

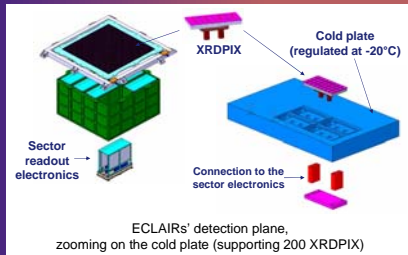
Selection of CdTe detectors for the detection plane of the ECLAIRs gamma-ray burst detector

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ABSTRACT : Schottky In/CdTe/Pt detectors (4x4 mm², 1 mm thickness, produced by ACRORAD Japan) have been chosen to set up the detection plane of the ECLAIRs French gamma-ray burst detector. The main specification of the instrument is to detect high redshift bursts from 4 keV up to 250 keV, over a wide field of view of 2 steradians. 200 elementary detection modules (XRDPiX) are used to build the camera. They are based upon an innovative hybridization of the low noise front-end electronics chip IDeF-X ECLAIRs with 32 CdTe detectors. In order to reduce the noise and reach the 4 keV limit, the detectors for the flight model are carefully selected. They present the best performance in terms of leakage current, energy resolution and low energy threshold. We report on these tests and the selection criteria elaborated from the study of a first set of 500 detectors.

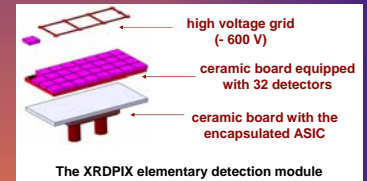
ECLAIRs = coded mask aperture telescope

- ↳ trigger of the SVOM mission, for the study of gamma-ray bursts
- ↳ provides detailed spectral and light curves analysis of the high-energy emission of the burst



Properties	Description
Energy range for detection	4 - 250 keV
Energy range for imaging	4 - 50 keV
Aperture	Coded mask
Field of view	2 steradians
Angular resolution	10 arc minutes
Sensitive area	1024 cm ²
Detector type	Schottky In/CdTe/Pt
Detector size	4 x 4 mm ² x 1 mm
Number of detectors	6400
Readout electronics	8 sectors
Elementary detection module	XRDPiX
Nominal temperature	-20°C

Properties of the ECLAIRs instrument and its detection plane



IDeF-X ECLAIRs = a 32-channel front end chip

- for low capacitive (2 to 5 pF) and low leakage current (1 pA to 2 nA) CdTe detectors
- low noise (floor ENC = 33 e- rms at tpeak = 6μs)
- low consumption (3 mW/channel)
- radiation hardness of the process technology (AMS CMOS 0.35 μm), suitable for space applications

PERFORMANCE TESTS ON INDIVIDUAL CDTE DETECTORS

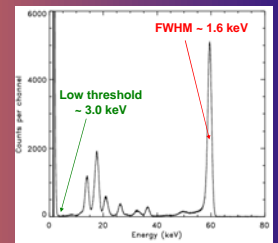
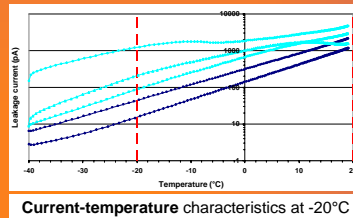
The experimental setup

Signal recovery
Connection to the high voltage
Beryllium entrance for illumination of the detectors with X- and gamma-rays
The support inside which the CdTe detector is placed to be tested

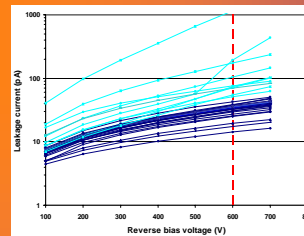
Equipment with 32 detectors tested at a time in a thermally regulated facility
→ leakage current measurements (left)
→ spectroscopy (right)

Temperature	-20°C ; +20°C
Reverse bias voltage	- 600 V
Radioactive source	Americium 241 (10 to 60 keV)
Total number of detectors	500
Number of detectors tested simultaneously	32

Testing conditions



In dark blue : detectors which fit in the selection criteria; in light blue : the ones which do not fit



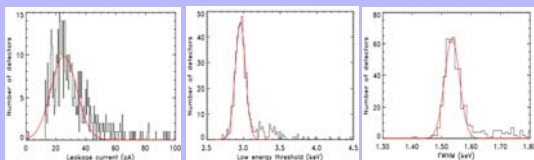
⇒ effective « detector resistivity » ~ 3.10¹³ Ω.cm at -20°C
(~4.10¹¹ Ω.cm at room temperature)

- ↳ Origin of the peaks :
 - emission of the Americium 241 (5 main peaks)
 - non total charge collection inside semiconductor
 - thin tail for the peak at 60 keV
 - X-ray fluorescence inside CdTe (2 escape lines around 32 and 36 keV)
 - backscattering (counts around 48 keV)

SELECTION CRITERIA RESULTING FROM THE STUDY OF A FIRST SET OF DETECTORS

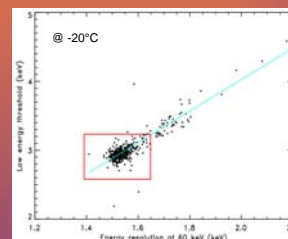
Objective of the selection : keep detectors presenting all the best performance, before hybridization with the ASIC, to get the most uniform XRDPiX modules
⇒ a 4 keV low energy threshold for the detection plane

Distribution of the 3 parameters taken into account for the selection : leakage current, low energy threshold and energy resolution
→ The detectors with the best characteristics are the most numerous ⇒ **homogeneity**

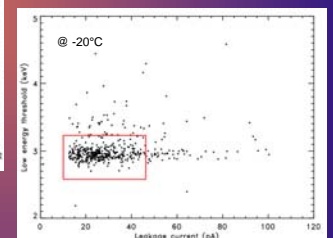


	@-20°C		@+20°C	
	Min	Max	Min	Max
Leakage current (pA)	10	46	1000	2800
Low energy threshold (keV)	2,6	3,2	3,1	4,0
Energy resolution at 60 keV (keV)	1,4	1,7	1,5	2,1

Selection criteria (minimum and maximum allowed)



The parameters are **correlated** to each other : a detector with a low leakage current will also present a low energy threshold and a low FWHM.
⇒ Selected detectors are inside the red square



CONCLUSIONS : Since the ECLAIRs instrument is made of 6400 Schottky In/CdTe/Pt detectors, the pre-flight selection of the detectors is a unique opportunity to study their characteristics. The upcoming tests on more than 10000 detectors will complete the study and the criteria will evolve. Individual detectors have shown the expected characteristics to reach the 4 keV threshold. But these results do not take into account the increase in leakage current which could be brought by gluing the detectors on the ceramic board during hybridization, nor the capacitive noise from the two ceramics. However, the on-going developments of the XRDPiX are promising and the first tests on the prototypes are expected by September 2008.

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