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CDE PERFORMANCE RESULTS ALONG THE LM2 & VM2
ENVIRONMENT TESTS

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1 Introduction

1.1 Purpose

Environment tests have been performed on CDE in LM2 mechanical structure (one layer of 12 CDEs), allowing a decoupling in both function and time of the CDE and mechanical structure:

- A first vibration test under the direction of LLR.
- A Vacuum Thermal Cycling test under the direction of DAPNIA, which has been performed in two runs (RAPPORT D'ESSAI DU CYCLAGE THERMIQUE Laboratory Model 2a).
- A second vibration test under the direction of LLR after the V.T.C.

Finally a third vibration test of CDEs in the VM2 structure has been performed under the direction of LLR. 9 over the 12 CDEs were scattered in the 8 layers of the VM2 structure. The 3 others were kept as reference for the removing from LM2 structure and then for their reinserting.

The cosmic muon test bench of Saclay has been used to follow the performances of the CDEs along the environment tests.

The measured performances are:

- The Light Yield (at the center of the crystal at each end and for each PIN, A and B)
- The energy resolution using the definition of the CDE specification document.
- The tapering using the Saclay (Tap saclay) definition and the one of the CDE specification document (Tap Spec).

Comparison was made between the first measurements done on the VM2 crystal at their arrival in France from Sweden with 10x10mm² PIN photodiodes and the one with glued DPDs.

The performances were checked and compared after each environment tests.

1.2 Definition

1.2.1 Acronyms

DAPNIA	Département d'Astrophysique de physique des Particules, de physique Nucléaire et d'Instrumentation Associée
LLR	Laboratoire Louis le prince Regnier
GLAST	Gamma-Ray Large Area Telescope
LAT	Validation Module #2 (12 Amcrys Xtals)
DPD	Dual PIN photoDiode
CDE	Crystal Detector Element
L.Y.	Light Yield Mean centered value of Right and Left PIN
VM2	Validation Model number 2
LM2	Laboratory Model number 2

1.2.2 Definitions

γ	Gamma Ray
Tap Saclay	Tapering in % slope on the total length of the crystal
Tap Swed	Tapering in % Ratio of the L.Y. at 3cm of both ends



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Tap Spec	Difference at +/-8cm from center of $(\text{Signal}_{\text{Right}} - \text{Signal}_{\text{Left}}) / (\text{Signal}_{\text{Right}} + \text{Signal}_{\text{Left}})$
nm	nanometer
μm	micrometer
mm	millimeter
cm	centimeter
eV	Electron Volt
MeV	Million electron Volt, 10^6 eV
e/MeV	electron by MeV deposit in Xtal
ph	photons

1.3 Reference documents

LAT-SS-00239-02	“Calorimeter CsI Crystal Fetector Element Specification”, Feb 2002
LAT-TD-00392-01	“Saclay Cosmic Test Bench: VM2 Xtal Results”, Oct 2001
LLR-GLAST-E-006-A	“LM2 and VM2 Performance Verification Plan”, Feb 2002
Sap-Glast-Y-5500-143-PA	“Rapport d’essai du cyclage thermique LM2A”, Marsh 2002

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2 CDE composition

The CDE of VM2 consist of:

- AMCRYS crystal, 333mm long and 19.9x26.7mm² section. The chamfers have been redone by LLR. The four long sides are depolished for tapering.
- DPDs (S8576) have been glued by “College de France” at each end of the crystal using primer and Daw-Corning 93400 silicon glue (about 0.6mm thick).
- Then the crystal has been wrapped with VM2000 by LLR (standard method with a recovering of about 2 to 3mm on one of the larger face and two sheets of white adhesive tape, the first about 1cm wide and the 2nd one 2.5cm)
- White frames at each end of the CDE surrounding the DPD, have been used to fix the CDE in both LM2 and VM2 structure.

The Table 1 summaries the constituted elements of the 12 CDEs and their position in LM2 (including the calibration parameter):

Xtal	DPD #	Wrapping	End Frame	Position	Pin	PIN A		PIN B	
						a (e/ch.)	b (e)	a (e/ch.)	b (e)
167P3-40-2	52	VM2000	White	1	C1-G	35,22	2561,7	142,64	10518,0
	58				C1-D	36,48	2281,3	144,60	11050,0
32K4-5-1	72	VM2000	White	2	C2-G	34,76	2517,1	140,79	10574,0
	70				C2-D	36,53	2819,2	140,52	11119,0
32K4-4-8	67	VM2000	White	3	C3-G	33,27	2312,3	128,22	9073,2
	69				C3-D	32,64	2806,8	133,59	9432,6
32K4-2-7	71	VM2000	White	4	C4-G	35,35	3086,7	130,01	7412,8
	68				C4-D	34,14	2365,9	143,52	9822,8
32K4-4-1	64	VM2000	White	5	C5-G	32,26	2838,0	142,52	12187,0
	75				C5-D	33,84	3235,9	140,15	9774,6
32K4-5-5	53	VM2000	White	6	C6-G	31,48	2171,8	142,93	11976,0
	56				C6-D	31,53	2825,9	144,79	11446,0
32K4-4-2	57	VM2000	White	1	C7-G	34,47	2663,4	144,11	10333,0
	54				C7-D	36,39	2284,4	151,55	10906,0
32K4-3-1	80	VM2000	White	2	C8-G	34,76	2517,1	140,79	10574,0
	82				C8-D	36,53	2819,2	140,52	11119,0
32K4-2-1	79	VM2000	White	3	C9-G	33,27	2312,3	128,22	9073,2
	78				C9-D	32,64	2806,8	133,59	9432,6
32K4-2-2	65	VM2000	White	4	C10-G	35,35	3086,7	130,01	7412,8
	73				C10-D	34,14	2365,9	143,52	9822,8
32K4-2-4	83	VM2000	White	5	C11-G	32,26	2838,0	142,52	12187,0
	66				C11-D	33,84	3235,9	140,15	9774,6
167P3-4-13	74	VM2000	White	6	C12-G	31,48	2171,8	142,93	11976,0
	81				C12-D	31,53	2825,9	144,79	11446,0

Table 1: CDE composition and test setup parameter

3 CDE performances

The Table 2 summarizes the performances of the 12 CDEs For PIN A and B (Note: it is the measurements done after the first vibration in LM2, as because of a soft acquisition bug we have only measured the PIN A performances for the initial test):

Crystal #	Side	PINA						PINB						
		L.Y. (e/MeV)	Res (%)	Tap Saclay(%)	f(-x)	f(x)	Tap Spec	L.Y. (e/MeV)	Res (%)	Tap Saclay(%)	f(-x)	f(x)	Tap Spec	PIN B/PIN A
167P3-40-2	L	873		42,3	0,12	-0,08	0,20	5491		45,6	0,14	-0,08	0,21	6,3
	R	910	6,7	-40,3				5835	3,1	-43,1				6,4
32K4-5-1	L	887		47,3	0,15	-0,06	0,20	5558		49,2	0,12	-0,10	0,22	6,3
	R	968	5,9	-37,9				5680	2,6	-42,7				5,9
32K4-4-8	L	855		36,7	0,14	-0,07	0,21	5292		35,9	0,12	-0,10	0,22	6,2
	R	917	6,2	-50,5				5457	2,6	-54,4				6,0
32K4-2-7	L	930		30,4	0,07	-0,10	0,16	5519		33,1	0,10	-0,07	0,17	5,9
	R	906	5,8	-37,8				5664	2,4	-37,8				6,2
32K4-4-1	L	898		26,2	0,10	-0,03	0,14	5659		28,0	0,08	-0,07	0,15	6,3
	R	963	5,6	-30,5				5762	2,3	-33,4				6,0
32K4-5-5	L	844		36,8	0,14	-0,07	0,20	5381		39,6	0,12	-0,10	0,22	6,4
	R	909	5,7	-48,0				5504	3,1	-53,9				6,1
32K4-4-2	L	870		28,2	0,08	-0,09	0,16	5478		31,0	0,11	-0,06	0,18	6,3
	R	864	5,8	-38,9				5768	2,5	-42,2				6,7
32K4-3-1	L	919		31,4	0,10	-0,04	0,14	5869		33,3	0,08	-0,07	0,15	6,4
	R	977	5,6	-26,5				5886	2,1	-29,9				6,0
32K4-2-1	L	922		38,3	0,12	-0,08	0,20	5713		40,0	0,11	-0,11	0,22	6,2
	R	960	5,3	-45,2				5759	2,7	-51,6				6,0
32K4-2-2	L	938		32,6	0,08	-0,10	0,18	5682		35,8	0,10	-0,09	0,20	6,1
	R	917	5,5	-43,0				5763	2,6	-45,5				6,3
32K4-2-4	L	878		46,5	0,14	-0,08	0,22	5474		48,9	0,13	-0,11	0,24	6,2
	R	937	5,4	-44,5				5577	2,7	-49,2				6,0
167P3-4-13	L	869		36,3	0,12	-0,06	0,17	5642		39,3	0,10	-0,08	0,18	6,5
	R	922	5,9	-35,4				5754	2,4	-37,5				6,2
Mean		910	5,8	38	0,11	-0,07	0,18	5632	2,6	41	0,11	-0,09	0,20	6,2
rms		37	0,4	7	0,03	0,02	0,03	158	0,3	8	0,02	0,02	0,03	0,2

Table 2: CDE performances summary



3.1 Light Yield

In the CDE specification the requiring L.Y. for PIN A and B are respectively 800 and 5000 e/MeV, so the L.Y. performance measured, 910+/-37 and 5632+/-158, are very satisfactory (See Table 2).

The homogeneity of the CDE is also satisfactory 3 to 4% (rms).

The L.Y. ratio between PIN B and A (6.2+/-0.2) is also in accordance with the active area ratio (6).

3.2 Energy Resolution

In the CDE specification the energy resolution with the muon is define as:

$$\text{Sigma}(\text{muon}) = \text{Sigma}(\text{Signal}_{\text{Right}} - \text{Signal}_{\text{Left}})^{0.5}$$

The measured value for PIN A and B are respectively 5.8+/-0.4% and 2.6+/-0.3%.

3.3 Tapering

In the CDE specification the tapering is define at +/-8cm from the center of the crystal, as the pitch of the hodoscope is 2.5cm we have used the slope of the linear regression of the L.Y. vs muon crossing position.

The measured value for PIN A and B are respectively 0.18+/-0.03 and 0.20+/-0.03, and the minimum value 0.14 and 0.15 respectively.

4 Comparison with initial Crystal performances

At their arrival in France the 16 crystals for VM2 have been measured with 10x10mm² PIN Photodiode associated to 1mm thick silicon optical joint first with their wrapping (Tyvek+Aluminium) then with VM2000 wrapping.

The results have been summarized in Saclay Cosmic Test Bench: VM2 Xtal Results and Table summarized the one of the 12 crystals used in LM2 environment tests.

The graph, figure 1, shows the L.Y. versus the PIN active area. The 10x10mm² PIN photodiode give a little bit greater L.Y. which is not so surprising as the setup is almost different: PIN centered, wrapping materiel, experimental setup.

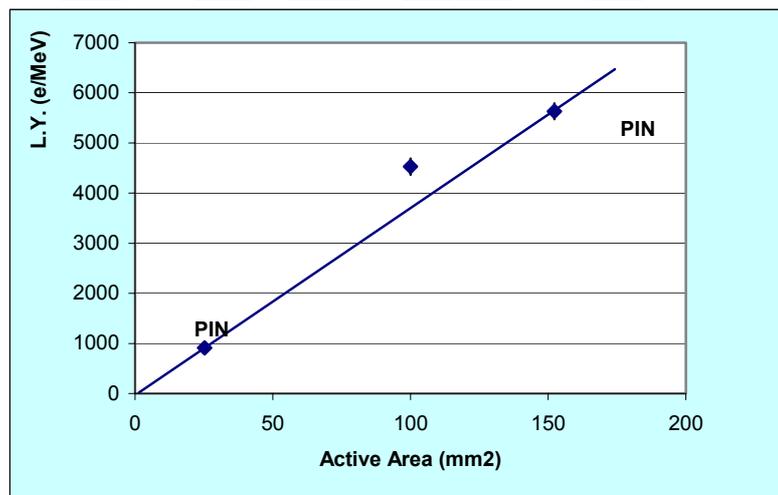


Fig 1: L.Y. versus Active Area



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Crystal #	Side	Sweden		Saclay measurements		
		Tyvek+Aluminium		VM2000		
		Tap Saclay(%)	L.Y. (e/MeV)	Tap Saclay(%)	L.Y. (e/MeV)	Tap Saclay(%)
167P3-40-2	L	61,7	2827	33,8	4340	17,7
	R	-61,7	2959	-39,3	4542	-20,5
32K4-5-1	L	65,6	3144	37,4	4557	21,5
	R	-57,9	3214	-40,1	4600	-23,6
32K4-4-8	L	63,7	3014	46,9	4337	28,7
	R	-63,7	3051	-29,9	4419	-15,4
32K4-2-7	L	54,2	3244	29,8	4680	13,5
	R	-54,2	3177	-29,9	4671	-14,1
32K4-4-1	L	50,6	3313	21,2	4734	7,6
	R	-50,6	3275	-29,2	4553	-9,8
32K4-5-5	L	67,6	3239	41,4	4572	28,9
	R	-69,6	3255	-33,0	4602	-15,8
32K4-4-2	L	52,4	3272	24,3	4260	9,1
	R	-50,6	3200	-32,9	4102	-10,0
32K4-3-1	L	41,9	3290	23,0	4452	15,7
	R	-41,9	3208	-25,3	4670	-3,5
32K4-2-1	L	59,8	3202	26,3	4774	13,9
	R	-67,6	3062	-41,8	4496	-18,1
32K4-2-2	L	54,2	3344	26,9	4688	11,4
	R	-54,2	3306	-32,8	4458	-16,7
32K4-2-4	L	63,7	3233	37,2	4507	27,7
	R	-65,6	3258	-42,5	4503	-24,8
167P3-4-13	L	52,4	3153	38,3	4540	20,4
	R	-47,0	3284	-26,9	4642	-10,6
	Mean	57	3189	33	4529	17
	rms	8	125	7	157	7

Table 3: Summary of measurements performed on VM2 crystal with 10x10mm2 PIN photodiodes

Apart the fact that the PIN A and B are not centered on the end of the crystal, we have no explanation of the increase of the tapering (Saclay definition): 17+/-7% with centered 10x10mm2 PIN photodiode and 38+/-7 and 41+/-8% for PIN A and B. Nevertheless it is a good thing.

5 CDE performances along the environment tests

The initial measurements (start on the table) have been performed only on PIN A.

The 3rd vibration done on VM2 structure, have been performed on 9 over the 12CDEs. The 3 CDEs # 167P3-40-2, 32K4-2-7 and 32K4-2-2 have been removed then reinserted in LM2 to simulate the handling of the 9 CDEs tested in VM2.

The Table 5 summarized the mean measurements done on the 12 CDEs (apart for the last test done only on the 9 CDEs put in VM2 structure).

The Table 6 summarized the results on the 3 CDEs, which have been removed from LM2 then reinserted. The figure 2 and 3 show the evolution of the L.Y. respectively in absolute value and relative value.



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		PIN A			PIN B		
		L.Y.	Res (%)	Tape Saclay	L.Y.	Res (%)	Tape Saclay
Start	Mean Left	895	%		37		
	RMS Left	30	3,3		8		
	Mean Right	930	%		-40		
	RMS Right	28	3,1		7		
First Vibrat., Start VTC	Mean Left	890	%		36	5563	%
	RMS Left	31	3,5	5,8	7	158	2,8
	Mean Right	929	%		-40	5701	%
	RMS Right	33	3,5	0,4	7	130	2,3
First VTC	Mean Left	869	%		39	5460	%
	RMS Left	31	3,6	6,2	7	160	2,9
	Mean Right	906	%		-38	5622	%
	RMS Right	35	3,8	0,4	7	129	2,3
2nd VTC, Start 2nd Vibrat.	Mean Left	885	%		36	5487	%
	RMS Left	32	3,6	5,6	7	152	2,8
	Mean Right	917	%		-39	5641	%
	RMS Right	30	3,3	0,4	6	141	2,5
2nd Vibration	Mean Left	880	%		37	5469	%
	RMS Left	35	4,0	5,7	7	173	3,2
	Mean Right	917	%		-39	5633	%
	RMS Right	33	3,6	0,4	6	134	2,4
3rd Vibration in VM2	Mean Left	889	%		38	5589	%
	RMS Left	33	3,7	5,3	8	212	3,8
	Mean Right	946	%		-36	5769	%
	RMS Right	30	3,2	0,4	7	183	3,2

Table 5: Mean CDE performances the after each environment test.

		PIN A			PIN B		
		L.Y.	Res (%)	Tape Saclay	L.Y.	Res (%)	Tape Saclay
Before Removing from LM2	Mean Left	907	%		35	5495	%
	RMS Left	36	3,9	5,9	8	87	1,6
	Mean Right	901	%	0,1	-41	5670	%

	RMS Right	6	0,7		4				
Afer reinserted in LM2	Mean Left	937	%		33	5636	%		35
	RMS Left	48	5,2	5,4	8	101	1,8	2,5	8
	Mean Right	933	%		-40	5943	%		-42
	RMS Right	7	0,8	0,5	4	93	1,6	0,2	3

Table 6: Mean performances of the 3 CDEs before and after removing from LM2.

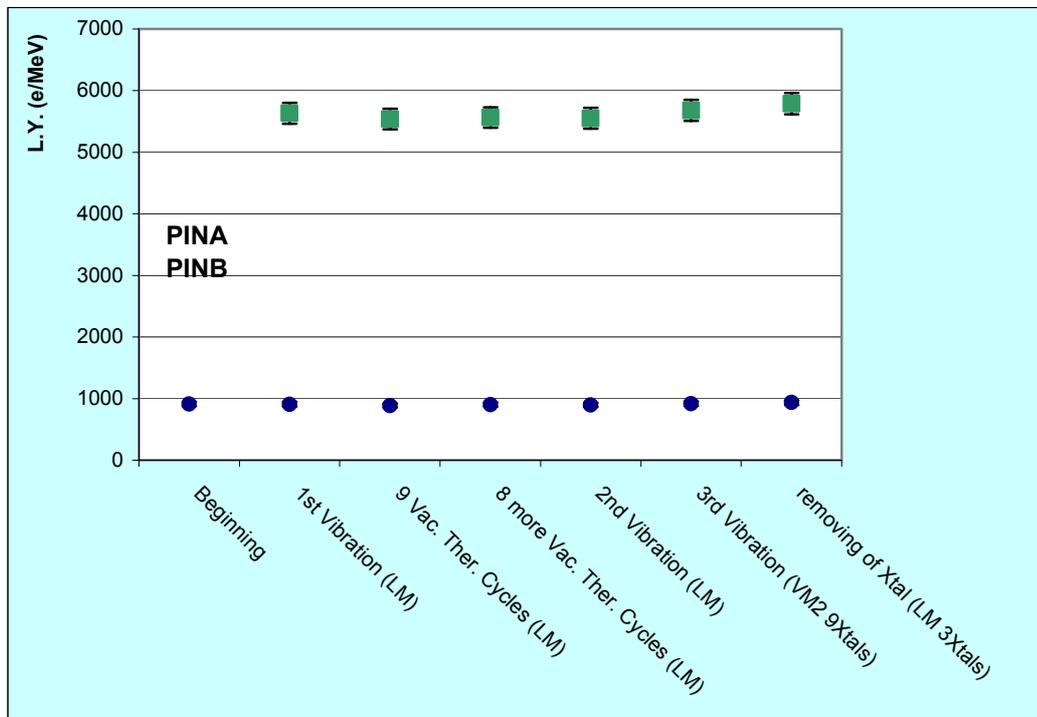


Fig 2: Absolute L.Y. versus environment test

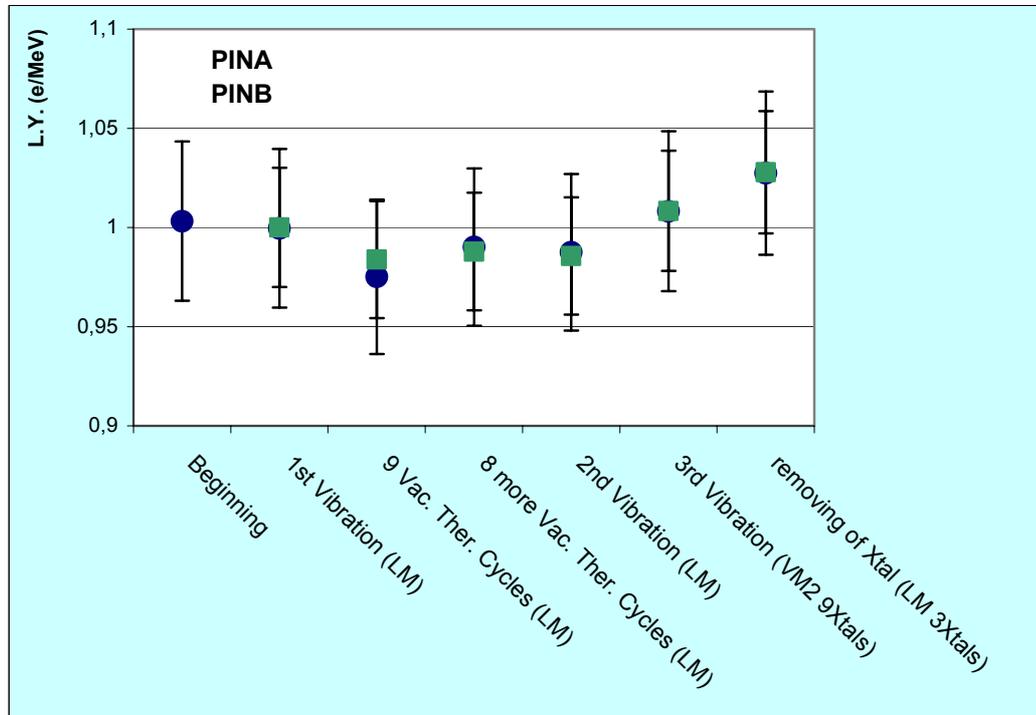


Fig 3: Relative L.Y. versus environment test

6 Conclusions

The measured performances on the CDEs in LM2 structure answer the CDE specification:

- L.Y. 910 and 5600 e/MeV respectively for PIN A and B.
- The energy resolution 5.8 and 2.6% respectively for PIN A and B.
- The Tapering between 0.14 - 0.22 for PIN A and 0.15 - 0.24 for PIN B.

Note we have to be wary with the tapering which seem to be very dependent of the setup.

Next issue: Testing the new CDE with only the 2 smaller faces depolishing to give the tapering.