Reduction Signals Method Preserving Spatial and Temporal Capabilities

Andrea Gonzalez-Montoro, Efthymios Lamprou, Alfonso Pérez, Liczandro Hernández, Gabriel Cañizares, Marta Freire, Edwin J. Pincay, John Barrio, Sebatián Sánchez, Filomeno Sanchez, Luis F. Vidal, Jose M. Benlloch and Antonio J. Gonzalez

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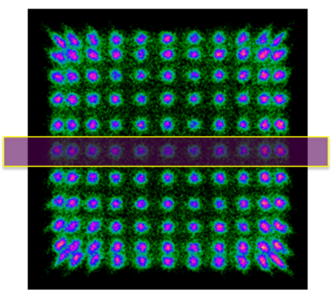
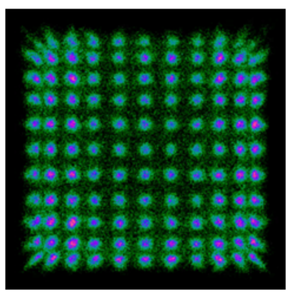
LYSO monolithic block of 50×50×15 mm^3 with black-painted lateral walls. Retro-reflectors are coupled to the entrance face bouncing back the scintillation preserving the light distribution . Also a crystal array of 32x32 elements (1.6 mm size, 6 mm height).

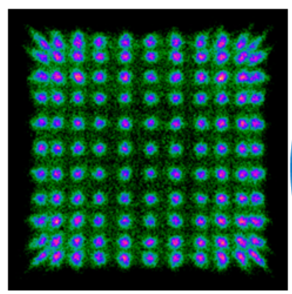
The photosensor is coupled to four different read-out schemes. Flood maps show impact positions of 11×11 collimated Na-22 sources:



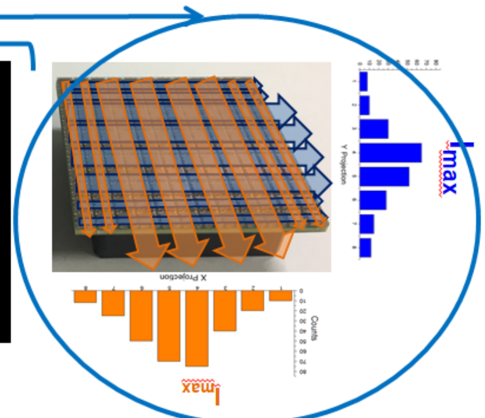
Standard 12+12 output signals read-out

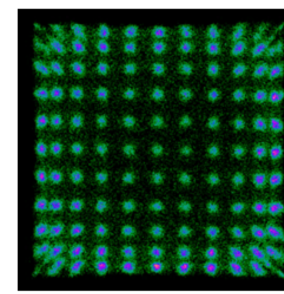


Reduction read-out 8+8: 144 → 24 → 8+8. RRE1



Reduction read-out 8+8: 144 → 64→ 8+8. RRE2





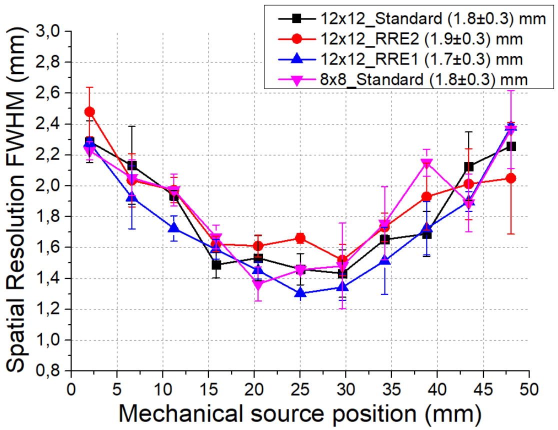
Standard 8+8 output signals read-out

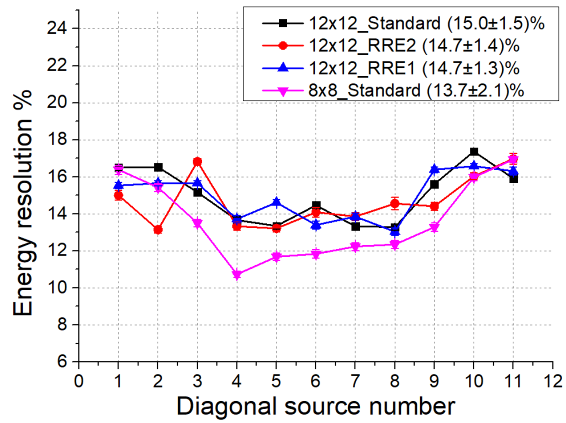
+ Arrays of 12x12 SiPM (3x3 mm^2) with 4.2 mm pitch

+ Arrays of 8x8 SiPM (6.1x6.1 mm^2) with 6.33 mm pitch

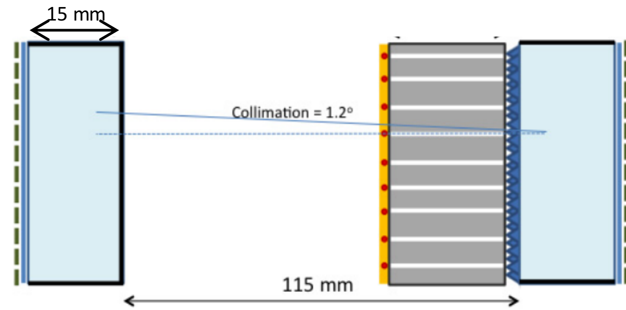
https://i3m-detectors.com

Monolithic Block:

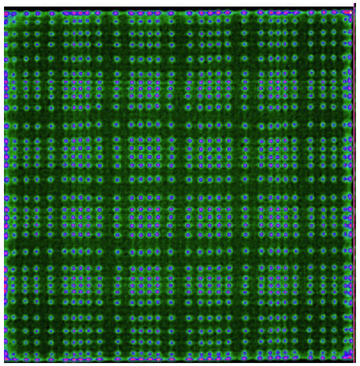


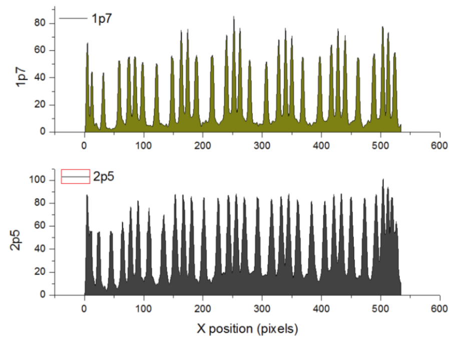


Similar results obtained for the four different tested set-ups.



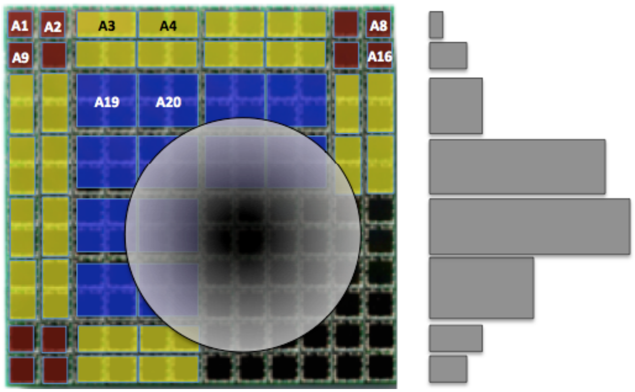
Crystal Array:





The RRE1 system resolves 1.6 mm pixels (32×32 crystal elements).

ASIC TOFPET 2: ONGOING



To match the 64 input signals, we propose using the first stage of the RRE2

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Goal:

To reduce number of readout channels, with the aim of reducing costs, related to the number of signals to process.

Without detector performance degradation. Four set-ups (two including the reduction readout system) have been tested.

Results:

Comparison with a standard 12x12 and 8x8 readout have been performed showing similar results.

The reduction system has been also tested within a crystal array with good performance.

We are implementing now its use with an ASIC.

Conclusion:

Goal achieved!

Reduction Signals Method Preserving Spatial and Temporal Capabilities

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Abstract

Our work is based on reducing the number of signals provided by a high-density photosensor array, independently of the coupled crystal type and geometry used, but preserving the detector performance, although the preferred choice is to be used with monolithic crystals for gamma ray detection. We used a monolithic LYSO crystal coupled to a 12x12 SiPM array. We can divide our readout reduction method in two parts, namely a symmetric reduction of signals matching the input signals of an ASIC with 64 channels (reduction from 144 to 64), and the one further reducing the signals to X and Y projections (from 144 to 16). We have evaluated the spatial and energy resolutions, but also the photon depth of interaction. The proposed readout allows us to resolve events in the whole volume of the monolithic block, with a reduction in the number of signals to digitize. Unprecedented results are shown in this work.

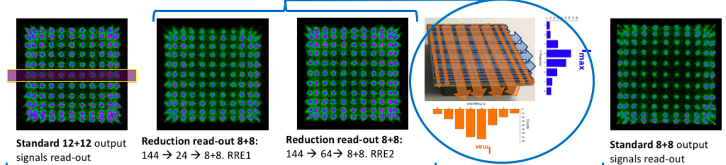
Introduction

We have followed former studies reducing number of readout channels, with the aim of reducing costs, related to the number of signals to process. We show in this work the performance of a detector block when using two reduction readout methods (providing 8+8 output signals), and its comparison with standard 12+12 and 8+8 readout systems.

Materials

LYSO monolithic block of 50×50×15 mm^3 with black-painted lateral walls. Retro-reflectors are coupled to the entrance face bouncing back the scintillation preserving the light distribution [1] [2]. Also a crystal array of 32x32 elements (1.6 mm size, 6 mm height).

The photosensor is coupled to four different read-out schemes. Flood maps show impact positions of 11×11 collimated Na-22 sources:



Standard 12+12 output signals read-out

Reduction read-out 8+8: 144 → 24 → 8+8. RRE1

Reduction read-out 8+8: 144 → 64 → 8+8. RRE2

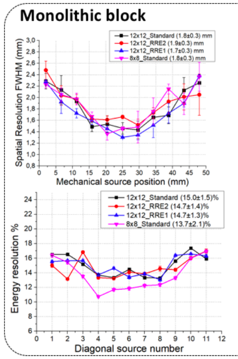
Standard 8+8 output signals read-out

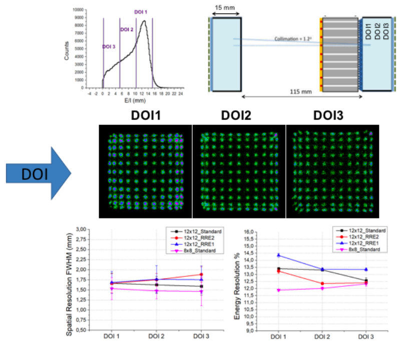
+ Arrays of 12x12 SiPM (3x3 mm^2) with 4.2 mm pitch

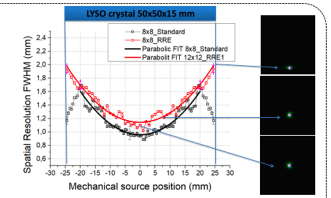
+ Arrays of 8x8 SiPM (6.1x6.1 mm^2) with 6.33 mm pitch

Results

Monolithic block







Spatial resolution: A collimated ^{22}Na source displaced in 0.5 mm steps shows that the proposed system allows us to resolve events at 0.3 mm from the crystal edge.

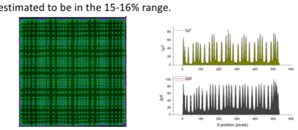
Energy resolution: Comparable results obtained for all cases. The active area when using 12x12 SiPM is 52% whereas in the 8x8 SiPM array is 92%.

DOI resolution: Preserved with (through lateral incidence measurements) a value of 3.7 ±0.2 mm. DOI correction seems feasible.

Crystal Array

Reduction read-out 8+8

The system resolves 1.6 mm pixels (32×32 crystal elements). A peak-to-valley ratio of about 10 determined. The energy resolution estimated to be in the 15-16% range.



ASIC TOFPET2

The ASIC TORPET2 exhibits high timing capabilities. Coincidence Time Resolution (CTR) → 200 ps [3] (FWHM, one-to-one coupling).

See oral presentation #561

To match the 64 input signals, we propose using the first stage of the RRE2: merging photosensor elements of the array at its center from four to one, and at its laterals from two to one, and thus leaving the corners with their original sampling. This allows one to reduce the 144 photosensor signals to only 64. Analysis of data is undergoing.

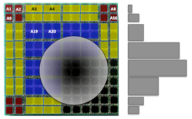


Figure 2. Reduction from the 144 signals to 64 by merging some at the laterals and centers.

Summary

- Two readout electronics only providing 8+8 output signals without limiting the detector performance. Tested it with both monolithic and crystal array scintillators.
- We obtained an energy resolution of 12.8 %, an average spatial resolution (100% crystal) of 1.9 mm, together with a DOI resolution as good as 3.7 mm. Allows to resolve sources in the 1 mm edge of the proposed crystal reducing the edge effect that typically rejects such events.
- The approach that less reduces the signals from 144 to 64, but matching ASIC inputs, has been developed and it is currently under analysis.

References:

[1] A. Gonzalez-Montoro, et al., TRPMS 1, 229 (2017).
[2] A.V.Stolin , et al., TNS 61, 2433 (2014).
[3] E. Lamprou, et al, NIMA 2017

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