Dual Isotope Imaging with LaBr3:Ce Crystal and H8500 PSPMT

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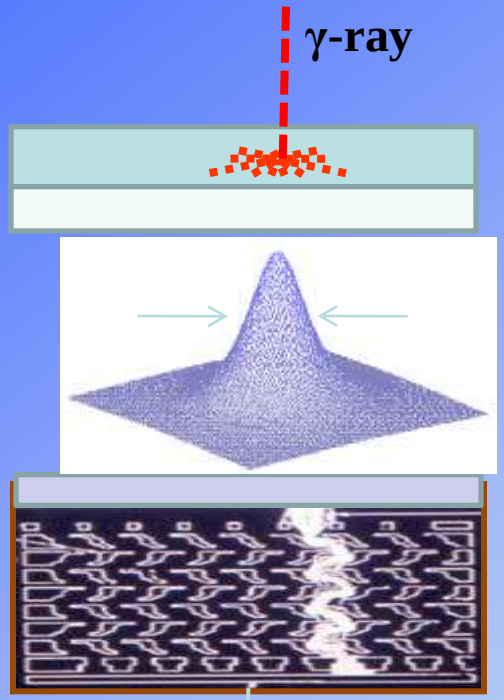
γ-ray imaging with scintillator and PSPMT

LaBr3(Ce) crystal 50 x 50 x 4.0 mm³



A single γ-ray interaction

Scintillation light PSF
FWHM = 15 mm

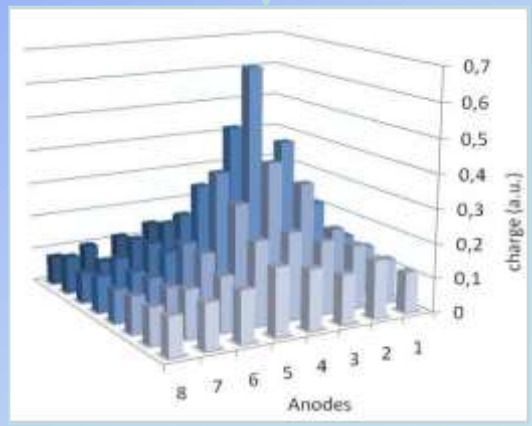
MA-PMT H8500 photodetector

Charge moltiplication channelling
(Not-electron shower),
<1.0 mm charge spread

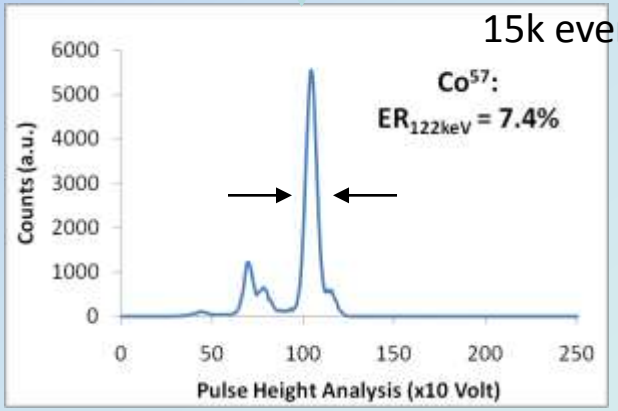
<u>Collected Charge distribution</u>

Equivalent to scintillation Light distribution

Position sensitive response

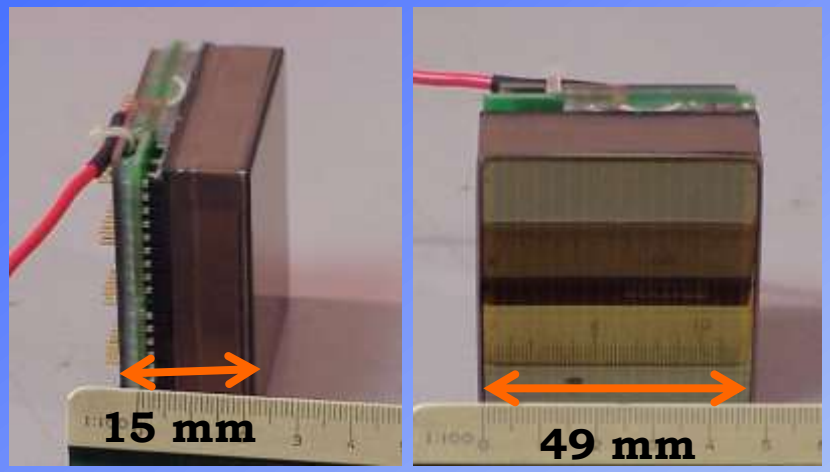


<u>Energy Spectrum</u>
15k events)



PSPMT and LaBr3 crystal characteristic

H8500C-MOD SBA Hamamatsu
Flat Panel Position sensitive PMT

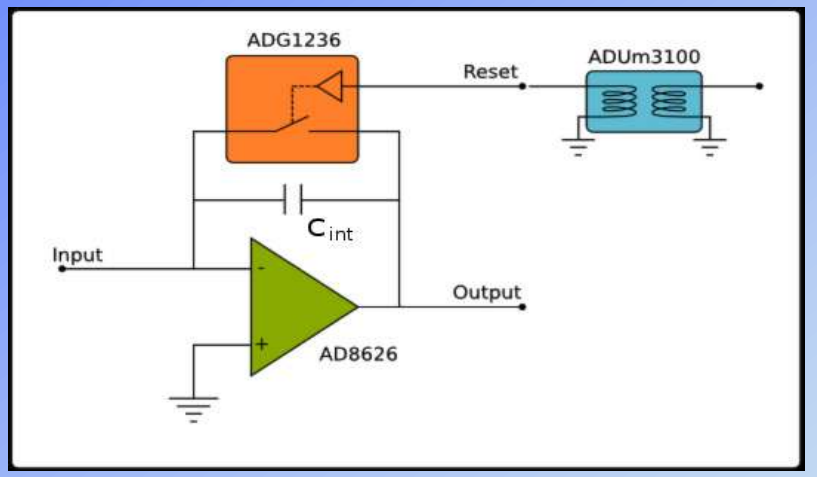


- Metal channel dynode
- QE typ. =38.7 % @ 380 nm
- Number of dinodes = 8
- Gain = 0.33 × 10^6 @ HV= -1000 V
- 8x8 anode array - 6.08 mm pitch

	Density (g/cm^3)	Light yield (*ph*/MeV)	Decay time (ns)	ΔE/E (PMT)
NaI(Tl)	3.67	41,000	230	9 % @140keV
CsI(Tl)	4.51	66,000	630	14 % @140keV
YAP	5.50	21,000	27	20 % @140keV
$LaBr_3$(Ce)	5.08	65,000	16 (97%)	**7 % @140 keV** **4 % @511 keV**
BGO	7.1	9,000	300	10 % @511 keV
LSO	7.4	30,000	40	10 % @511 keV
LYSO	7.1	25,000	42	11 % @511 keV

Electronic Readout

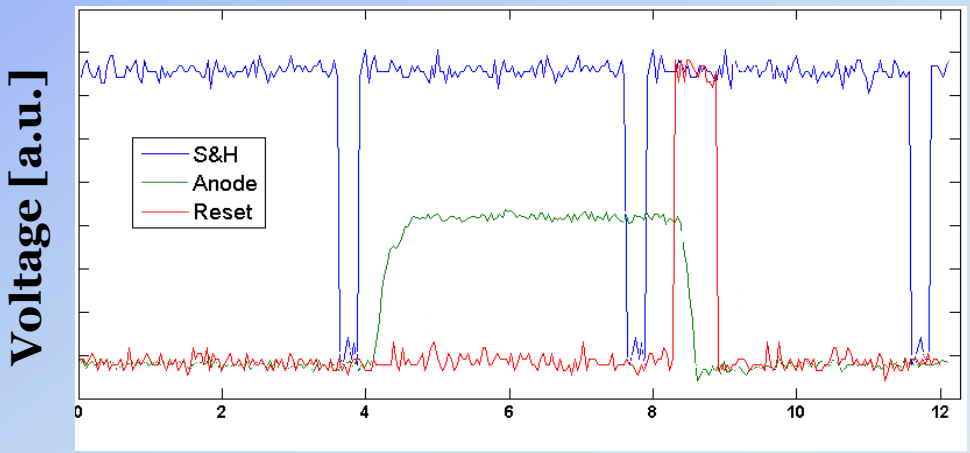
Front end and ADCs PCBs



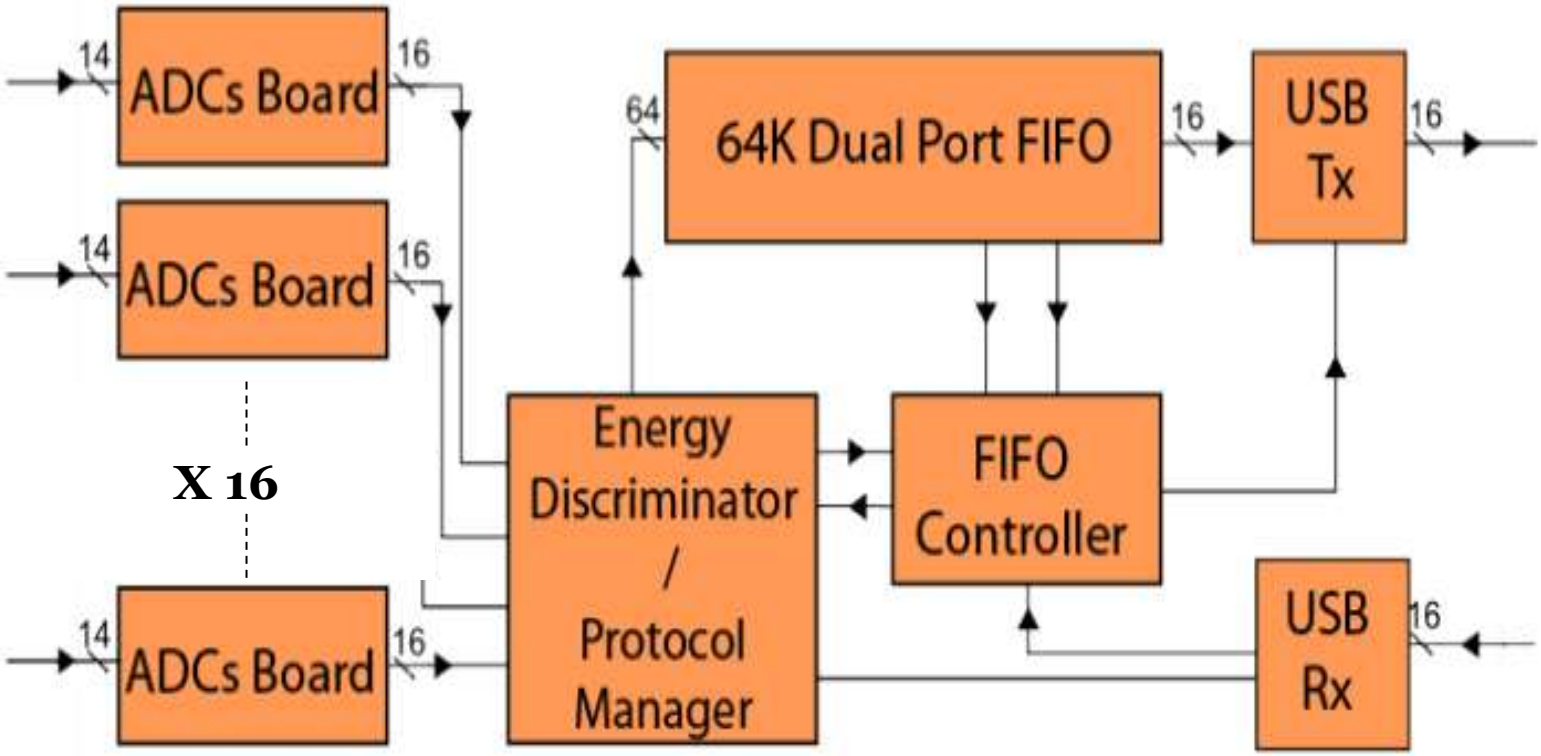
Schematic of the analog frontend

The electronic readout works without trigger:

Sampling frequency is fixed, data is transferred to the pc only if the sum of the collected value exceeds a configurable threshold



FPGA Firmware



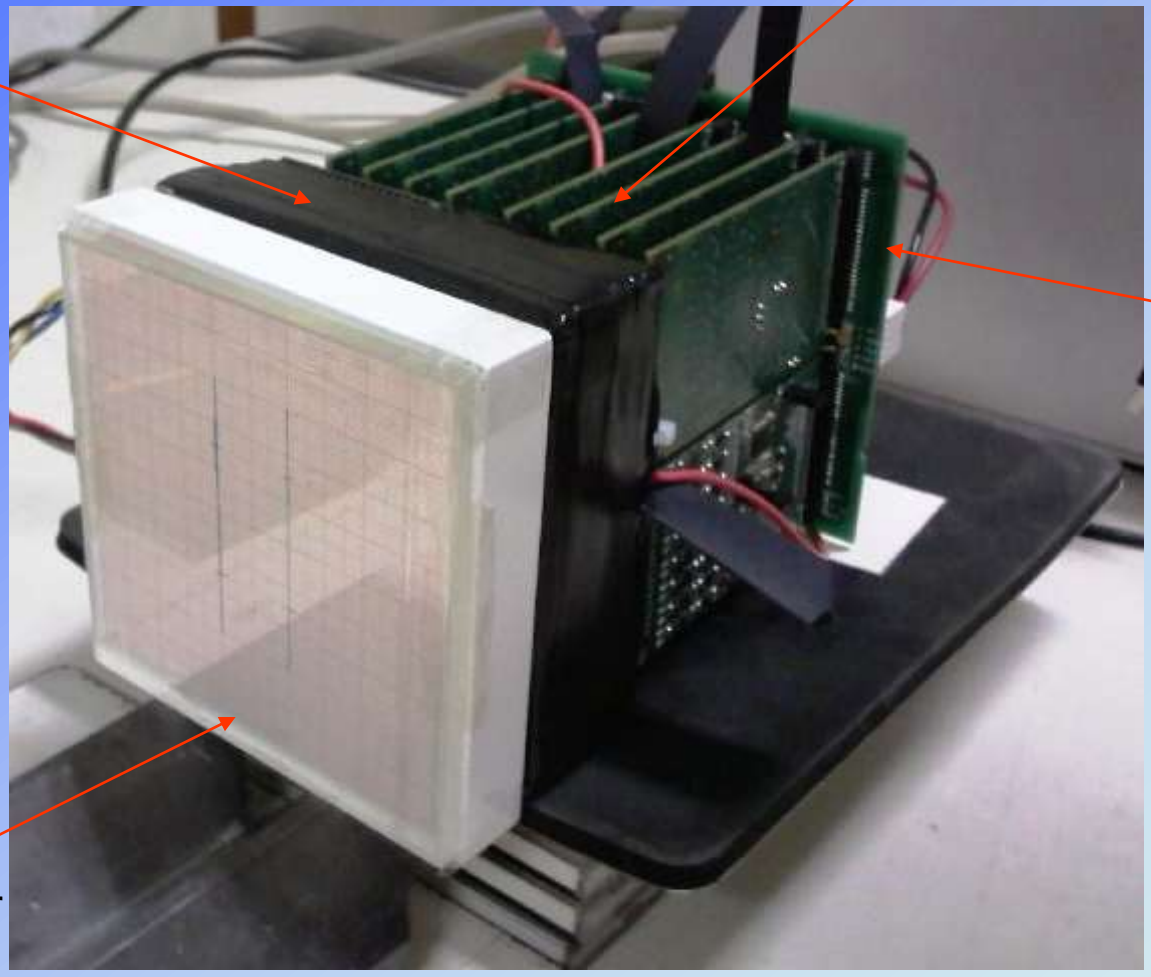
FPGA functions:

ADCs controller (14 bit resolution, up to 250 ksample/second
Energy Discriminator (on line settable threshold)
480MB/s USB 2.0 data transfer

Gamma Camera Assembly

10 cm x 10 cm LaBr3 crystal taped with four H8500 PSPMT

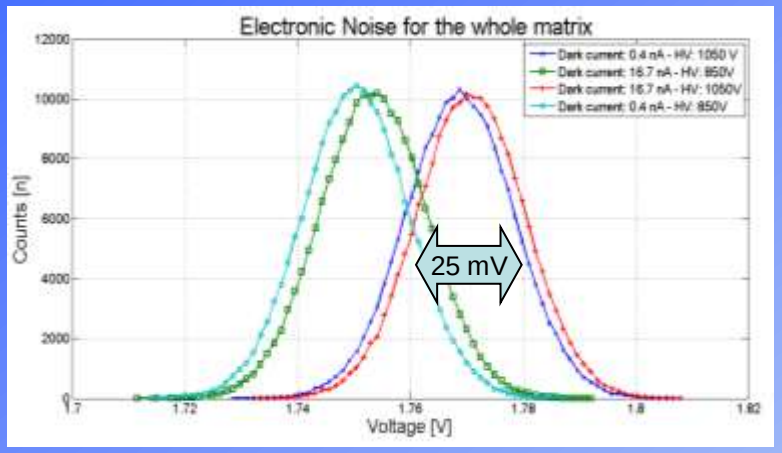
16 PCBs for frontend electronic readout

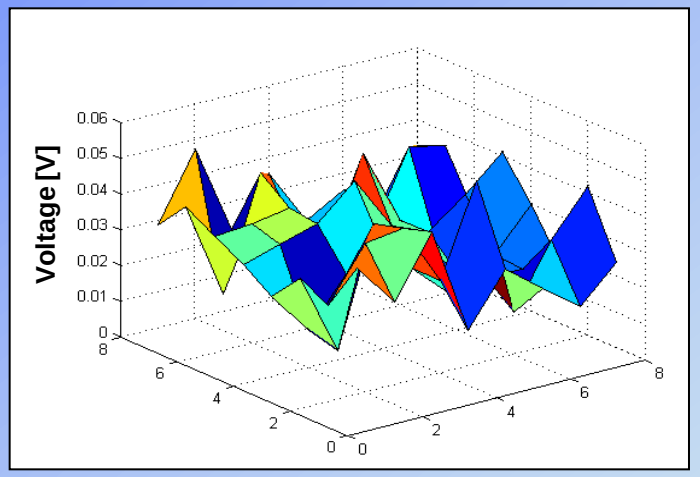


Docking PCB with FPGA logic

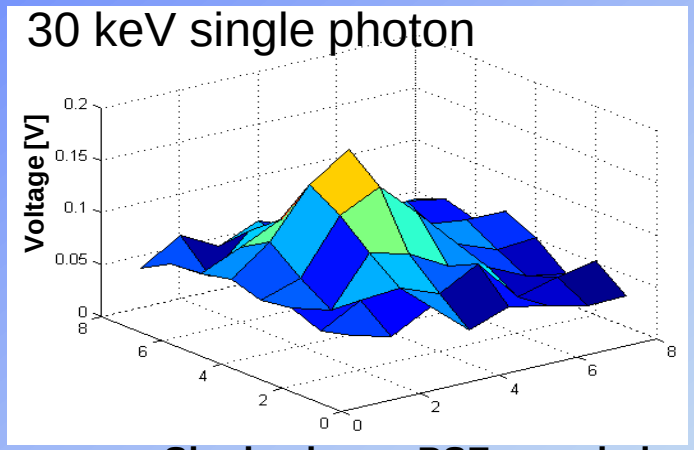
Parallel hole collimator for imaging purpose (1mm hole, 0.2mm septa, 15mm length)

Electronic Noise

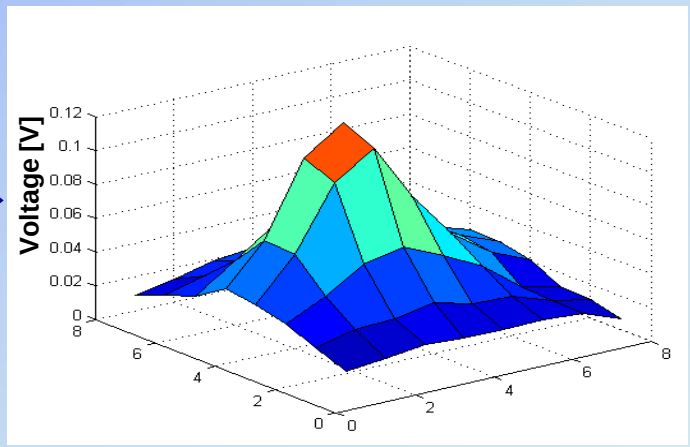




Electronic offset due to the readout system



Single charge PSF sampled by the 8x8 readout system



Corrected charge PSF

Energy Resolution

$$\left(\frac{\Delta E}{E}\right)^2 = ER_{TOT} = \sqrt{ER_{in}^2 + ER_{stat}^2 + ER_{noise}^2}$$

$ER_{intrinsic} \approx 4.4\ \%$ (Moszyriski et al. Trans.on Nuclear Science, 2008)

$$ER_{stat} = \frac{2.35}{\sqrt{0.38 \cdot 0.7 \cdot 0.14 \cdot 65000}} \approx 5\ \%$$

PSPMT Q.E.

1° dynode efficiency

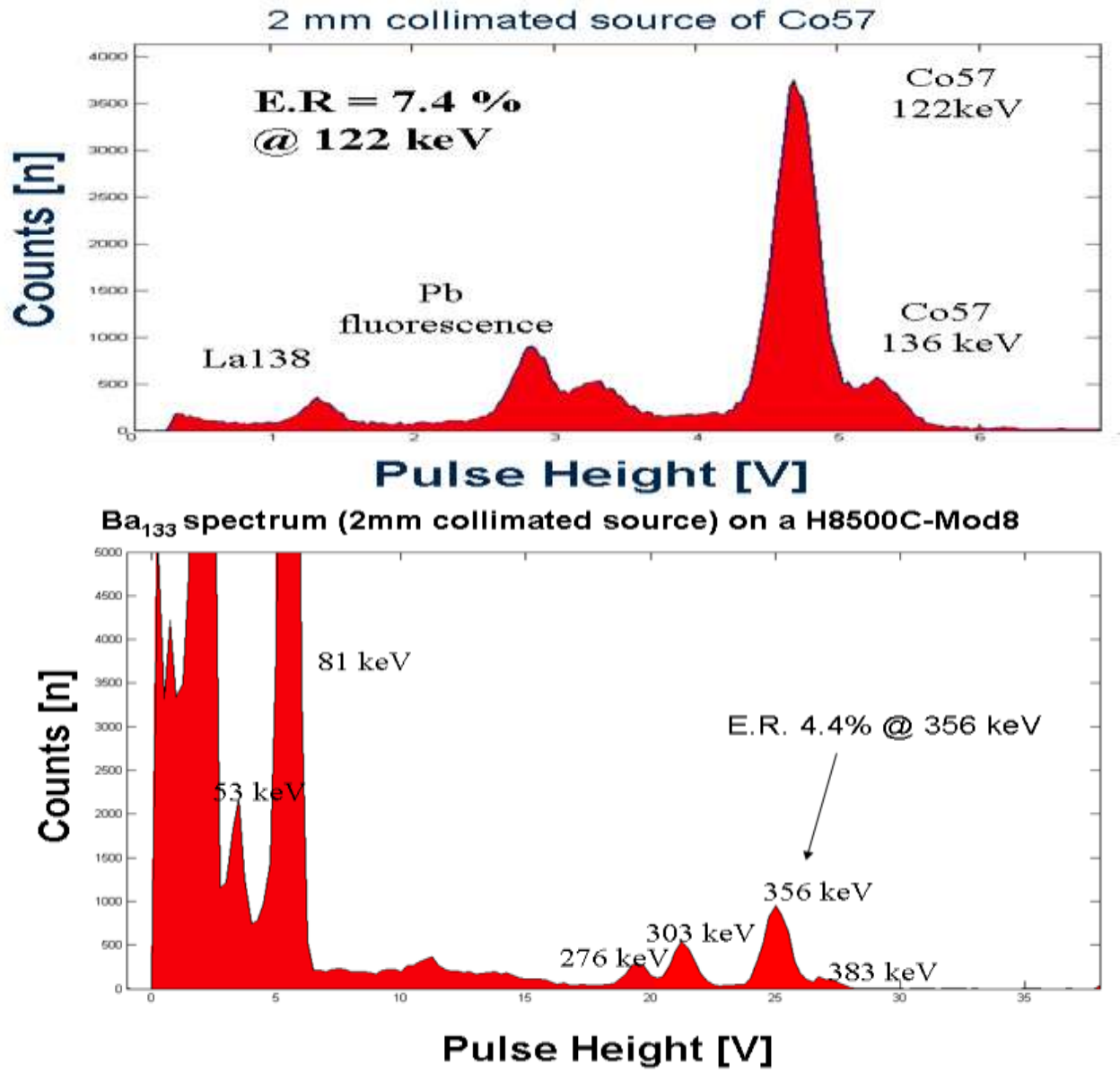
energy of Tc99m photons

ph/MeV

$ER_{noise} \approx <1\ \%$ (for a 12 V measured photopeak)

$ER_{TOT} \approx 7.2\ \%$ @ 140 keV

Energy Resolution results with collimated source



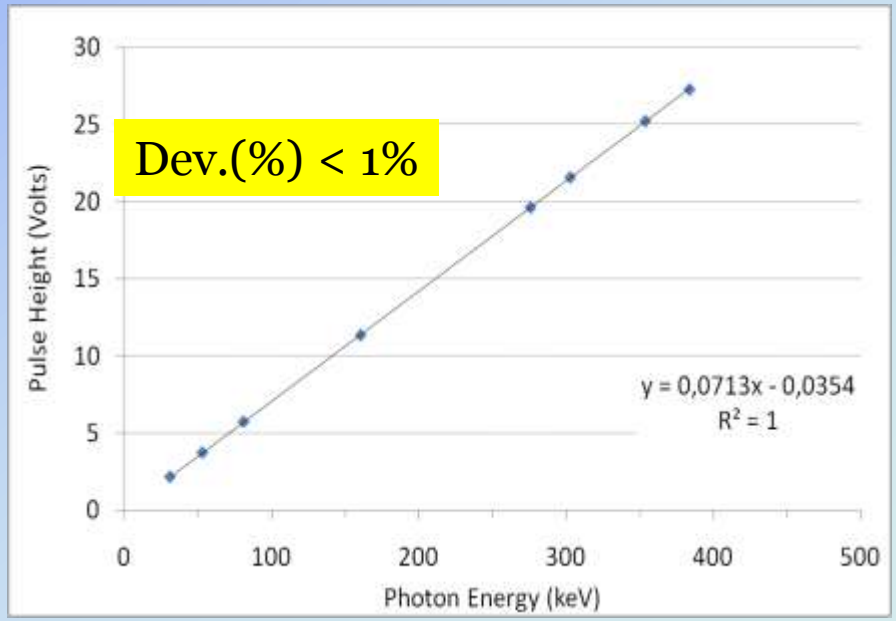
Energy Resolution results with collimated source

Ph Energy (keV)	LaBr3	NaI(Tl)
31	15.0 %	15.0 %
60	10.4 %	10.5 %
80	9.1 %	9.4 %
122	7.4 %	9.1 %
356	4.4 %	7.5 %

Comparison between E.R. obtained with PS-PMT (H8500) and multi channel readout with LaBr3 and NaI continuous crystals.

Different works demonstrate the linear response of the LaBr3 crystal in term of measured energy resolution, thanks to the very low intrinsic variation.

Energy Resolution linearity plot for LaBr3

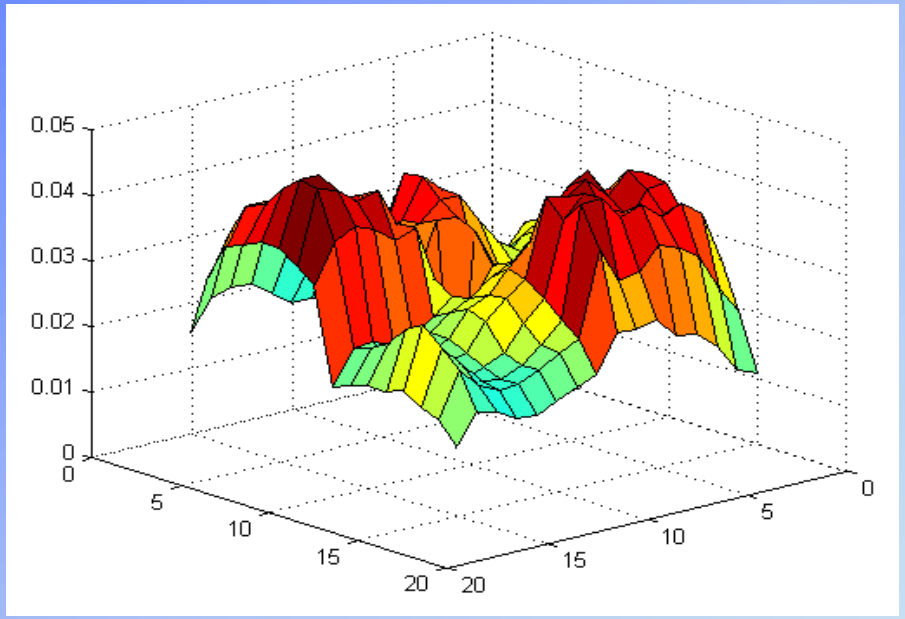


Wide area irradiation: loss of E.R. ?

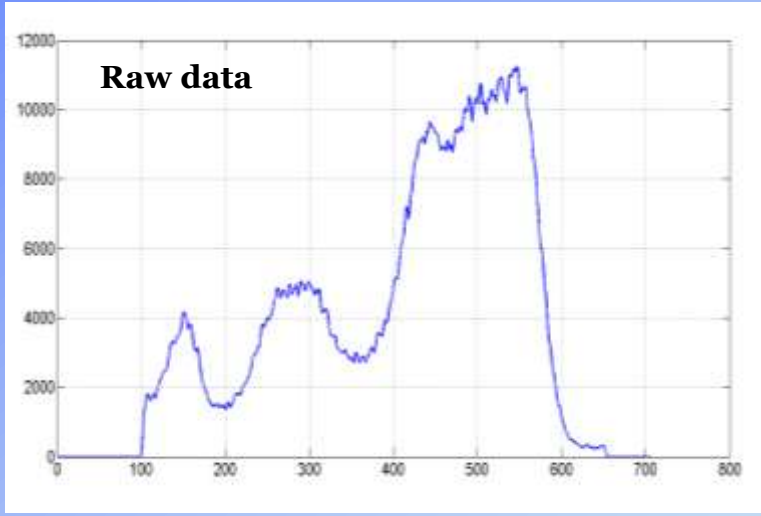
PSPMT presents different gain on the different anodes (from 1:1.5 to 1:3).

Even more, different PMT have different gains.

To avoid loss of E.R. a gain correction is needed, especially if the gamma camera is based on an array of PSPMT.

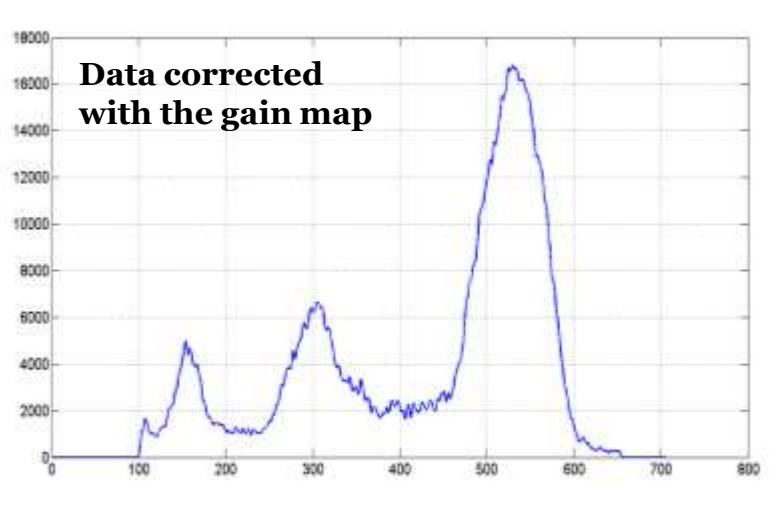


Gain map obtained with a flood field irradiation



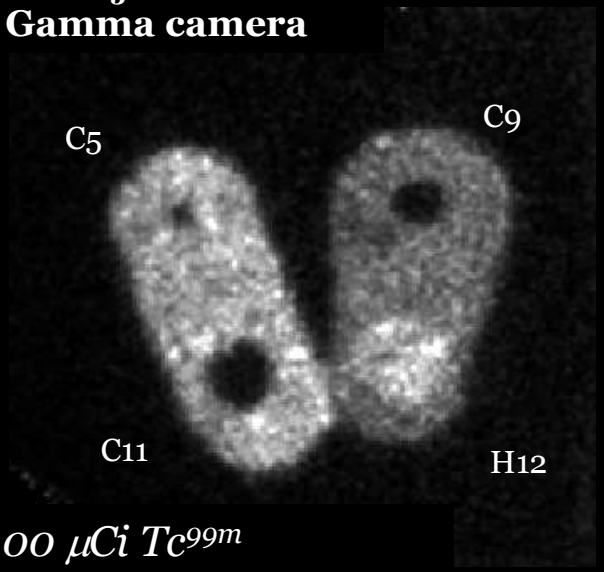
Gain

correction



Picker Phantom Results

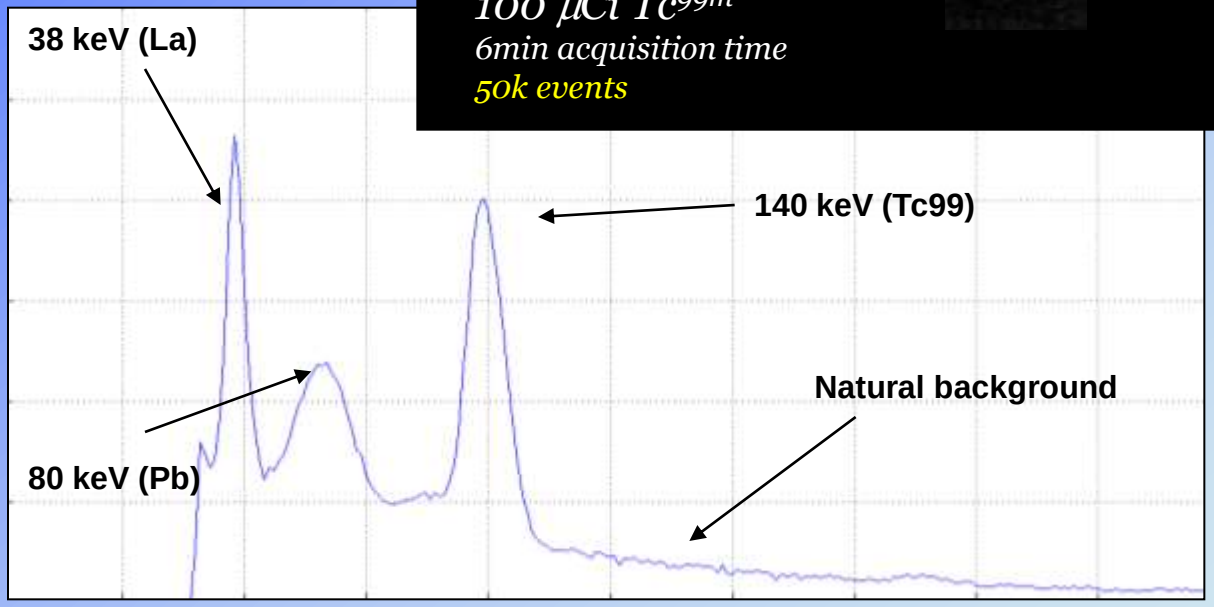
LaBr $_3$ – 10x10 cm²
Gamma camera



100 μCi Tc^{99m}
6min acquisition time
50k events

"Anger" camera
(GP collimator)

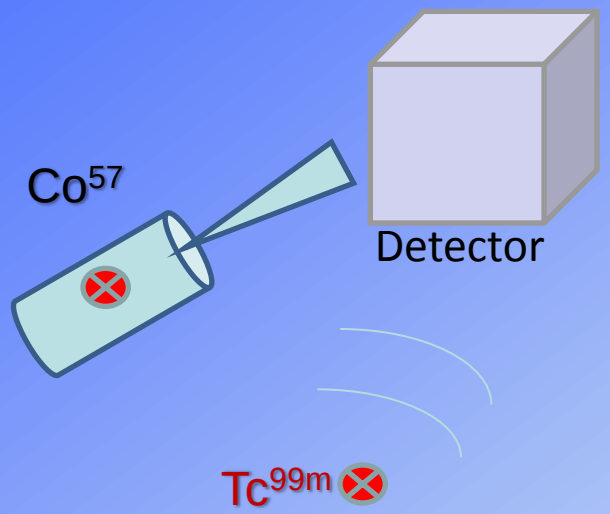
20 mCi Tc^{99m}
6 min acquisition time
15M events



Rate: 290 ev/s from Tc99m
90 ev/s from background

Dual Isotope Analysis

Measurement Setup

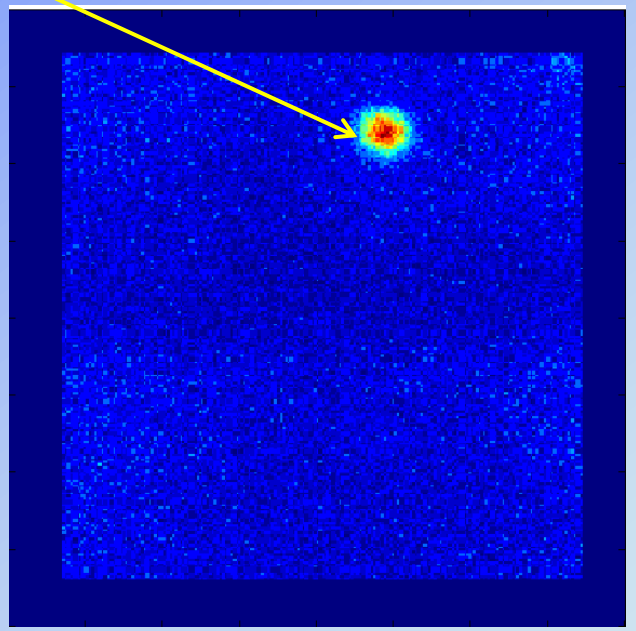


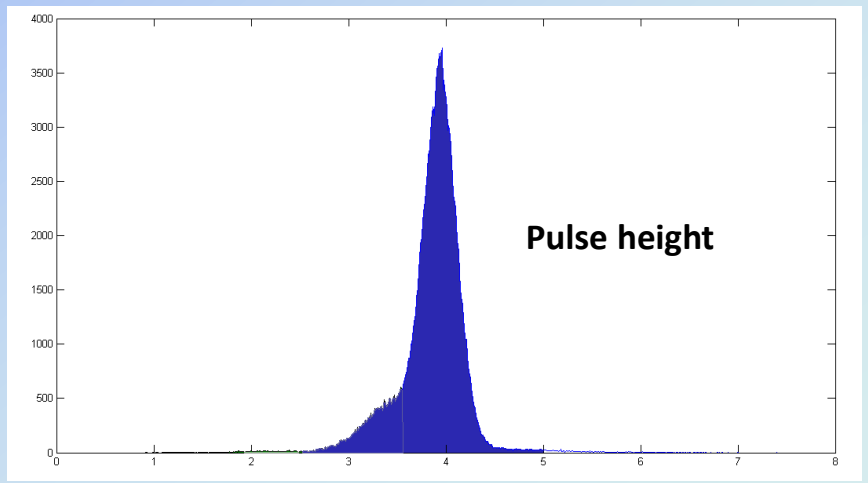
- Flood field Tc^{99m}
- 4 mm collimated Co^{57}

1:10 Co57 versus Tc99m ratio
(~13'000 of Co57 and 130'000 of Tc99m absolute detected gamma)

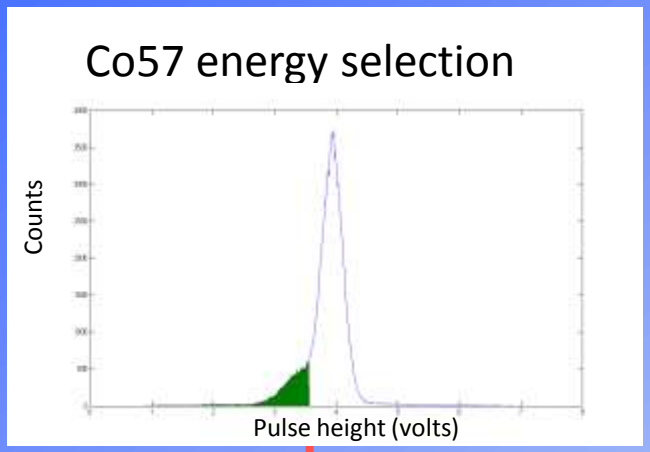
~ 4 mm diameter Co57 source

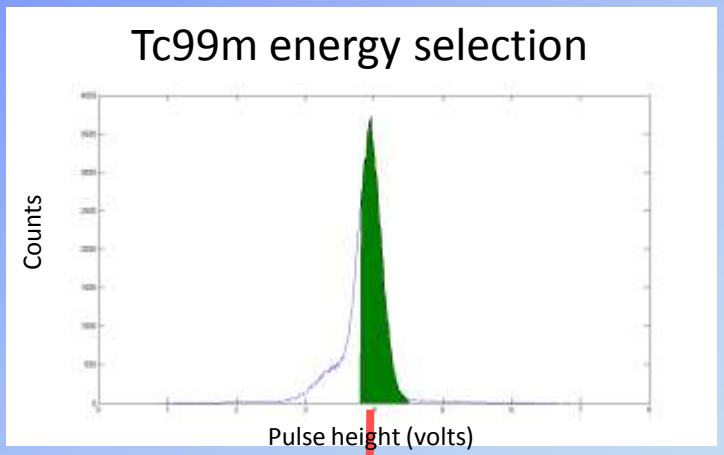
Original image
(after LUT correction)



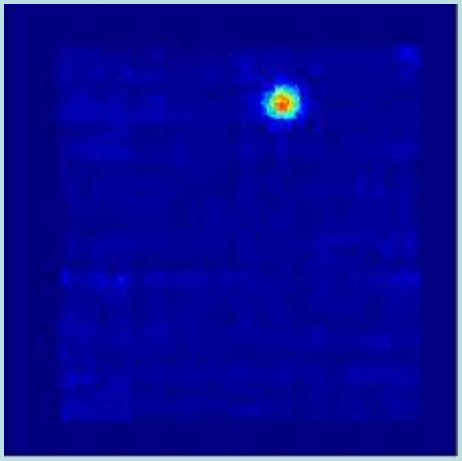


Energy Selection

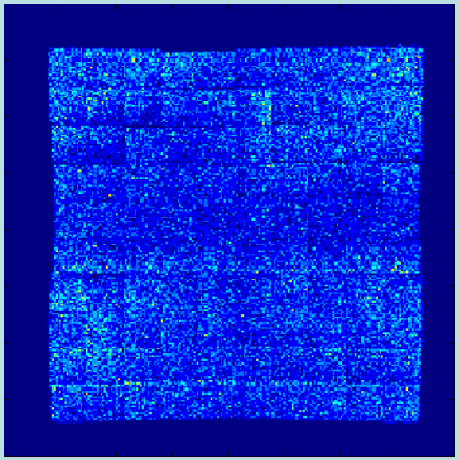




1° IMAGE: Co57 window



2° IMAGE: Tc99m window



Conclusions

• Interesting result on a 10x10cm LaBr3 crystal gamma camera for gamma-ray imaging was presented

• A low noise electronic read-out was realized, with low noise contribute to ER (<2%) and with the possibility to correct anode gain variation thanks to the single channel approach

• 7% ER at 140keV was achieved on PSPMTs array, and a dual Co57-Tc99m isotope discrimination was showed

• LaBr3 gamma camera represents a very high spatial and energy resolution gamma-ray detector (SPECT, Compton camera, probe..)

Thank you for your attention!

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