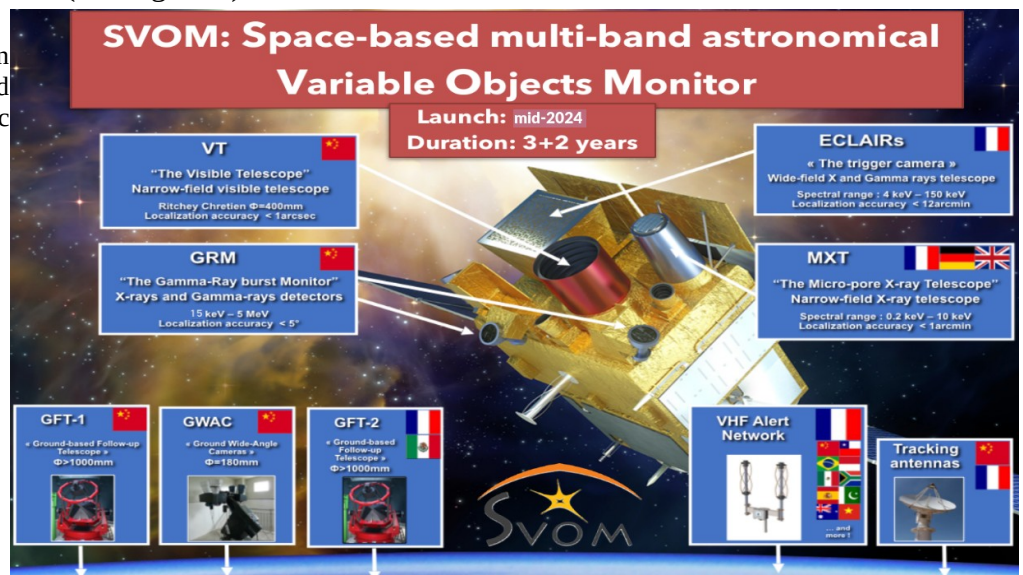


## Boosting localization capabilities of the SVOM/ECLAIRs camera

Gamma-ray bursts (GRBs) are the most energetic cosmological (up to  $z \sim 9.3$  so far) events in the Universe signalling the catastrophic formation of a stellar compact object (black hole or neutron star) and the launch of ultra-relativistic (Lorentz factor  $\Gamma > 100$ ) jets following the gravitational core collapse of some massive stars ( $M > 25 M_{\text{sun}}$ ) or the merger of two neutron stars, the latter leading to strong emission of gravitational waves (GW) detectable in the local Universe ( $<$  a few hundreds of Mpc). GRBs first appear as bright, very short (from a few ms to a few hundreds of seconds) and highly variable flashes of X-/Gamma-ray photons (prompt emission) followed by a multi-wavelength long-lasting and fastly decaying afterglow emission. GRBs allows us to study a rich, complex and fascinating physics with the goals to put some constraints on the demography of stellar-mass BHs & NSs over cosmic times, to improve our understanding on the physics of relativistic jets (e.g. particle acceleration and emission processes, jet structures & energetics, interactions with surroundings).

The French-Chinese Space-based multi-band Variable Object Monitor (SVOM) mission launched in June 2024 is dedicated to the study of GRBs as well as other high-energy transients (e.g. tidal disruption events, active galaxy nuclei, X-ray binaries, magnetar flares). To do so, the spacecraft embarks a suite of wide-field high-energy instruments and narrow-field X-ray & optical instruments. This space segment is complemented on ground with a dedicated network of robotic wide-/narrow-field telescopes in optical and/or nIR (see Figure 1).

Figure 1 – The SVOM mission with its space science payload and ground network of robotic telescopes.



The prime instrument onboard SVOM is the ECLAIRs camera (see Figure 2) in charge of autonomously detecting GRBs and other high-energy transients within its field of view (FoV) and providing their first localisation. It was built as a collaboration between several French labs (IRAP, CEA and APC) under the science lead of IRAP and a supervision by the French space agency CNES. ECLAIRs is a 2-D wide field ( $\sim 2$  sr i.e.  $89 \times 89$  sq. deg.) coded mask camera working in the 4 – 150 keV. ECLAIRs is made of a  $80 \times 80$  CdTe pixel array on top of which there is a coded mask made of opaque and transparent elements in X-rays. A passive shield made of layers of lead and copper surrounds the mask and detection plane in order to prevent background radiation from outside the field of view from reaching the detection plane.

The ECLAIRS mask pattern (see Figure 2) has been designed in such a way that depending on its position with respect to the instrument optical axis a bright X-ray source within the instrument FoV will project a unique shadow onto the detection plane (called a shadowgram) that is characteristic of its position in the sky. Deconvolution of the measured shadowgram by the mask pattern enables to reconstruct a sky image in which the source could be localized.

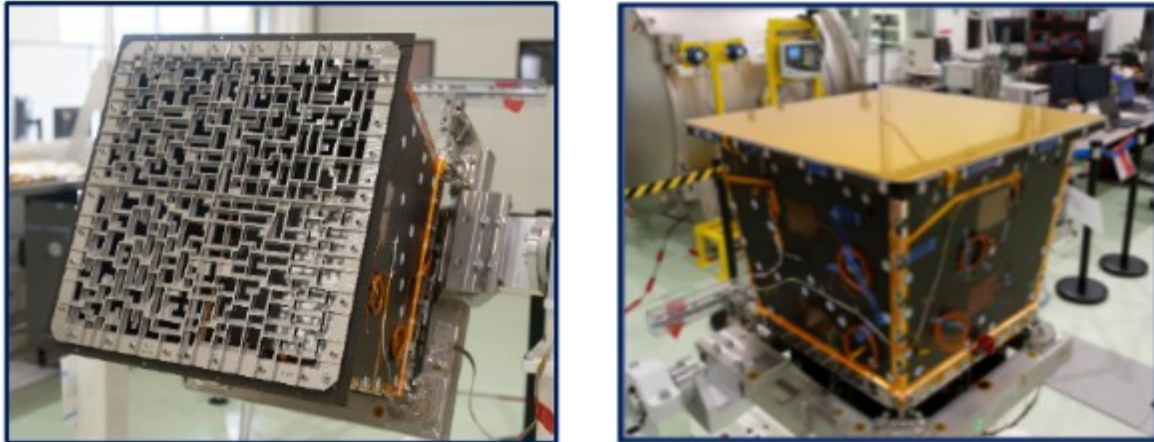


Figure 2 – Pictures of the ECLAIRS flight model. ECLAIRS is a coded-mask camera with a wide field of view (FoV) of 89x89 sq. degrees. The instrument is made of a coded mask placed at ~46 cm in front a pixelated CdTe detection plane (80x80 pixels).

Since the SVOM launch, ECLAIRS regularly detects and localizes various high energy transients within its FoV. However in some cases, bright GRBs detected by other HE missions and/or the SVOM/ Gamma-Ray Monitor are seen through the shield above ~50 keV indicating that these sources are located outside the ECLAIRS FoV. In such cases, ECLAIRS is currently unable to provide any localization for these events.

The main aim of the internship is to investigate methods to provide localization to events detected by ECLAIRS outside its field of view based on the signal measured on the detection plane. To do so, the intern will make use of the ECLAIRS suite of Monte-Carlo simulation codes. Both the accuracy and precision of the developed localization methods will be evaluated by using in-flight data from SVOM and other HE instruments.

During the internship, the student will learn more about the fascinating, rich and complex physics of GRBs, compact objects and accretion/ejection processes thanks to a collaborative work within the SVOM group at IRAP. He/she will learn about space missions and acquire solid skills in coding in Python and in Monte-Carlo simulation. The intern will also discover and participate to the life of a research laboratory.

If you are interested in applying to this internship, please contact me at [ogodet@irap.omp.eu](mailto:ogodet@irap.omp.eu).

## **References**

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