



The GRB Joint Scientific Analysis Pipeline of the ECLAIRs and GRM Instruments Onboard SVOM

F. Piron^{1,10} , F. Daigne^{2,3,10}, T. Maiolino^{1,10} , P. Maeght^{1,10}, U. Jacob^{1,10}, M. G. Bernardini^{1,4,10}, D. Corre^{2,10}, J. Wang^{2,10}, F. Lacreu^{2,10}, G. Tcherniatsky², L. Domisse², T. Barlyaeva¹, A. Maiolo¹, J.-L. Atteia⁵ , L. Bouchet⁵, M. Brunet⁵, J.-P. Dezalay⁵, O. Godet⁵ , S. Guillot⁵, H. Yang⁵, B. Arcier⁵, S. Mate⁵, N. Dagoneau⁶ , L. Jouvin⁶, K. Tazhenova⁶, T. Sadibekova⁷, P. Bacon⁸, N. Bellemont⁸, F. Cangemi⁸, A. Coleiro⁸, J. He⁹, Y. Huang⁹ , L. Li⁹, H. Shi⁹, J. Wang⁹, P. Wang⁹, L. Zhang⁹, X.-Y. Zhao⁹, and S. Zheng⁹

¹Laboratoire Univers et Particules de Montpellier, Université Montpellier, CNRS/IN2P3, F-34095 Montpellier, France; piron@in2p3.fr

²Sorbonne Université, CNRS, UMR 7095, Institut d'Astrophysique de Paris, 98 bis bd Arago, 75014 Paris, France; daigne@iap.fr

³Institut Universitaire de France, France

⁴INAF – Osservatorio Astronomico di Brera, Via Bianchi 46, I23807 Merate, LC, Italy

⁵Institut de Recherche en Astrophysique et Planétologie, Université de Toulouse/CNRS/CNES, 9 avenue du colonel Roche 31028 Toulouse, France

⁶CEA Paris-Saclay, Institut de Recherche sur les lois Fondamentales de l'Univers, 91191 Gif sur Yvette, France

⁷Université Paris-Saclay, Université Paris Cité, CEA, CNRS, AIM, 91191 Gif-sur-Yvette, France

⁸Université Paris Cité, CNRS, CEA, Astroparticule et Cosmologie, F-75013 Paris, France

⁹State Key Laboratory of Particle Astrophysics, Institute of High Energy Physics, Chinese Academy of Sciences, Beijing 100049, China

Received 2025 December 17; revised 2026 March 16; accepted 2026 March 23; published 2026 September 25

Abstract

The study of the prompt high-energy emission of Gamma-Ray Bursts (GRBs) with Space-based multi-band Variable Objects Monitor (SVOM) relies on the observations performed by ECLAIRs (4–150 keV) and the Gamma-Ray Monitor (GRM, 0.015–5 MeV), the two wide field-of-view instruments onboard the satellite. In this article, we introduce the *eclgrm* pipelines running at the French Science Center of SVOM, which combine the ECLAIRs and GRM data to generate scientific data products describing the GRB broad-band temporal and spectral properties. The architecture of the pipelines is presented, as well as their activation following each onboard trigger, and their workflow. The statistical data analysis methods employed by the pipelines are described, along with the scientific data products that are created in real time or from the full event data. We also present the *eclgrm-ui* user interface which allows the scientists on shift to monitor the automated data processings in the pipelines, and to optimize the analysis results interactively.

Key words: (stars:) gamma-ray burst: general – space vehicles: instruments – methods: data analysis

1. Introduction

The Space-based multi-band Variable Objects Monitor (SVOM) observatory (Cordier et al. 2026a; Li et al. 2026) is primarily dedicated to Gamma-Ray Burst (GRB) science (Wei et al. 2016). The two wide field-of-view (FoV) instruments onboard the satellite, the coded-mask camera ECLAIRs (4–150 keV, Godet et al. 2026) and the Gamma-Ray Monitor (GRM, 0.015–5 MeV, Sun et al. 2026), are monitoring the transient sky and detecting GRBs in X-ray and gamma-ray energy bands, allowing to characterize the temporal and spectral properties of the GRB high-energy prompt emission. The satellite of SVOM has been placed on a low-Earth orbit, with a quasi-anti solar pointing to favor rapid follow-up observations of SVOM GRBs by ground telescopes. This implies periodic passages of the Earth in the FoVs of the instruments onboard SVOM (Cordier et al. 2026a).

The ECLAIRs-GRM system represents a step forward in the spectral characterization of the population of long and short GRBs, allowing the investigation of a possible thermal component superimposed to their non-thermal emission (Bernardini et al. 2017) or of spectral breaks distinctive of synchrotron emission (e.g., Oganessian et al. 2017). The search for these additional components will benefit mainly from the ECLAIRs low-energy detection threshold at 4 keV, but also from the combination of ECLAIRs and GRM data covering a broad energy range. More than one hundred GRBs are detected each year by ECLAIRs and/or the GRM, which will also provide new insights on the GRB class, for example the spectral characterization of the short GRB sub-class showing a soft extended emission after the initial hard spike (Bernardini et al. 2017). The first GRB detections described in Daigne et al. (2026) already demonstrate the ability to characterize the GRB population in all its diversity.

In order to best exploit the potential of combining ECLAIRs and GRM observations of GRBs, two pipelines (*eclgrm-vhf*

¹⁰ These authors contributed equally to this work.

and *eclgrm-xband*) have been developed to analyze their data immediately once they are available at the SVOM French Science Center (FSC; Louvin et al. 2026). The pipelines have been deployed in Docker containers running at the FSC, and they use a common library of algorithms to create the Scientific Data Products (SDPs hereafter, see Claret et al. 2026; Louvin et al. 2026) characterizing the GRB prompt high-energy emission. A user interface (*eclgrm-ui*) has also been developed to monitor the data processings in the pipelines and, if needed, to restart some processes manually to refine the results:

1. The GRB quick analysis pipeline (*eclgrm-vhf*) processes the ECLAIRs and/or GRM count rate light curves that are built onboard following each GRB alert and quickly transmitted to the ground via VHF antennas (Cordier et al. 2026b). For each instrument, and also for the joint ECLAIRs and GRM analysis, the pipeline creates the related quick SDPs, which are used to promptly characterize the source and help validate the trigger as a genuine GRB.
2. The GRB complete analysis pipeline (*eclgrm-xband*) processes the ECLAIRs and GRM event data which are registered onboard and transmitted to the ground via X-band antennas several times per day (Yurong et al. 2026). The pipeline performs a complete temporal and spectral analysis of the GRB, for ECLAIRs alone and for the ECLAIRs-GRM system, and it creates the related X-band SDPs. The X-band SDPs that are based on GRM data only are computed by the GRM pipeline running at the GRM Instrument Center (GRM-IC) in China (Wang et al. 2026), using a similar methodology and a common SDP data model (Louvin et al. 2026).
3. The *eclgrm-ui* user interface is used by the ECLAIRs-GRM Instrument Scientist (ECLGRM-IS hereafter) on shift, who is an expert on the software for ECLAIRs and GRM data analysis. The role of the IS is to monitor the automated processings in the pipelines, to inspect the analysis results and improve them if needed, and to validate the output SDPs (Claret et al. 2026).

In Section 2 we describe the architecture of the pipelines. The quick and complete analysis pipelines are described in Sections 3 and 4, respectively. In Section 5, we summarize the functionalities of the user interface and their use by the ECLGRM-IS. Section 6 presents our conclusions and the possible future pipeline improvements. Table A1 in appendix lists all acronyms used in the article.

2. Pipeline Architecture and Activation

The onboard trigger and observation scenarios (ECLAIRs and/or GRM trigger, satellite autonomous slew to place bright GRB candidates detected onboard by ECLAIRs at the center

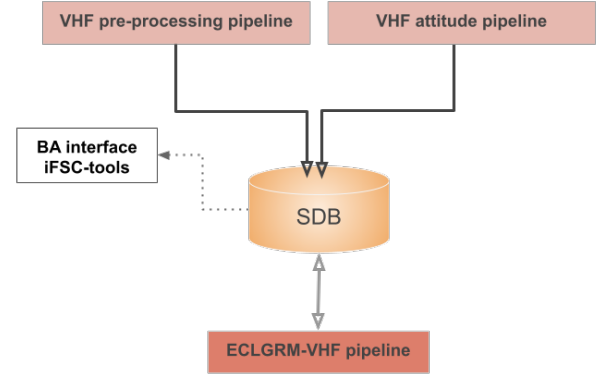


Figure 1. Functional diagram of the *eclgrm-vhf* pipeline. The two FSC pipelines in pink generate SDPs that are retrieved and used by the *eclgrm-vhf* pipeline through the FSC SDB.

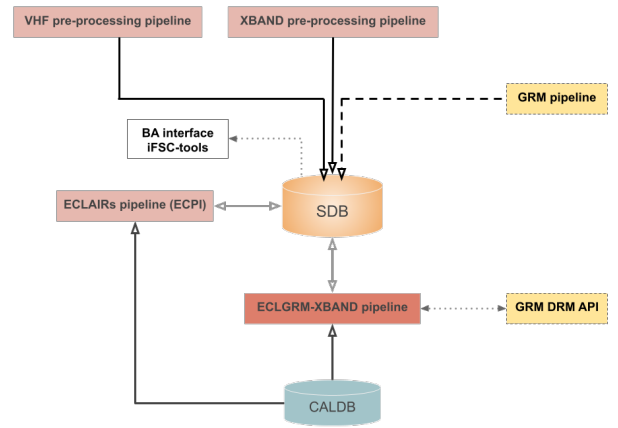


Figure 2. Functional diagram of the *eclgrm-xband* pipeline. The three FSC pipelines in pink create SDPs that are retrieved and used by the *eclgrm-xband* pipeline through the FSC SDB. The two services running at the GRM-IC (Wang et al. 2026; Zhao et al. 2026) are indicated in yellow: the GRM pipeline creates the GRM calibrated event data products, which are transferred to the FSC SDB, while requests to the GRM DRM API are sent directly.

of its FoV) result in different types of VHF and X-band data received on the ground and pre-processed upstream of the *eclgrm* pipelines. Depending on which input SDPs are available at a given time, the FSC orchestrator (Louvin et al. 2026) activates specific *eclgrm* processes, referred to as “targets” hereafter. The *eclgrm-vhf* pipeline features a total of three targets, while the *eclgrm-xband* pipeline features two targets. Besides this automated processing mode that is activated after each onboard trigger, the pipelines can also be restarted manually through the *eclgrm-ui* with different parameters.

Figures 1 and 2 show the functional diagrams of the *eclgrm-vhf* and *eclgrm-xband* pipelines, respectively. The pipelines need products from the FSC VHF or X-band pre-processing pipelines (Louvin et al. 2026), which convert the instrument and satellite raw data into SDPs in FITS format. Two other

FSC services are used: the Science Database (SDB) to fetch or send SDPs, and the Calibration Database (CALDB) to retrieve the ECLAIRs response files that are needed by the spectral analysis in the *eclgrm-xband* pipeline. In addition, the *eclgrm-xband* pipeline is fed with the ECLAIRs calibrated event data that are produced by the quick-look automated analysis of the ECLAIRs pipeline (ECPI, Goldwurm et al. 2026), and it has two external dependencies at the GRM-IC: (i) the GRM calibrated event data that are produced by the GRM pipeline and then transferred to the FSC SDB via the Chinese Science Center of SVOM (Yurong et al. 2026), and (ii) an API to retrieve the response files for the three Gamma-Ray Detectors (GRDs) of the GRM (Sun et al. 2026; Zhao et al. 2026).

Each target follows a standardized workflow consisting of a series of successive analysis tasks, each of them being designed to produce a specific set of SDPs. Each task operates as follows: retrieval of the SDP FITS templates, download of the input files, initialization of the task parameters, execution of the scientific algorithms, filling of the output SDP FITS files with the analysis results (computed physical quantities, see the next sections), and export to the SDB along with the ancillary files. The latter include figures and control plots, which are generated at each step of the data analysis sequence to assess the quality of the results. More details on the SDP level definition can be found in Yurong et al. (2026) and Claret et al. (2026), while Louvin et al. (2026) present the SDP data model and the use of their FITS templates.

3. The GRB Quick Analysis Pipeline

3.1. Purpose

The *eclgrm-vhf* pipeline uses the ECLAIRs and GRM data received via the VHF network to compute rapidly all the necessary SDPs to characterize the prompt high-energy emission of a GRB candidate in real time: GRB and background count light curves, emission duration, on-ground detection significance, peak fluxes, hardness ratios (HRs) and early classification (likely GRB type or other astrophysical event). This scientific analysis is very rapid and takes less than one minute, typically.

3.2. Activation Targets and Dependencies

The three pipeline targets are VHF-ECL and VHF-GRM, for processing ECLAIRs and GRM onboard light curves, respectively, and VHF-ECLGRM for the joint analysis. The input SDPs of the first two targets are created at the FSC (see Figure 1):

1. The VHF pre-processing pipeline provides the time and localization of the onboard alert(s), as well as the onboard count light curves (OBLCs). The OBLCs are built around the trigger time in different pre-defined

Table 1
Time Resolutions and Energy Bands in the *eclgrm-vhf* Pipeline

Time Resolutions and Energy Bands	VHF-ECL Target	VHF-GRM Target
OBLC pre-defined time resolutions (s)	low: 6.4 ; mid: 0.8 ; best: 0.1	low: 6.4 ; best: 0.8 ; high ^a : 0.001
OBLC pre-defined energy bands (keV)	1: 5–8 ; 2: 8–20 ; 3: 20–50 ; 4: 50–120	1: 4–550 ; 2: 550–5000
QT90 default energy band	1+2+3+4	1
QHR default energy bands	4/1 ; 4/2 ; 4/(1+2)	2/1
VHF-ECLGRM target		
QHR default energy bands	(GRM 2)/(ECL 1+2+3+4), (GRM 1)/(ECL 1), (GRM 1)/(ECL 1+2)	

Notes. The mid and best time resolutions for the OBLCs are available only in a limited time interval around the trigger time. The OBLC time resolutions and energy bands are pre-defined onboard. The QT90 and QHR energy bands are the default values used in the pipeline automated mode.

^a The high time resolution GRM OBLC covers an interval of ± 2 s around the trigger time, and is built from the sum of the three GRD count rates. This light curve is rebinned with a 50 ms time resolution that is adapted to GRB durations smaller than 0.8 s.

energy bands and with pre-defined time resolutions (see Table 1).

2. The VHF attitude pipeline provides the SDPs containing the satellite attitude and orbital position, which are unevenly sampled around the trigger time.

The number of activated targets and the corresponding data flow and SDP outputs depend on the SVOM trigger scenario (He et al. 2026; Schanne et al. 2026):

1. The VHF-ECL target is activated when ECLAIRs OBLCs are available in the FSC SDB, which happens only if ECLAIRs is triggered over a timescale shorter than 10 minutes.
2. The VHF-GRM target is always activated since GRM OBLCs are built in all trigger scenarios. In the specific case where ECLAIRs triggers first, the GRM trigger is inhibited (to download only the best alert localization to the ground), and the possible GRM detection of the GRB candidate is assessed by the *eclgrm-vhf* pipeline.

The successive tasks executed by the *eclgrm-vhf* pipeline for the VHF-ECL and VHF-GRM targets are described below. For the VHF-ECLGRM target, only the HR and early classification tasks are performed.

3.3. Temporal Analysis Tasks

The Quick Light Curve (QLC) task first creates informative plots to help understand the observational context around the trigger time: summary of ECLAIRs onboard alert(s), pointing

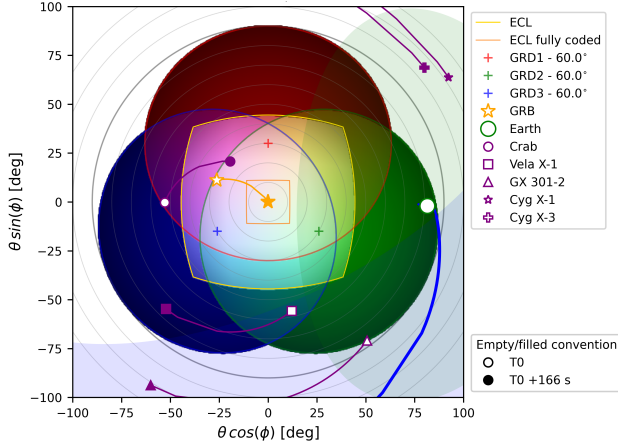


Figure 3. GRB 250205A (burst-id sb25020504) in the ECLAIRs and GRM FoVs: localization in the partially- and fully-coded FoVs of ECLAIRs, and in the GRD FoVs (with a radius arbitrarily set to 60°). The GRB trajectory is displayed from the trigger time T_0 (empty orange star) to the end of the slew (filled orange star), as well as bright known X-ray sources. The sky portions occulted by the Earth at these times are displayed by the light green and blue shaded areas, respectively.

directions of the instruments, angular positions of the GRB and of nearby known X-ray sources in the FoVs of ECLAIRs and of the three GRDs (see Figure 3), GRB angular distance to the Earth's limb, and possible source occultation by the Earth. Then, it creates count light curves (CLCs) in different energy bands from the OBLCs, using the best (smallest) time resolution available at any time. By using the Bayesian Blocks method (Scargle et al. 2013), it identifies the two optimal background time intervals (before and after the GRB signal) for each CLC, along with the best-fit background model, and it calculates the background-subtracted count light curves (BSCLCs). Currently, the pipeline considers two background models: Model-T, a polynomial function of time, and Model-E, a polynomial function of the cosine of the angle $\theta_E(t)$ between the detector's main axis and the direction of Earth's center. Both models have been tested using GEANT4 simulations of the main sources of background in orbit: the cosmic X-ray background (CXB), its reflection on the Earth's atmosphere, and the Earth's albedo (Mate et al. 2019; Maiolo 2023). As the SVOM satellite follows a quasi-antisolar pointing, the sky fraction occulted by the Earth varies along the orbit and modulates the background rate (see Godet et al. 2026). These variations can be more rapid in case of slew, where Model-T often fails while Model-E provides good background fits, as shown in Figure 4.

The Quick T90 duration (QT90) task estimates the GRB signal duration in a selected energy band (see Table 1). Following the QLC task, it simulates one thousand CLCs through Poisson resampling, and background-subtracted cumulative count light curves (BSCCLCs). The plateau at the end of each BSCCLC is identified automatically (see Figure 5), allowing to compute the

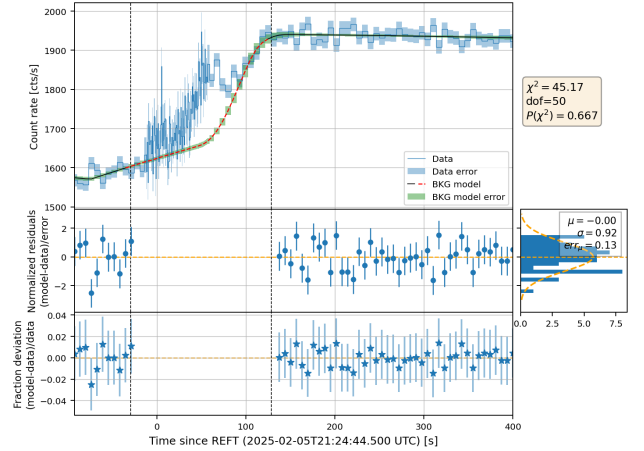


Figure 4. GRB 250205A (burst-id sb25020504) automated analysis by the *eclgrm-vhf* pipeline: the top panel shows the CLC in the GRM/GRD1 4–550 keV energy band. The two background intervals (left and right) are indicated, as well as the best-fit background Model-E. The mid and bottom panels show the normalized residuals of the fit and the deviation between the background data and the best-fit model, respectively.

distribution of the times t_x at which $x\%$ of the total signal counts is reached, and the distribution of the durations $QT_{90} = t_{95} - t_{05}$, $QT_{80} = t_{90} - t_{10}$, and $QT_{50} = t_{75} - t_{25}$, which contain 90%, 80%, and 50% of the GRB counts, respectively. The final times and durations are given as the median of their respective distributions, with 68% confidence intervals. The QT90 task also calculates the on-ground significance of the GRB signal in the QT_{90} time interval following the prescription of Vianello (2018).

3.4. Final Tasks

The Quick Peak Flux (QPF) task computes, for each BSCLC generated by the QLC task, the maximum count rate (in counts s^{-1}) along with its respective error, and the time at which this peak is observed.

The Quick Hardness Ratio (QHR) task computes the ratio of the total numbers of signal counts in the QT_{90} time interval between two energy bands (high/low) as defined in Table 1.

The Crude Classification (CRCLASS) task is being developed to classify ECLAIRs and GRM triggers automatically (as long or short GRBs, magnetar flares, solar flares, particle events, etc.) through a Bayesian classification scheme based on the onboard information and VHF products from the previous tasks.

4. The GRB Complete Analysis Pipeline

4.1. Purpose

The *eclgrm-xband* pipeline uses the ECLAIRs and GRM complete event data to perform a full temporal and spectral study of the GRB prompt high-energy emission, and to create the related X-band SDPs: light curves in different energy bands, final estimates of the emission duration, time-integrated and time-resolved reconstruction of the GRB photon spectra

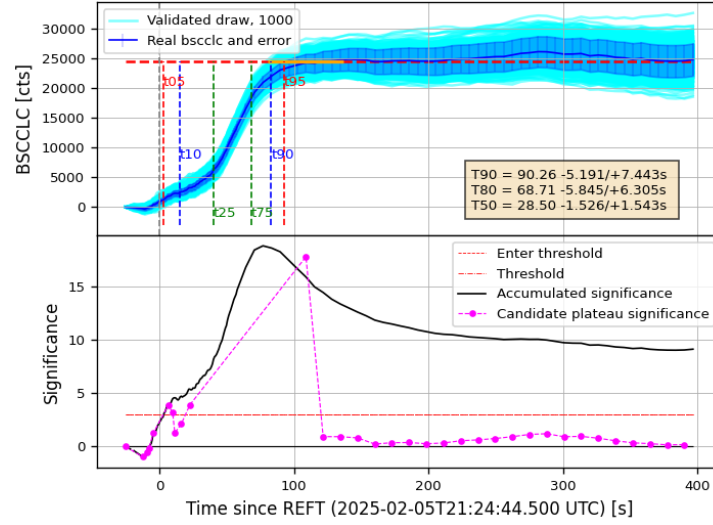


Figure 5. GRB 250205A (burst-id sb25020504) automated analysis by the *ecigrm-vhf* pipeline: the top panel shows the BSCCLC (in blue) in the GRM 4–550 keV energy band. The 1000 BSCCLCs simulated through resampling are shown in cyan. The horizontal dashed red line indicates the GRB count fluence. The bottom panel shows the significance of the accumulated signal between the current plateau and a new plateau candidate (magenta filled circles), and from the start of the light curve (black line).

(assuming different models) and associated by-products (broad-band spectral energy distribution, fluxes and fluences), time-dependent HRs, and spectral lags. It also computes the rest-frame luminosity and energetics if the source redshift has been measured. The analysis of ECLAIRs data takes a few minutes only, while the joint analysis of ECLAIRs and GRM data can be completed in 15 minutes, typically.

4.2. Activation Targets and Dependencies

The two pipeline targets are XBAND-ECL to process ECLAIRs data, and XBAND-ECLGRM for a joint analysis with the GRM. Their input SDPs are created at or outside the FSC (see Figure 2):

1. The FSC VHF pre-processing pipeline provides the onboard alert information (see Section 3).
2. The FSC X-band pre-processing pipeline provides the ECLAIRs non-calibrated event data, as well as the satellite attitude and orbital position sampled every second.
3. The FSC ECPI pipeline (Goldwurm et al. 2026) provides the ECLAIRs calibrated event data (ECL-EVT-CAL). Moreover, the *ecigrm-xband* container includes the ECPI software to call specific modules directly.
4. The GRM pipeline (Wang et al. 2026) provides the calibrated event data of each GRD (GRM-EVT-TRIG).
5. The FSC CALDB (Louvin et al. 2026) provides the ECLAIRs response files (on-axis effective area, off-axis efficiency, energy redistribution).
6. The GRM DRM API (Zhao et al. 2026) provides the Detector Response Matrix (DRM) of each GRD, which is

computed for each GRB to account for the indirect signal induced by the scattering of the source photons on the Earth’s atmosphere. Unlike the previous services whose output products are retrieved from the FSC SDB, this API is called directly by the *ecigrm-xband* pipeline (see Figure 2).

The XBAND-ECL target is activated if ECLAIRs is triggered and if ECL-EVT-CAL event data are available in the FSC SDB. If successful, then the XBAND-ECLGRM target is activated provided GRM-EVT-TRIG event data are available as well. The successive tasks described below are performed for each target (unless otherwise specified).

4.3. Temporal Analysis Tasks

The Merge (MRG) task is specific to the XBAND-ECL target. It creates the missing ECLAIRs calibrated event files (if any) by running the EPCI software, and merges them into a single file (ECL-EVT-CAL-MRG). Then, it identifies the pixels and surface of the ECLAIRs detection plane that were illuminated by the GRB before the satellite slew, where the source position is stable in the FoV.

The ECLAIRs Position (PO_ECL) task first creates informative plots, like the QLC task (see Section 3). The task is called a second time after the T90 task (see below) to compute the GRB position through image deconvolution by running the ECPI/IMAG module (Goldwurm et al. 2026) on the ECLAIRs T_{90} time interval.

The CLC task bins ECLAIRs and GRM calibrated event data in time and in different energy bands. Unlike VHF OBLCs, the time resolution of the X-band CLCs and their energy bands can be set freely. Moreover, the ECLAIRs CLCs

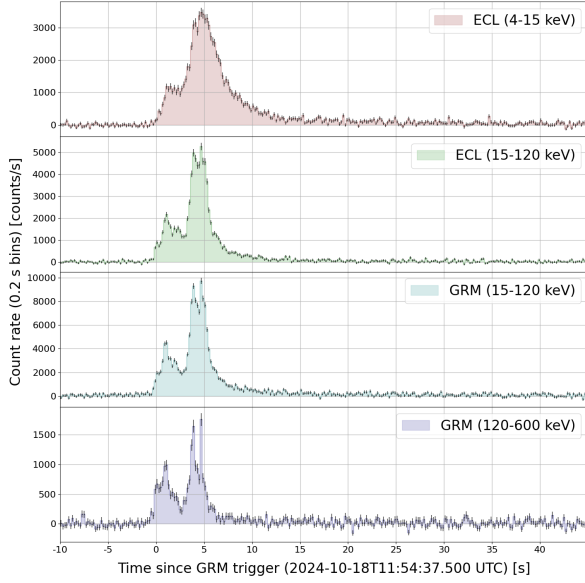


Figure 6. GRB 241018A (burst-id sb24101802) analysis by the *ecigrm-xband* pipeline: BSCLCs in ECLAIRs and the GRM in different energy bands. The ECLAIRs light curves are based on the detection plane pixels illuminated by the GRB.

can be built by considering only the pixels in the detector plane which were illuminated by the GRB. This method reduces the background noise while preserving most of the source signal. In automated mode, the *ecigrm-xband* pipeline uses the low/mid/best time resolutions defined in Table 1, and the following energy bands (in keV): 4–20, 20–50, 50–80, 80–120, 4–120 for ECLAIRs; and 15–50, 50–300, 300–550, 550–5000, 15–550 for the GRM. Once created, the CLCs are analyzed with the same algorithms as in the QLC task (see Section 3), as shown by the BSCLCs in Figure 6.

The T_{90} duration task estimates the GRB T_{90} , T_{80} and T_{50} durations, as well as the on-ground significance, of the GRB signal from the BSCLCs of ECLAIRs and GRM, with the same algorithms as in the QT90 task (see Section 3). In automated mode, these quantities are computed in the 4–120 keV and 50–300 keV energy bands for ECLAIRs and the GRM, respectively. In addition, the T_{90} task defines the time intervals (episodes hereafter) for the time-integrated (over the ECLAIRs T_{90} by default) and time-resolved spectral analyses.

4.4. Spectral Analysis Tasks

For each episode, the CSP, BCSP, ICSP, DRM and IDRM tasks compute the input SDPs of the spectral analysis. Nearly logarithmic pulse-invariant (PI) energy channels are first defined, which follow the instrument’s energy resolution. Then, two techniques are employed to build the count spectra: the counting technique, which is suitable for the GRM and can also be used for ECLAIRs, and the imaging technique, which is preferred for ECLAIRs. In the counting technique, calibrated event data (ECL-

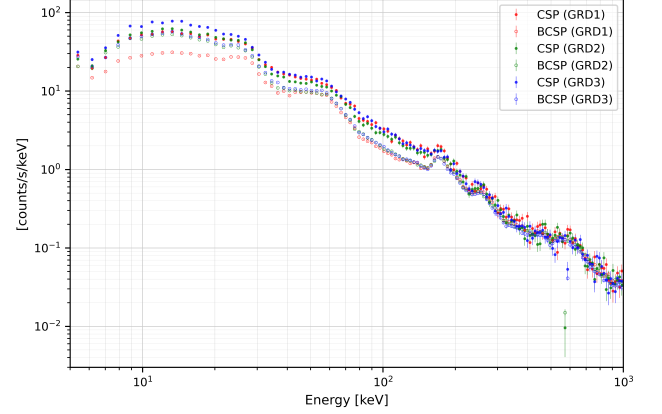


Figure 7. GRB 241018A (burst-id sb24101802) analysis by the *ecigrm-xband* pipeline: time-integrated total count spectra (CSP, filled circles) and background count spectra (BCSP, open circles) in the three GRD detectors of the GRM, for the time interval corresponding to the GRB T_{90} duration in ECLAIRs.

EVT-CAL-MRG and GRM-EVT-TRIG) are binned to produce the total count spectrum (CSP task) in each detector. The corresponding background count spectra (BCSP task) are obtained by creating a CLC for each channel, and fitting it in the background time intervals defined by the CLC task, using a Poisson likelihood to account for possibly low count rates (see Figure 7). In the imaging technique, one single GRB count spectrum (ICSP task) is built by running the ECPI/SPEX module (Goldwurm et al. 2026) on a selected range of energy channels. Finally, the DRMs that are appropriate for each technique (DRM or IDRM tasks) are obtained from the ECLAIRs CALDB or from the GRM DRM API, and rebinned to match the energy channels.

For each episode, the spectral (SP) analysis task uses the Python interface of the Xspec software¹¹ to compute the GRB photon spectrum (in $\text{ph cm}^{-2} \text{s}^{-1} \text{keV}^{-1}$), assuming different spectral models. While custom models will be available in manual mode, the automated mode considers only three models: the Band function (Band et al. 1993) and its asymptotic limits (power-law with or without exponential cutoff). The three spectral fits are performed using the proper statistics, namely *pgstat* or *chi* statistics¹² for count spectra obtained with the counting or imaging technique, respectively. Since these models are nested, the SP task then performs a likelihood ratio test to identify the best-fit model. Finally, the task computes the associated (photon and energy) fluxes and fluences in various energy bands.

Figure 8 shows the time-integrated count spectra of GRB 241018A in ECLAIRs and the GRM, jointly fitted by the Band model from 5 keV to 1 MeV (SP task of the XBAND-ECLGRM target). The high quality of the fit is indicated by the low value of the reduced fit statistics (1.3), and by the good residuals across

¹¹ <https://heasarc.gsfc.nasa.gov/docs/software/xspec/index.html>

¹² See Appendix B of the Xspec documentation: <https://heasarc.gsfc.nasa.gov/docs/software/xspec/manual/XspecManual.html>

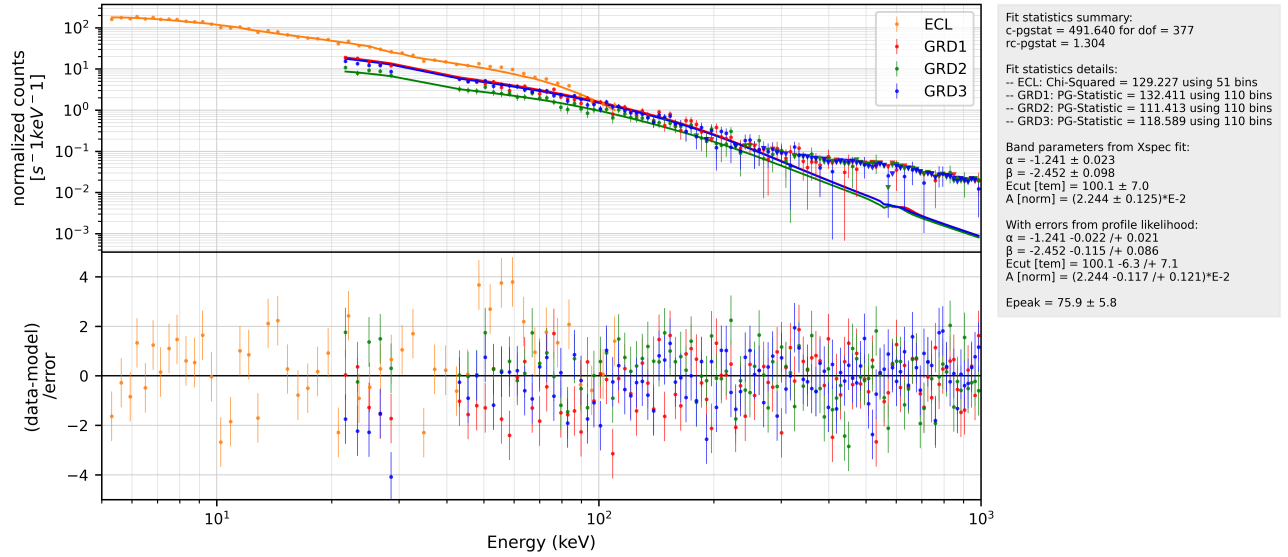


Figure 8. GRB 241018A (burst-id sb24101802): time-integrated joint spectral fit of ECLAIRS and GRM data with the Band function from 5 keV to 1 MeV, for the time interval corresponding to the GRB T_{90} duration in ECLAIRS. The top panel displays the GRB count spectrum in ECLAIRS obtained with the ECPI/SPEX module (Goldwurm et al. 2026), and the background-subtracted count spectrum in each GRD of the GRM (from the CSP–BCSP difference). Triangles indicate 95% upper limits for the energy channels lacking significant signal. The continuous curves show the count spectra that are predicted in the detectors by folding the best-fit Band model with their spectral responses. The bottom panel shows the normalized residuals of the joint fit. The GRM *pgstat* and ECLAIRS *chi* statistics are combined in the fit as described in the legend, which also gives the best-fit parameters and their 68% errors obtained either from the error matrix or from their profile likelihood.

the whole spectrum, without adding any systematic uncertainties on the spectral responses despite the high signal-to-noise ratio of the spectrum and the flux statistical accuracy of a few percent only. According to the SVOM mission high-level requirements, the ECLAIRS and GRM flux calibration should be precise to $\pm 20\%$ for transient sources (in their nominal energy range). The fit displayed in Figure 8 is thus remarkable, since systematic errors that are much smaller than the requirements would suffice to flatten the residuals.

4.5. Final Tasks

For each episode, the HR task computes the ratio between two energy bands (high/low) of the GRB signal measured in counts, photon fluence and energy fluence. In automated mode, the HR task uses the following high/low energy bands (in keV): [80–120]/[4–20], [80–120]/[20–50] and [80–120]/[50–80] for the XBAND-ECL target, and [50–300]/[4–120] for the XBAND-ECLGRM target.

The LAG task computes the time lags between the CLCs (from the CLC task) in separate energy bands, following the method developed by Bernardini et al. (2015). For each pair of light curves, a modified cross-correlation function (CCF, Band et al. 1997) is calculated for a series of time delays, and the lag is defined as the time delay that maximizes the CCF. The uncertainties on the CCF are derived by applying a flux-randomization method (Peterson et al. 1998). In automated mode, the LAG task uses the same high/low energy bands as the HR task.

5. The User Interface for the ECLAIRS-GRM Instrument Scientist

The *eclgrm-ui* user interface lists all the processes executed in the *eclgrm* pipelines (see Figure 9). Each process corresponds to a given SVOM burst-id and to a given *eclgrm* target. The burst-id is generated by the FSC VHF manager (Louvin et al. 2026) for each new GRB candidate that triggered ECLAIRS and/or the GRM. In automated mode, each target can be executed several times, as complementary VHF or X-band data are received on ground and the *eclgrm* input SDPs are updated in the SDB by the FSC pre-processing or ECPI pipelines. The *eclgrm-vhf* and *eclgrm-xband* pipelines run sequentially, queuing each new process until the current one completes.

The *eclgrm-ui* user service has several functionalities. It gives access to the configuration file and log of each process, and offers a dedicated dashboard for each of the five targets to visualize the analysis results and their associated control plots. Moreover, the ECLGRM-IS can restart part or all of the analysis tasks interactively through the *eclgrm-ui* configuration editor, to optimize the results with a different choice of parameters. In this manual mode, the output SDPs are sent to the FSC SDB only if desired, which automatically shares them with the SVOM Burst Advocate through the iFSC-Tools (see Figures 1 and 2). The ECLGRM-IS is responsible for the validation of the *eclgrm* SDPs, for their report in General Coordinates Network (GCN) circulars and for their display in the SVOM GRB public table (Claret et al. 2026).

Process table

Filter: sb24082109

Last run: sb24082109 Cron queue: 1

Burst id	Trigger time [UTC]	Target	Proc ver	Proc date [UTC]	Proc type	Status	Obs id	Pass id
sb24082109	2024-08-21T18:35:55.270	ECLGRM-VHF-ECL	v5	2025-12-01T15:49:15	user	Complete		
sb24082109	2024-08-21T18:35:55.270	ECLGRM-VHF-ECLGRM	v8	2025-12-01T15:50:29	default	Complete	2566914140	n.a.
sb24082109	2024-08-21T18:36:02.700	ECLGRM-VHF-GRM	v3	2025-12-01T15:45:32	user	Complete		
sb24082109	2024-08-21T18:35:55.270	ECLGRM-XBAND-ECL	v6	2025-10-22T14:12:10	user	Complete	1996490421	000899_SYNC
sb24082109	n.a.	ECLGRM-XBAND-ECLGRM	v4u02	2025-11-17T18:12:35	user	Complete	1996490421	n.a.
		ECLGRM-XBAND-ECLGRM	v4u01	2025-11-17T17:56:23	user	Complete	1996490421	n.a.
		ECLGRM-XBAND-ECLGRM	v4	2025-10-22T14:37:04	default	Complete	1996490421	n.a.
		ECLGRM-XBAND-ECLGRM	v3	2025-06-02T08:57:42	default	Complete	1996490421	n.a.
		ECLGRM-XBAND-ECLGRM	v2	2025-04-22T14:23:36	default	Complete	1996490421	n.a.
		ECLGRM-XBAND-ECLGRM	v1	2024-12-19T06:15:54	default	Complete	1996490421	000899_SYNC

Figure 9. Main page of the *eclgrm-ui* user interface, for GRB 240821A (burst-id sb24082109). Different target executions (processes) are displayed, with four buttons (right side) to access the log, the internal dictionary, the dashboard and the analysis configuration editor (gear wheel). Processes marked as v[n]u[mm] correspond to the manual reprocessings where the output SDPs were not sent to the FSC SDB.

6. Conclusions

The two *eclgrm* data processing pipelines have been running at the FSC since the launch of the SVOM satellite on 2024 June 22. They produce the (real-time) VHF and (complete) X-band SDPs (light curves, durations, spectra, etc.) related to the GRB prompt high-energy emission (from 4 keV to 5 MeV), combining the ECLAIRs and GRM observations in joint analyses. For each GRB candidate detected by both instruments, the *eclgrm* pipelines generate more than forty SDPs and store them in FITS format in the FSC SDB.

The *eclgrm-ui* user interface has been also used extensively to monitor the data processings in the pipelines and to refine the results whenever needed. The three *eclgrm* services thus allow the ECLGRM-IS to support SVOM Burst Advocate activity in real time, to contribute to the GCN circulars on ECLAIRs and GRM, and to provide scientifically-validated products for the SVOM GRB public table.

While the main functionalities of the pipelines are in place, and their performance was demonstrated on past GRB events, more developments are envisaged to complement the existing products. Not exhaustively, this includes computing the emission durations in additional energy bands, improving the classification algorithm, developing an automated identification of the emission episodes for the time-resolved spectral analysis, and accounting for the systematic uncertainties on the spectral responses (as discussed in Godet et al. 2026) in the reconstruction of GRB spectra.

Acknowledgments

The Space-based multi-band Variable Objects Monitor (SVOM) is a joint Chinese-French mission led by the Chinese National Space Administration (CNSA), the French Space Agency (CNES), and the Chinese Academy of Sciences (CAS). We gratefully acknowledge the unwavering support of NSSC, IAMCAS, XIOPM, NAOC, IHEP, CNES, CEA, and CNRS.

Appendix List of Acronyms

The following table expands and defines all of the acronyms that are used in the main text of this article.

Table A1
List of Acronyms and their Definition

Acronym	Definition
API	Application Programming Interface
CALDB	Calibration Database
BSCLC	Background-Subtracted Count Light Curve
BSCCLC	Background-Subtracted Cumulative Count Light Curve
BCSP	Background Count Spectrum (Counting Technique)
CCF	Cross-Correlation Function
CLC	Count Light Curve
CSP	Total Count Spectrum (Counting Technique)
CRCLASS	Crude Classification
DRM	Detector Response Matrix (Counting Technique)
ECL-EVT-CAL	ECLAIRs Calibrated Event Data

Table A1
(Continued)

Acronym	Definition
ECLGRM	ECLAIRs-GRM System
ECLGRM-IS	ECLGRM Instrument Scientist
ECLGRM-VHF	ECLGRM Quick Analysis Pipeline (VHF data)
ECLGRM-XBAND	ECLGRM Complete Analysis Pipeline (X-band data)
ECLGRM-UI	ECLGRM User Interface
ECPI	ECLAIRs Pipeline
FSC	French Science Center
GCN	General Coordinates Network
GRM	Gamma-Ray Monitor
GRM-EVT-TRIG	GRM Calibrated Event Data
GRM-IC	GRM Instrument Center
GRD	Gamma-Ray Detector
HR	Hardness Ratio
ICSP	Source Count Spectrum (Imaging Technique)
IDRM	Detector Response Matrix (Imaging Technique)
IS	Instrument Scientist
MRG	Merge
OBLC	Onboard Light Curve
QHR	Quick Hardness Ratio
QLC	Quick Light Curve
QPF	Quick Peak Flux
SDB	Science Database
SDP	Scientific Data Product
SP	Spectrum
VHF-ECL	ECLAIRs Target of the <i>eclgrm-vhf</i> Pipeline
VHF-ECLGRM	ECLGRM Joint Target of the <i>eclgrm-vhf</i> Pipeline
VHF-GRM	GRM Target of the <i>eclgrm-vhf</i> Pipeline
XBAND-ECL	ECLAIRs Target of the <i>eclgrm-xband</i> Pipeline
XBAND-ECLGRM	ECLGRM Joint Target of the <i>eclgrm-xband</i> Pipeline

ORCID iDs

F. Piron  <https://orcid.org/0000-0001-6885-7156>
T. Maiolino  <https://orcid.org/0000-0002-4918-7182>
J.-L. Atteia  <https://orcid.org/0000-0001-7346-5114>
O. Godet  <https://orcid.org/0000-0001-7635-9544>
N. Dagoneau  <https://orcid.org/0000-0002-1361-2562>
Y. Huang  <https://orcid.org/0000-0002-3515-9500>

References

- Band, D. L., Matteson, J., Ford, L., et al. 1993, *ApJ*, **413**, 281
Band, D. L. 1997, *ApJ*, **486**, 928
Bernardini, M. G., Ghirlanda, G., Campana, S., et al. 2015, *MNRAS*, **446**, 1129
Bernardini, M. G., Xie, F., Sizun, P., et al. 2017, *ExA*, **44**, 113
Claret, A., Turpin, D., Moreau, C., et al. 2026, *RAA*, **26**, 104033
Cordier, B., Wei, J. Y., Zhang, S. N., et al. 2026a, *RAA*, **26**, 104001
Cordier, B., Jeannin, L., Lafabrie, P., et al. 2026b, *RAA*, **26**, 104006
Daigne, F., Turpin, D., Atteia, J.-L., et al. 2026, *RAA*, **26**, 104035
Godet, O., Atteia, J.-L., Schanne, S., et al. 2026, *RAA*, **26**, 104007
Goldwurm, A., Bacon, P., Bellemont, N., et al. 2026, *RAA*, **26**, 104011
He, J., Sun, J.-C., Huang, Y., et al. 2026, *RAA*, **26**, 104019
Li, D., Zhang, Y., Su, R., et al. 2026, *RAA*, **26**, 104002
Louvin, H., Corre, D., Formica, A., et al. 2026, *RAA*, **26**, 104032
Maïolo, A. 2023, PhD thesis, Université Montpellier
Mate, S., Bouchet, L., Atteia, J.-L., et al. 2019, *ExA*, **48**, 171
Oganesyan, G., Nava, L., Ghirlanda, G., & Celotti, A. 2017, *ApJ*, **846**, 137
Peterson, B. M., Wanders, I., Horne, K., et al. 1998, *PASP*, **110**, 660
Scargle, J. D., Norris, J. P., Jackson, B., & Chiang, J. 2013, *ApJ*, **764.2**, 167
Schanne, S., Château, F., Dagoneau, N., et al. 2026, *RAA*, **26**, 104010
Sun, J.-C., Dong, Y.-W., He, J., et al. 2026, *RAA*, **26**, 104018
Vianello, G. 2018, *ApJS*, **236**, 17
Wang, P., Zhang, L., Wang, J., et al. 2026, *RAA*, **26**, 104021
Wei, J., Cordier, B., Antier, S., et al. 2016, arXiv:1610.06892
Yurong, L., Meng, B., & Mingyue, W. 2026, *RAA*, **26**, 104004
Zhao, X.-Y., He, J., Zheng, S.-J., et al. 2026, *RAA*, **26**, 104020