# ECLAIRs: the hard X-ray imager and trigger of SVOM

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## ECLAIRs Scientific Objectives and Design Performance

• ECLAIRs is the hard X-ray imager and trigger of SVOM, whose launch is planned in December 2021. This is a coded-mask imager made of a detection plane with 6400 carefully selected CdTe detectors (Remoué et al. 2010) located behind a coded mask in Tantalum, as shown in the rightmost figure of this panel. Without its radiator, ECLAIRs is 80 cm high, with a surface of 60×60 cm and a weight of about 80 kg.
• Interesting features of ECLAIRs include: an energy range extending down to 4 keV, allowing the exploration of soft GRBs and highly redshifted GRBs; the capability to detect and localize GRBs autonomously over timescales ranging from 20 ms to 20 minutes with count-rate and image triggers; and the transmission of all the photons to the ground, allowing detailed offline analysis of the transient hard X-ray sky.
• The Point Source Localization Error reaches 11.5 arc minutes for sources detected with SNR = 8, ensuring that they will be within the field of view of the narrow-field telescopes (MXT and VT) after a slew of the satellite.
• According to the pointing law of SVOM the center of the 2 sr field of view will be close to the anti-solar direction (Wei et al. 2016), favoring the detection of GRBs in the night hemisphere, which are immediately observable from the ground. Consequently, the Earth will cross the field of view every orbit.
• ECLAIRs is expected to detect ≈200 GRBs of all types during the nominal duration of the mission (3 years). Detailed information about the instrument can be found in Godet et al. (2014).


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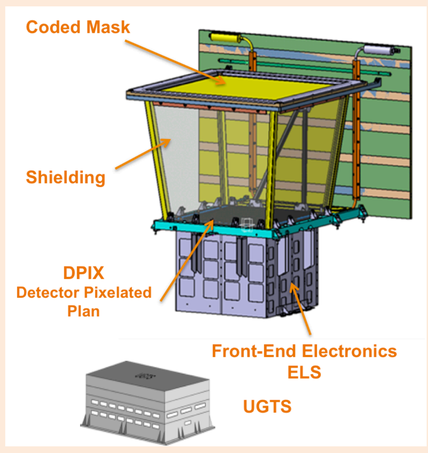
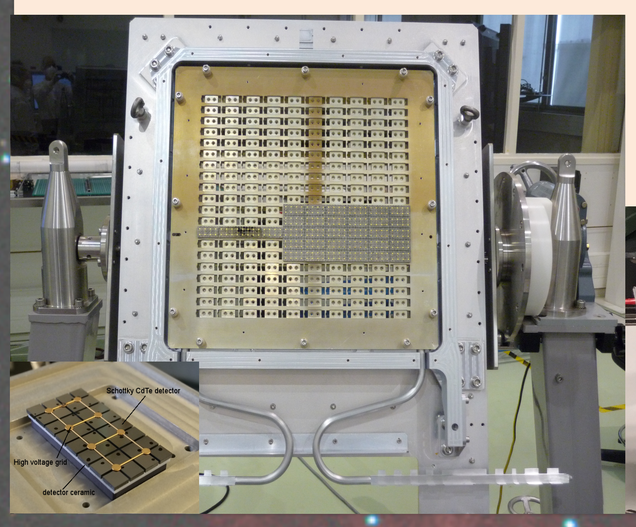
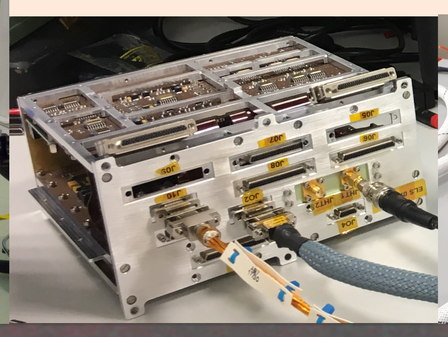
| **Energy range** | 4 – 150 keV |
| **Detecting area** | ≈1000 cm$^2$ |
| **Detectors** | 6400 CdTe detectors (mounted as 200 modules) |
| **Effective area in 10-70 keV** | ≥340 cm$^2$ |
| **Effective area @ 6 keV** | ≥200 cm$^2$ |
| **Field of view** | 2.06 sr total |
| **Sensitivity to 1 sec long GRB** | 2.5 $10^{-8}$ erg cm$^{-2}$ s$^{-1}$ in [5–50] keV |
| **Source Localization Error** | 11.5 arcminutes for sources with SNR=8 |
| **Energy resolution at 60 keV** | < 1.6 keV |
| **Time resolution** | 10 microsecond |
| **Dead time** | <5% for $10^5$ cts/s |
| **Data rate** | ≤18 Gb/day |

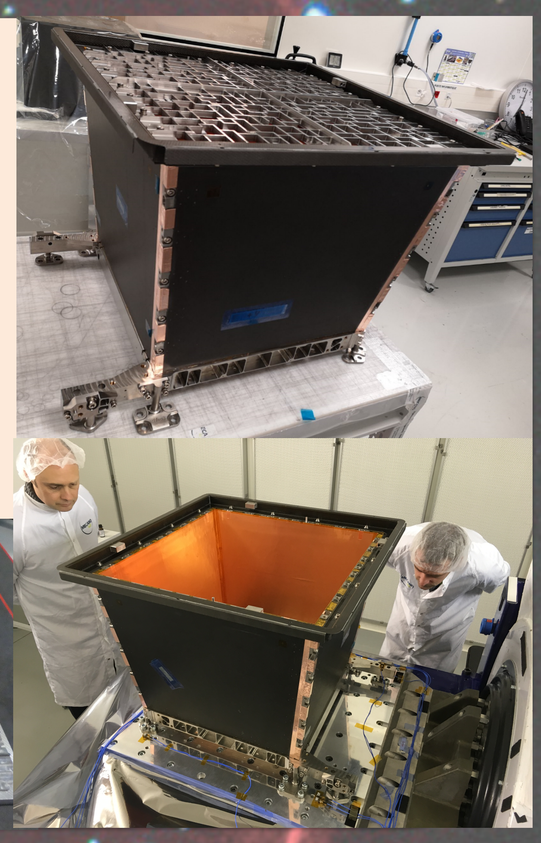



## Construction of the Instrument

• The instrument is now in phase C, and all the subsystems are under construction. The pictures of this panel show some real hardware. They are not to scale, and we refer the reader to the previous panel for a global view of the instrument. From left to right, the pictures show:
-- The prototype detection plane with 1088 active detectors (out of 6400), and an inset showing a module of 32 detectors with their readout ASIC.
-- The front-end electronics designed to read out 1 sector of 800 detectors. The entire detection plane encompasses 8 sectors.
-- The onboard data processing unit called UGTS (Unité de Gestion et de Traitement Scientifique – in french).
-- The coded mask , made with a foil of Tantalum sandwiched between 2 structures in Titanium.
-- The structure of the instrument, supporting the graded shield (Pb+Cu) and the coded mask.



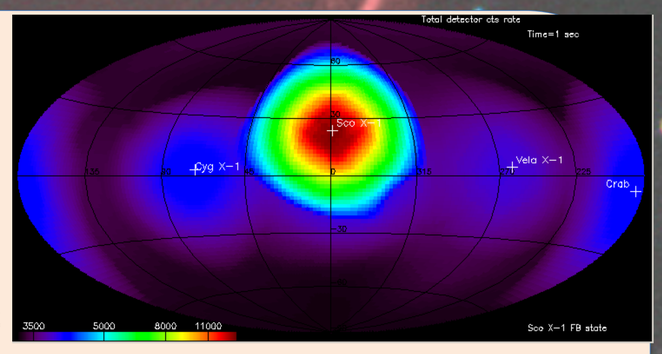


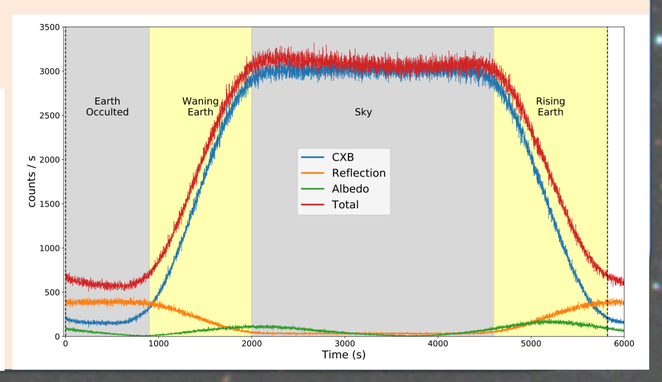
As can be seen, ECLAIRs is a compact instrument with highly multiplexed detectors and electronics and powerful computational resources.

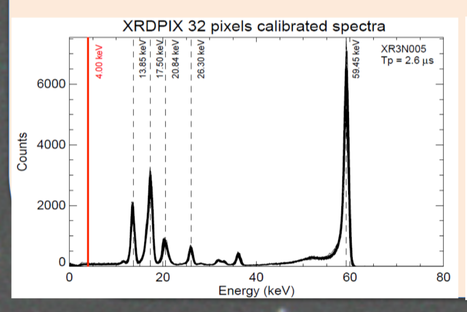
## Measured and Simulated Performance

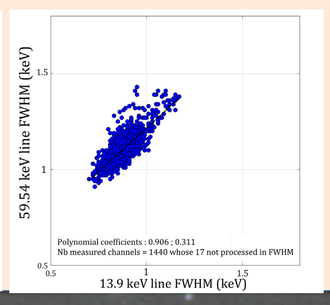
• The performances of several detection modules (each of them consisting of 32 detectors read by an ASIC) have been measured with a source of Americium 241 (Lacombe et al.2018). The results of these tests are illustrated in the four leftmost figures of this panel, which represent (from left to right):
-- The superimposition of the 32 spectra of one detection module, demonstrating the homogeneity of the spectral response of the 32 detectors.
-- The spectral resolution of two lines of $^{241}$Am, which is better than 1.5 keV for nearly 99% of the detectors.
-- The energy threshold, which is below 4 keV for 95% of the detectors.
-- The deadtime, which remains below 5% for count rates under $10^5$ c/s on the detection plane, corresponding to a flux of 250 c/s/cm$^2$ (Bajat et al. 2018).

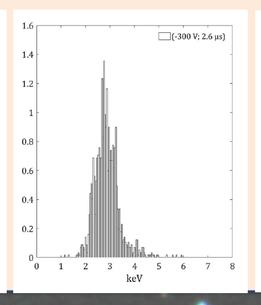
•In parallel with these measurements, the response of the instrument has been simulated in detail, with Monte Carlo simulations, which have been used to evaluate the effective area of the instrument (bottom plot N°5 from left) or the expected background variation along the orbit (rightmost bottom plot) clearly showing the passage of the Earth in the field of view. The top right figure shows the background counts in the energy range [4-120] keV, as a function of the pointing direction. The bright region is due to the X-Ray binary SCO-X1. These plots show that ECLAIRs background will be variable temporally, spatially and spectrally, requiring special procedures for onboard GRB detection. Detailed description of the trigger and its performance can be found in Schanne et al. (2018) and Dagonneau et al. (2018), while Bernardini et al. (2017) discuss the spectroscopic performance of ECLAIRs for long and short GRBs.

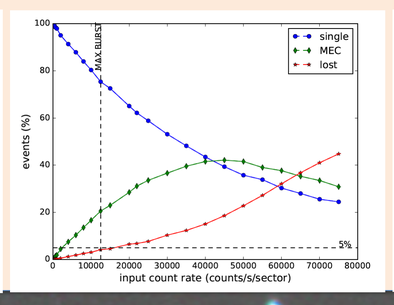


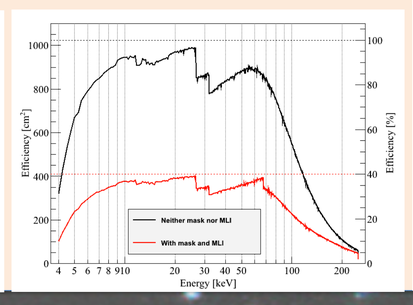




## Conclusion

• We have presented the status of the realization of ECLAIRs, which is due to launch onboard SVOM in December 2021. The realization of the subsystems is on schedule for the integration of the instrument that will start in the first quarter of 2020. The interest reader will find more information about the instrument and its performance in the list of selected references below.

## Selected References

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