On coupling Silicon Photomultipliers to novel scintillation detectors

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erc
European Research Council
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KU LEUVEN

DTU Nutech
Center for Nuclear Technologies

nks
Nordic nuclear safety research

Gamma-ray spectroscopy devices:

HPGe detectors at student lab,

Aarhus University, Denmark

HAGAR NaI detector,

iThemba LABS, South Africa

$CeBr_3$ detector,

KU Leuven, Belgium

$LaBr_3$(Ce) scintillators

Resolution **2.7-3.3%** for 662 keV gamma rays from Cs

Density **5.07 g/cm^3**

Internal contamination problems due to Lanthanum

Patented by Saint Gobain (though also sold through Canberra, ORTEC..)

Price ~ **9 000 EUR** per scintillator for 1.5"*1.5" model (in 2015)

$CeBr_3$ scintillators

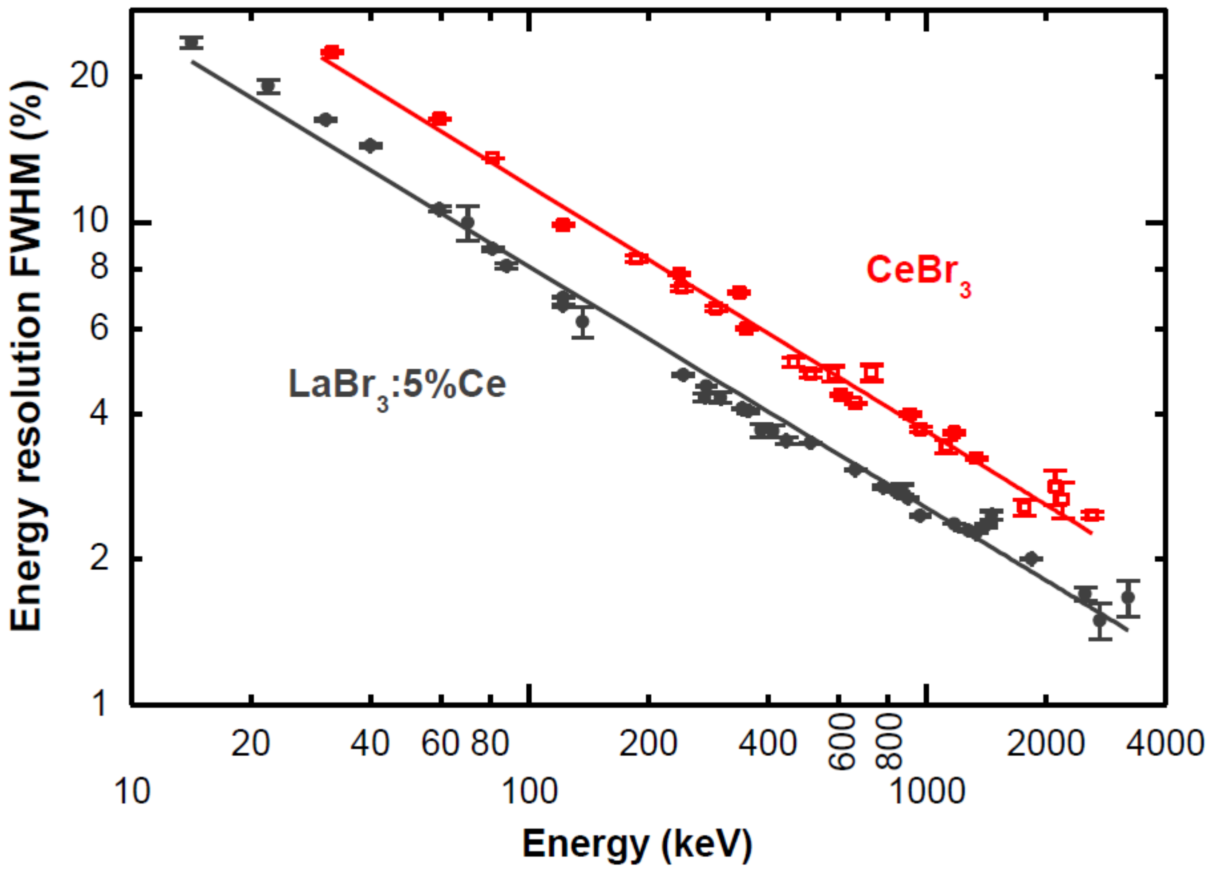
Resolution **3.8-4.0%** for 662 keV gamma rays from Cs

Density **5.19 g/cm^3**

No internal background (apart from ^{227}Ac contamination)

Produced by Scionix Holland, RMD, Kinheng Crystal..

Price ~ **4 500 EUR** per scintillator for 1.5"*1.5" model (in 2015)



F. G. A. Quarati *et al.*, NIM A 729, (2013), 596 - 604

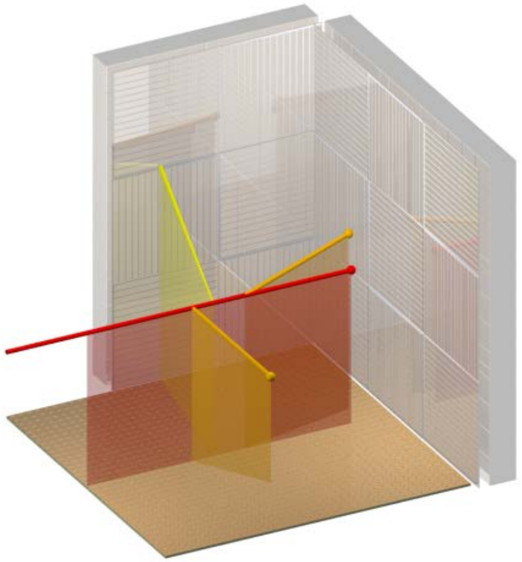
Increasing interest for using $LaBr_3$ and $CeBr_3$ in environmental applications:

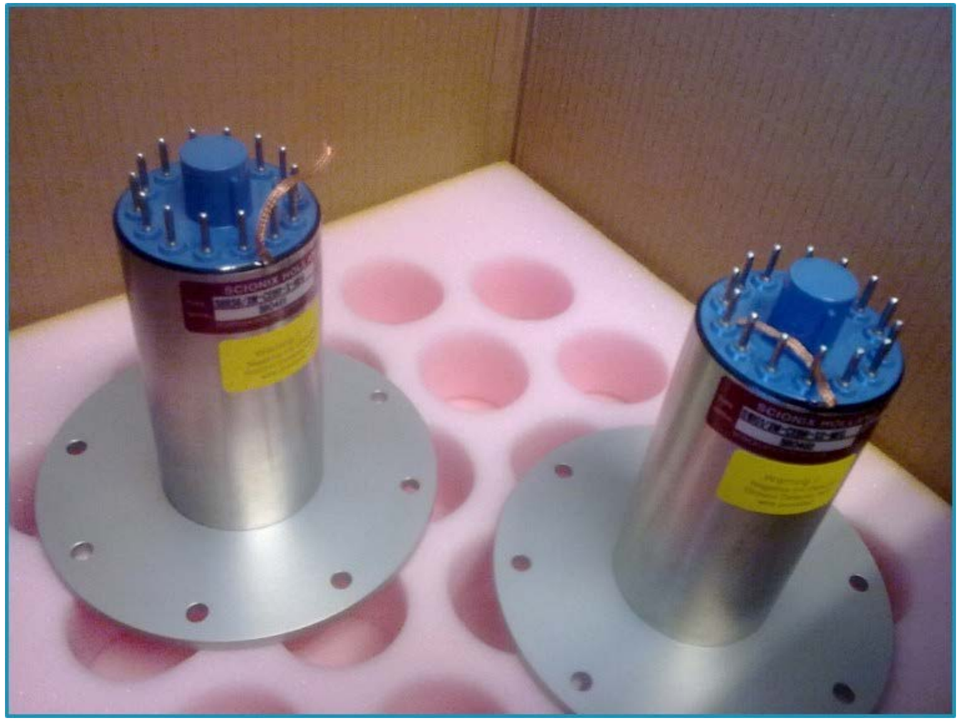
- *'Application of a $LaBr_3$(Ce) Scintillation Detector to an Environmental Radiation Monitor'*, Y.Y. Ji, H.Y. Choi, W. Lee, C.J. Kim, H.S. Chang, and K.H. Chung, IEEE Transactions on Nuclear Science, Vol. 65, No. 8, August 2018.

- *'Novel spectrometers for environmental dose rate monitoring'*, P. Kessler, B. Behnke, R. Dabrowski, A. Rottger, and S. Neumaier, Journal of Environmental Radioactivity 187 (2018) 115 – 121.

SpecMAT (Spectroscopy of Exotic nuclei with a Magnetic Active Target)

A high-efficiency gamma-ray array within a solenoid magnet

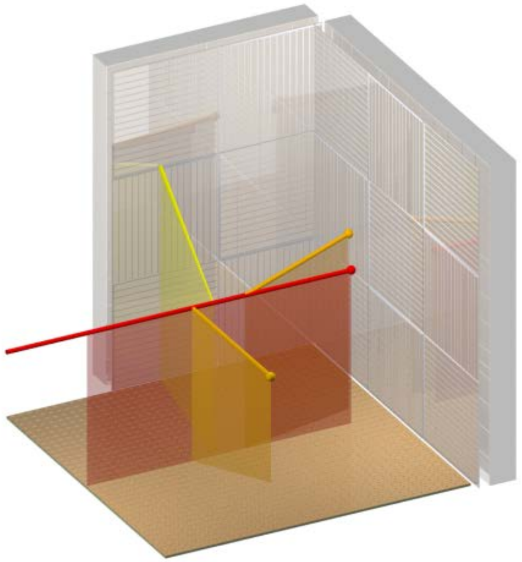


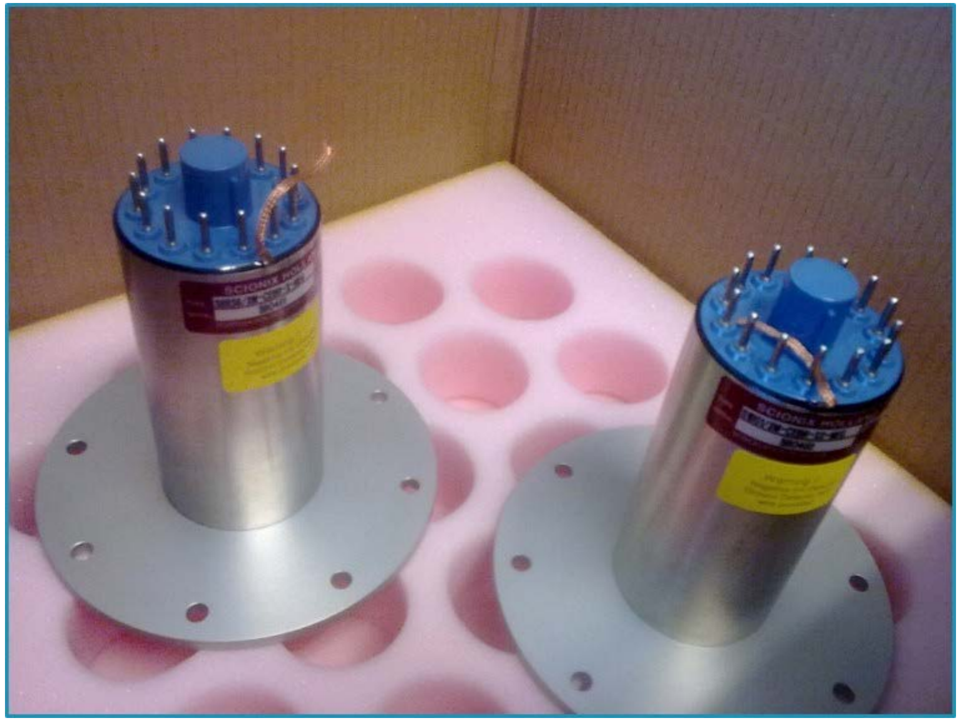


SpecMAT (Spectroscopy of Exotic nuclei with a Magnetic Active Target)

A high-efficiency gamma-ray array within a solenoid magnet

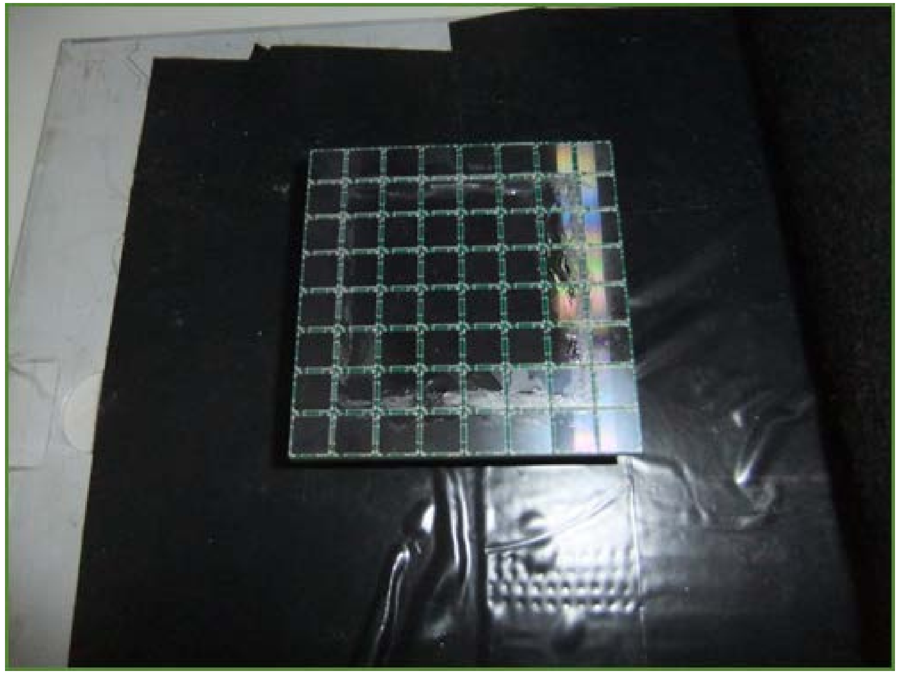
- cannot use PMTs for these conditions





Silicon Photomultipliers (SiPMs)

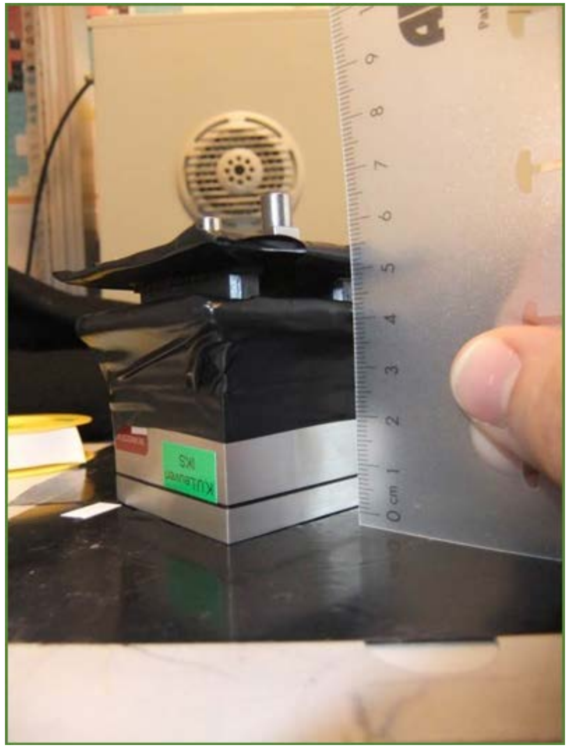
- Single photon sensitivity and amplitude resolution
- Far lower voltages required than with PMTs
- Less bulky than PMTs
- Insensitive to magnetic fields



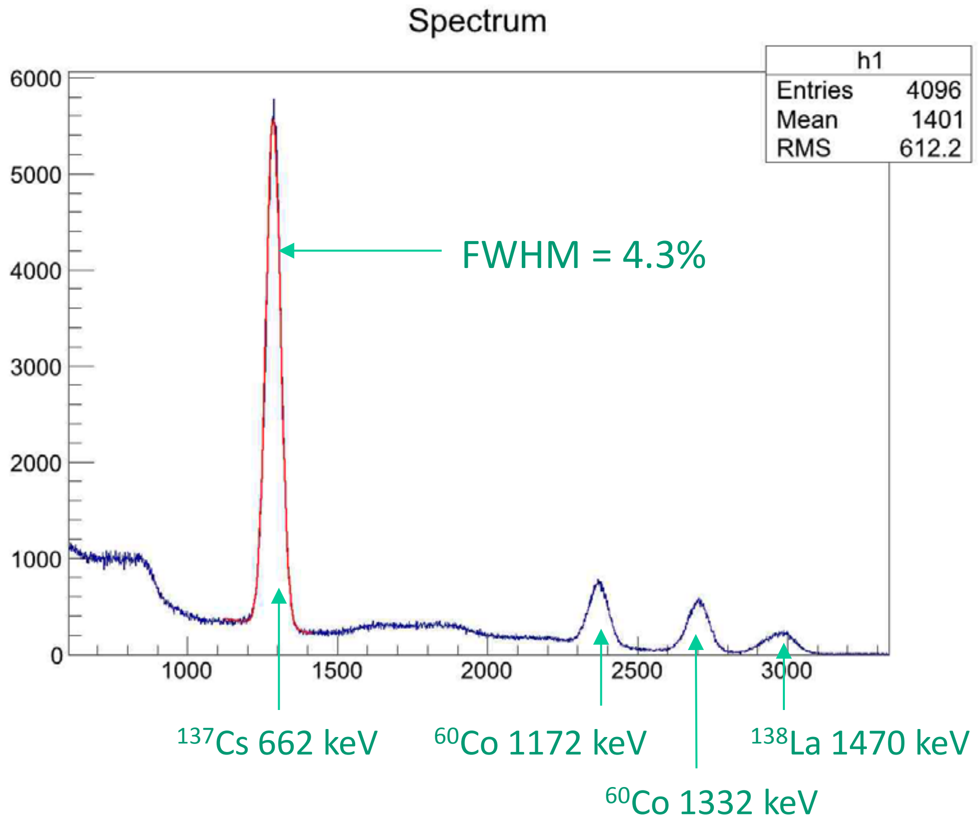
8*8 SiPM board

$LaBr_3$ crystal

SiPM test results with C-series SiPMs and $LaBr_3$ crystal:
(nominal value with PMT, FWHM < 3.0%)

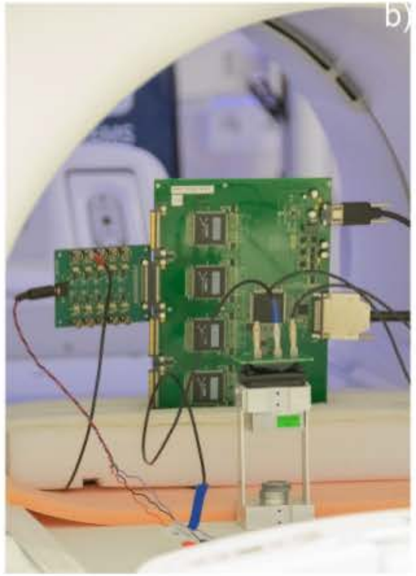


Crystal connected to 8*8 SiPM board



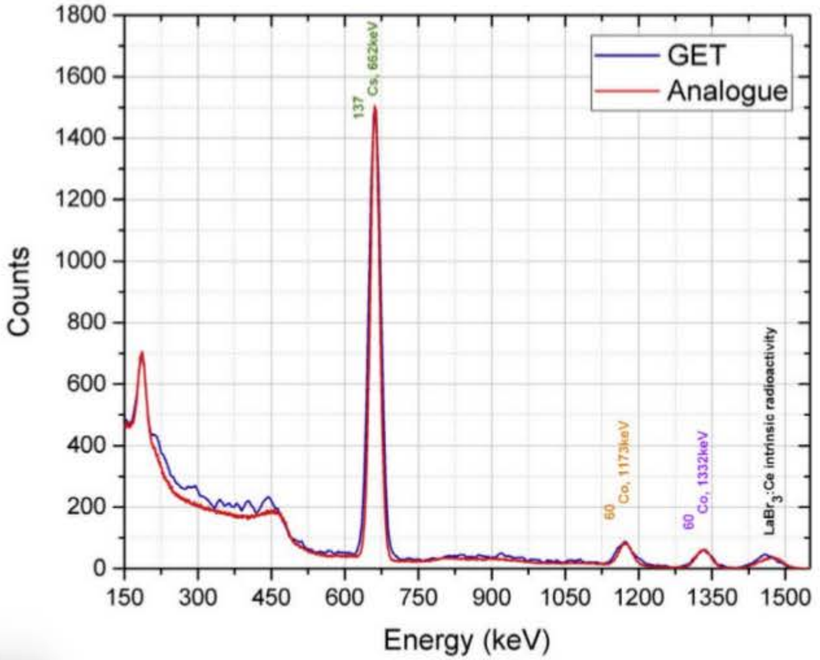
Data from J.A. Swartz & H. De Witte

Subsequent tests with J-series SiPMs in B = 3 T



These tests had:

- Front-end board in B-field
- Higher pixel density of SiPMs
- Leuven hospital MRI magnet



LaBr₃(Ce) + J-series SensL SiPMs	Analogue readout (% FWHM)	CAEN digital	GET
No field	2.94 ± 0.01	3.22 ± 0.01	3.85 ± 0.03
B = 3 T	2.97 ± 0.01	3.24 ± 0.01	3.88 ± 0.01
$LaBr_3(Ce)$ + PMT best value:	~2.8 (our collaboration)		
	~2.6 (suppliers)		

Data from: O. Poleshchuk, J.A.Swartz, R. Raabe, M. Babo, S. Ceruti, T. Marchi, J.C. Yang

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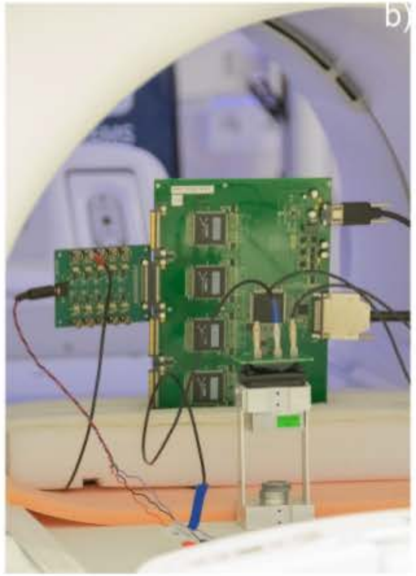

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ELSEVIER

GET: A generic electronics system for TPCs and nuclear physics instrumentation

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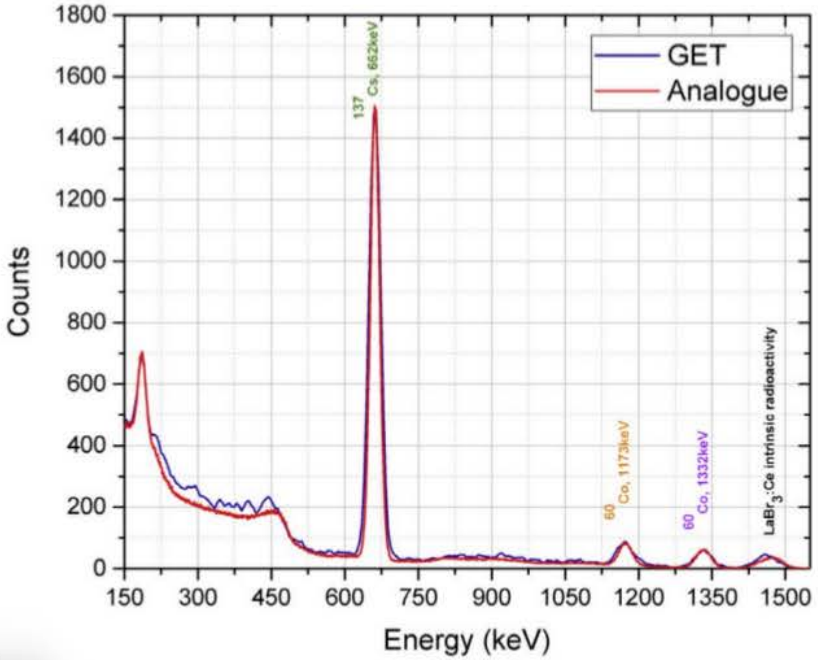
ABSTRACT

General Electronics for TPCs (GET) is a generic, reconfigurable and comprehensive electronics and data-acquisition system for nuclear physics instrumentation of up to 33792 channels. The system consists of a custom-designed ASIC for signal processing, front-end cards that each house 4 ASIC chips and digitize the data in parallel through 12-bit ADCs, concentration boards to read and process the digital data from up to 16 ASICs, a 3-level trigger and master clock module to trigger the system and synchronize the data, as well as all of the associated firmware, communication and data-acquisition software. An overview of the system including its specifications and measured performances are presented.



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Data from: O. Poleshchuk, J.A.Swartz, R. Raabe, M. Babo, S. Ceruti, T. Marchi, J.C. Yang

Summary of scintillator tests:

Material	Dimensions	Shape	SiPMs + GET @1.7T	SiPMs + GET	SiPMs	GET + Scintipack	Osprey	Scintipack	Manufacturers
LaBr3	1.5"×1.5"	cylinder				3.1%	2.8%	2.8%	2.6%
LaBr3	1.5"x1.5"	cube	**5.0%**	**5.1%**	**4.3%**				3.1%
LaBr3	2.0"×2.0"	cube			4.2%				3.0%
CeBr3	1.5"×1.5"	cylinder					4.2%		4.0%
CeBr3	1.5"x1.5"	cube			**5.1%**				**4.4%**
CeBr3	2.0"×2.0"	cylinder				**5.1%**	4.5%	4.8%	**4.0%**

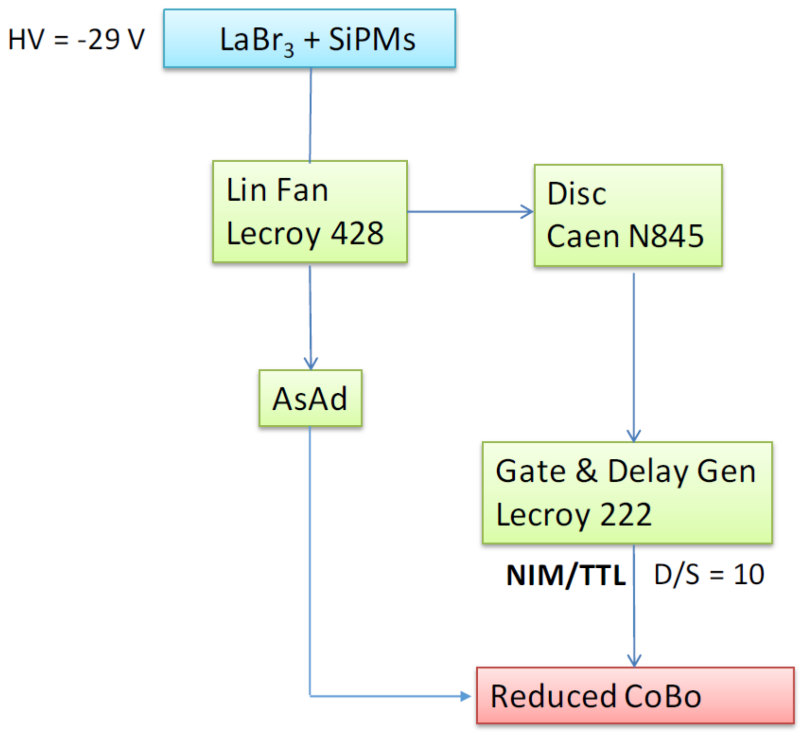
Final verdict, after C-series SiPM tests: $CeBr_3$ crystals to be used with SiPMs

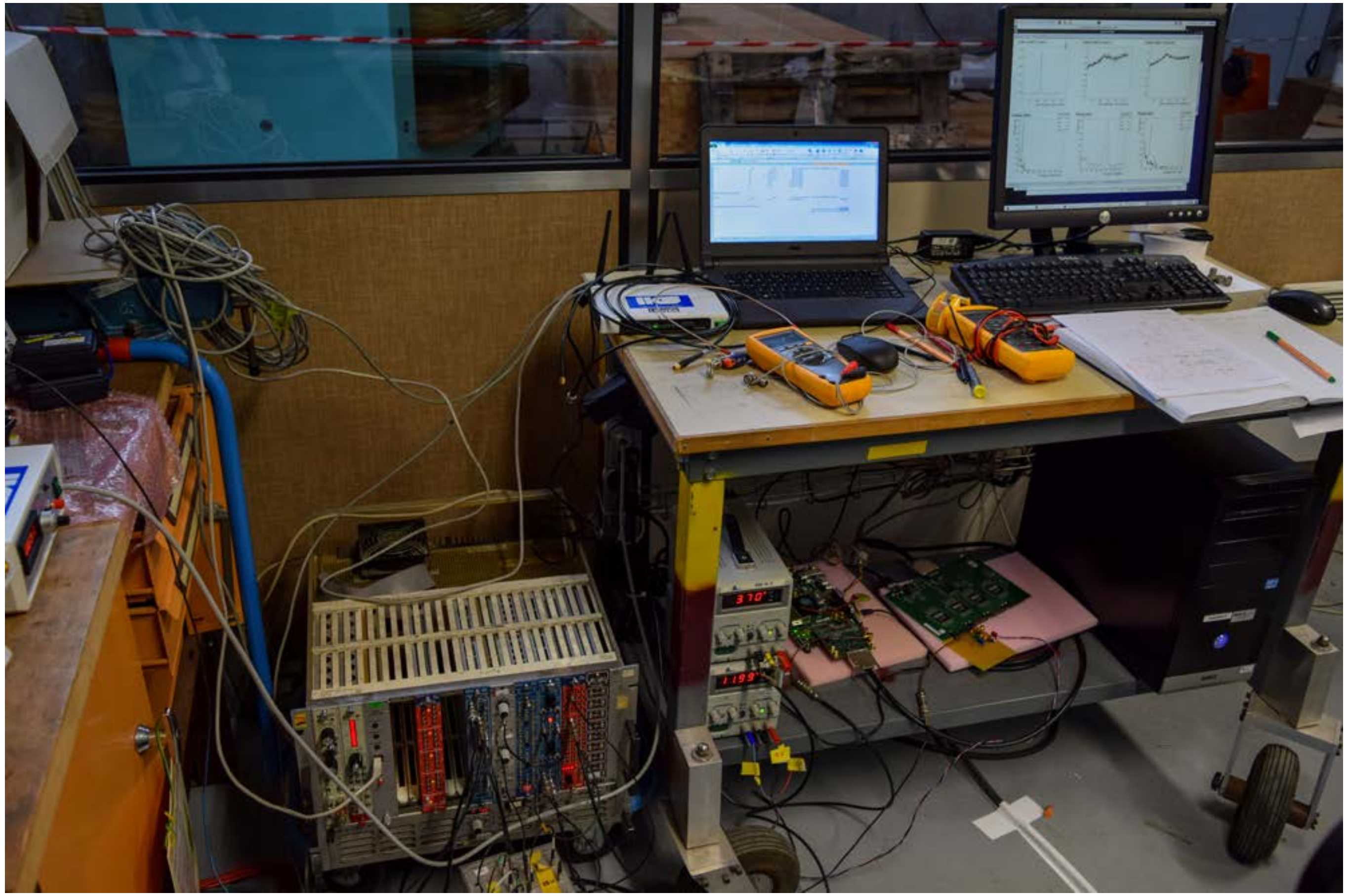
Tusing takk

Backup slides

Tests of SiPMs in high magnetic field

- 38*38 mm^2 LaBr3 crystals coupled to 8*8 array of 6*6 mm2 SiPMs, and
- put in magnetic field of up to B = 1.7 T





Electronics diagram for data acquisition with GET digital electronics system

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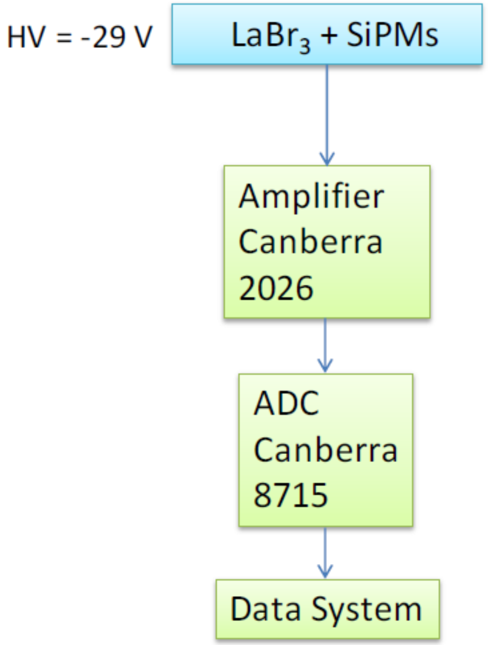

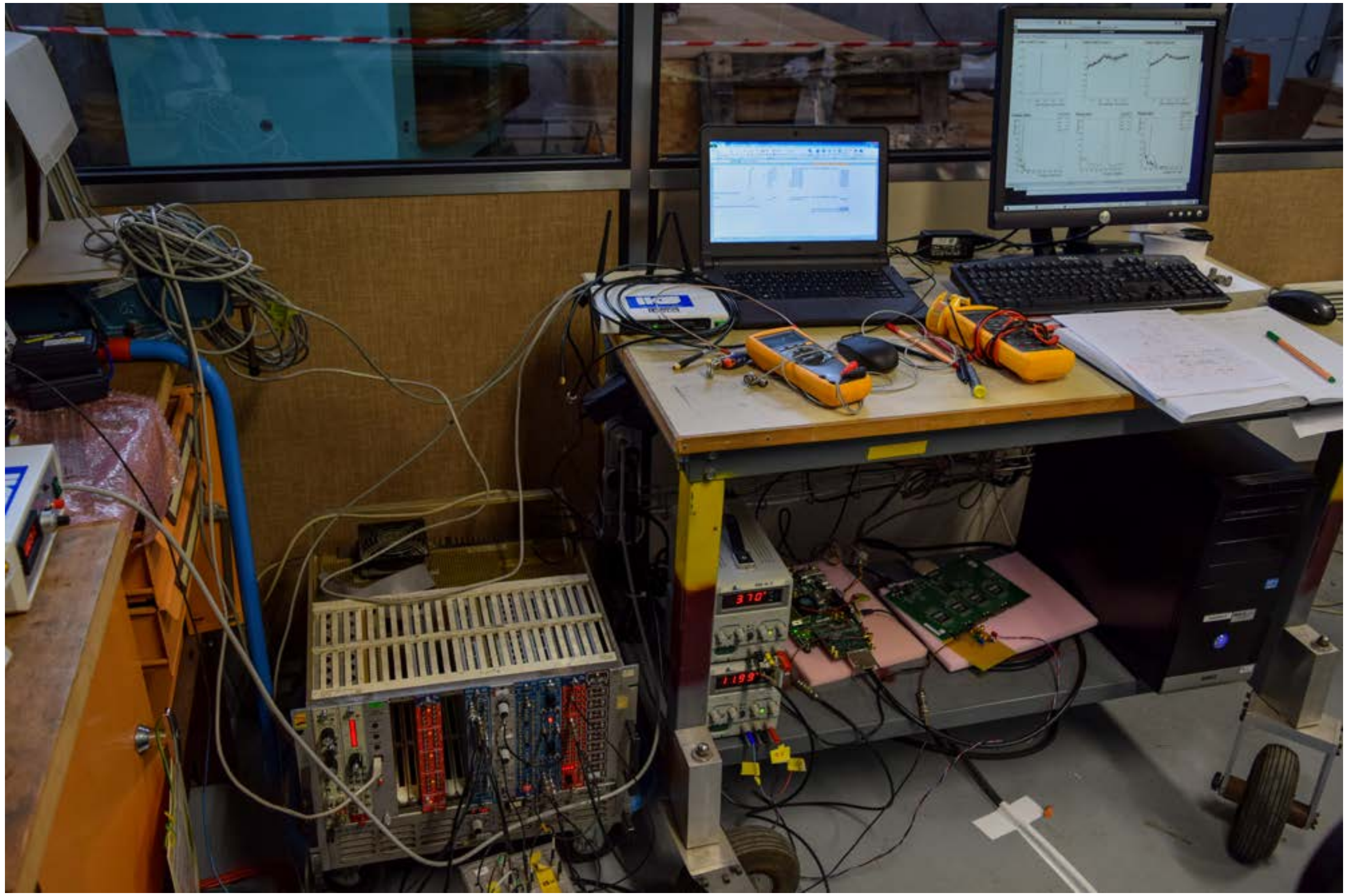

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