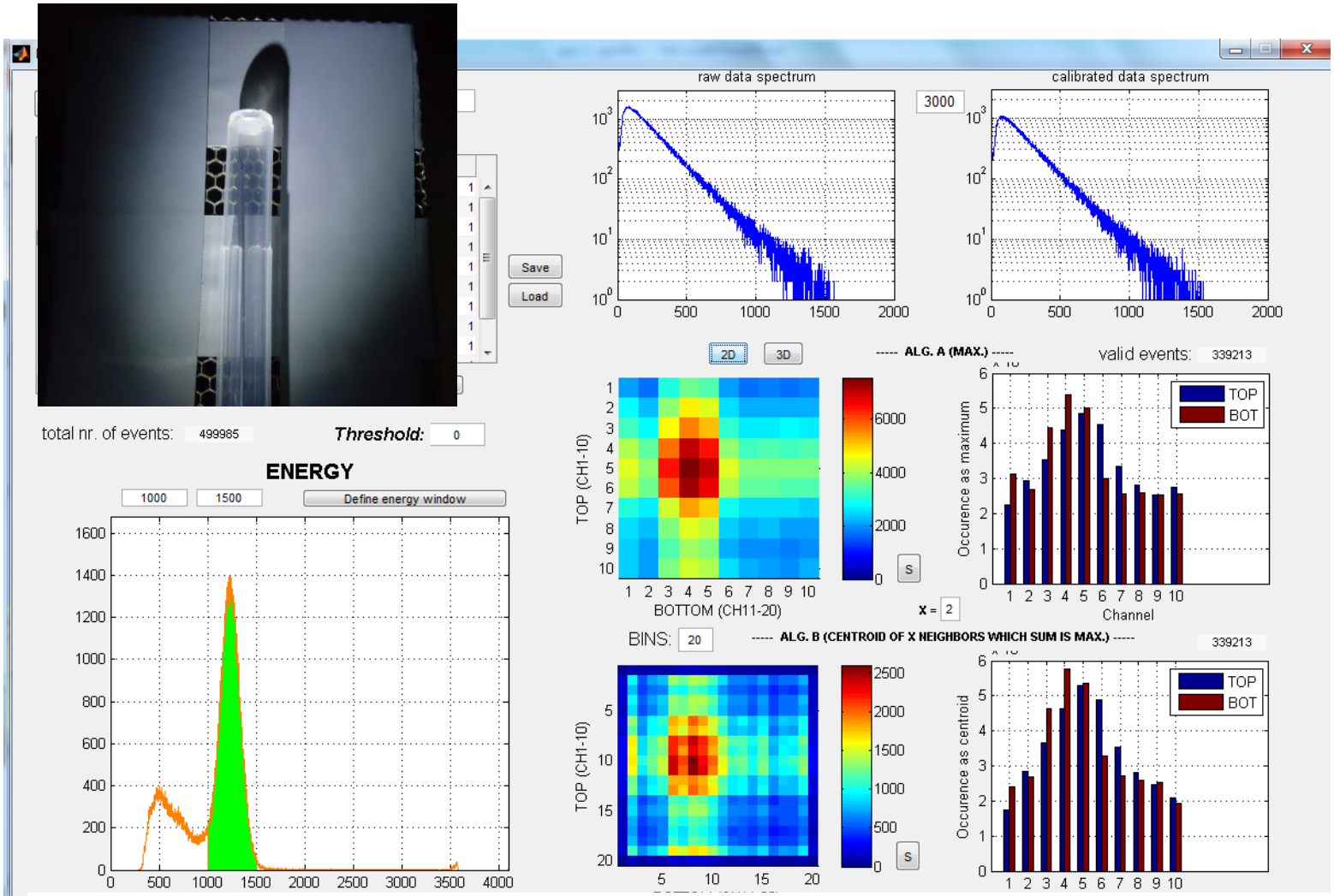
L=40 mm, d= 2 mm, t ≈ 200 μm

Syringe needle with ^{99m}Tc



RESULTS – 10x10 SiPM PROOF-OF-CONCEPT PROTOTYPE

Imaging with ^{99m}Tc (140 keV)



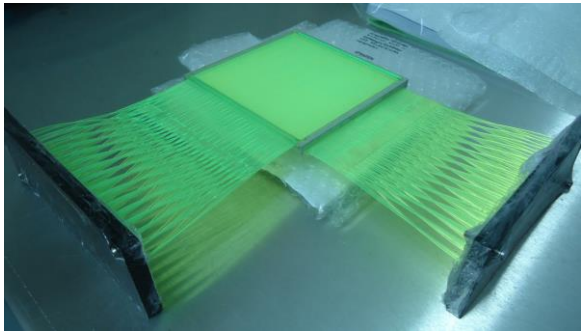
A ~ 100 uCi E_{res} ~ 20% FWHM

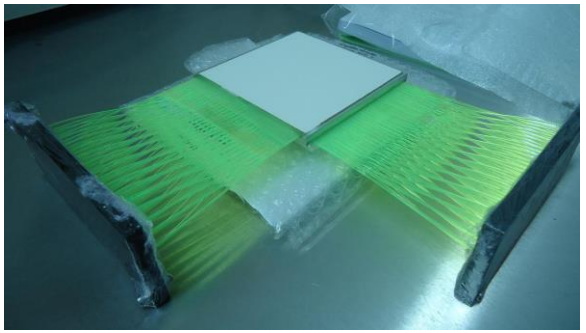
V_{bias} common to each 10 SiPM, T = 20°C

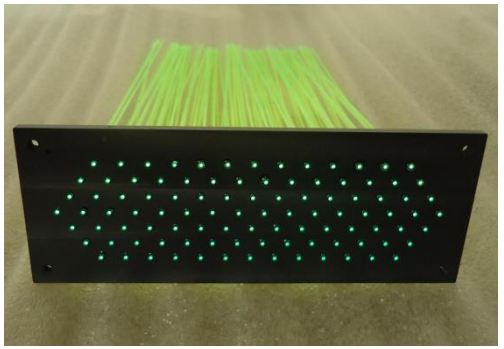
ONGOING AND FUTURE WORK

Larger prototype (10x10 cm^2 → 100x100 SiPMs):

- larger crystal assembled with fibers glued to SiPM-coupling pieces
- 4 E-PMTs to read out crystal
- biasing SiPMs in groups of 8







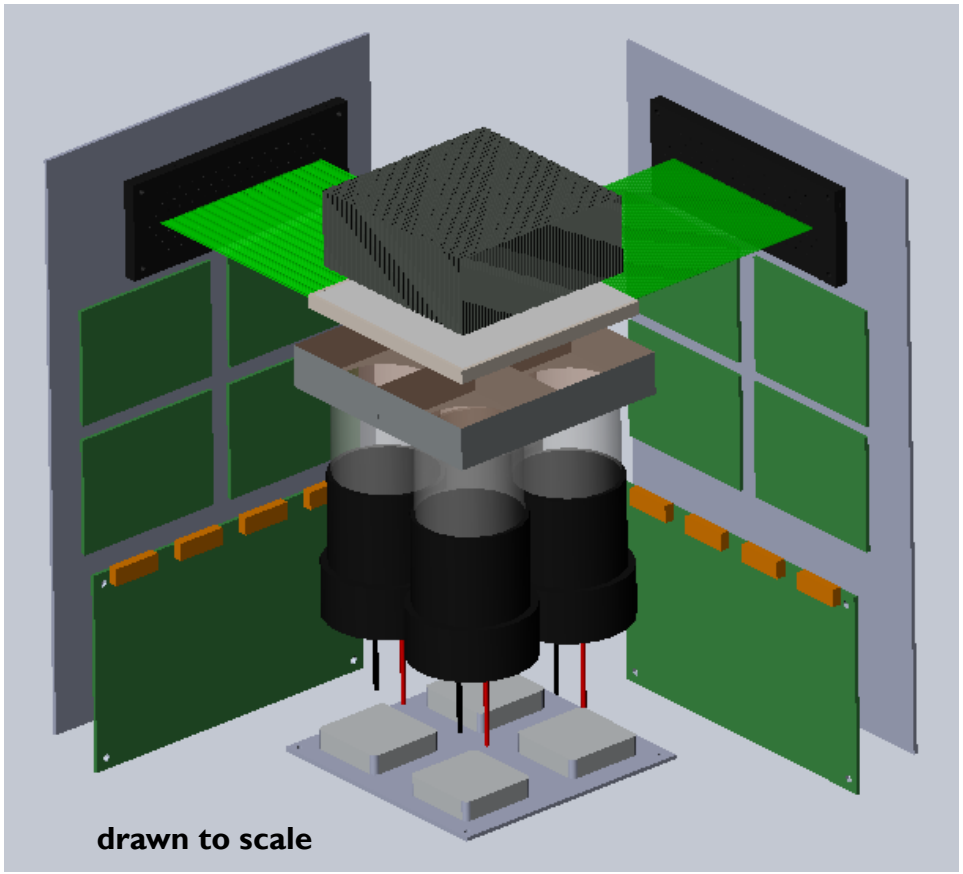
ISA Intelligent Sensing Anywhere

16 channel SiPM power supply PCB developed by ISA S.A. (Coimbra), 8 bit DAC to adjust ~ 69-73 V

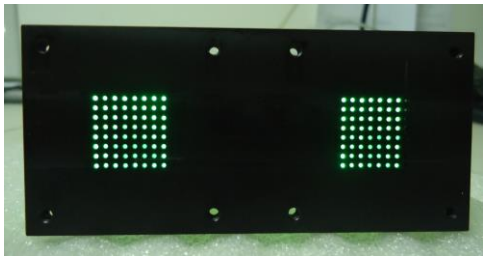
ONGOING AND FUTURE WORK

Larger prototype (10x10 cm^2 → 100x100 SiPMs):

- biasing R6236 E-PMTs with individual compact PCB HV supplies
- readout with VA32HDR14.2 chips → DAQ with X3-10M (also V_{bias} control)
- SiPM cooling
- Small animal or phantom studies, prototype characterization



drawn to scale



Hamamatsu C11152-51

THANKS FOR THE ATTENTION!

Questions?

Remarks?

Doubts?

Ideas?

Coffee? ☺

Acknowledgments:

- DRIM team @ UA (João Veloso, Carlos Azevedo, Ana Luísa, Lara, Moutinho, …)
- A.J.D. Soares (project mentor)
- Jorge Isidoro (Nuclear Medicine @ HUC)
- ISA S.A. (Rodrigo Ferreira, Miguel Ferreira)

Conventional gamma camera

Main components	Function
Collimator (Pb)	accept only γ-rays alligned with holes
Scintillation crystal, e.g. NaI(Tl)	convert γ-rays into visible light
Photodetectors, e.g. PMT	convert light into electric signals
Electronics and software	signal processing and image formation