Status of ECLGRM software and pipelines

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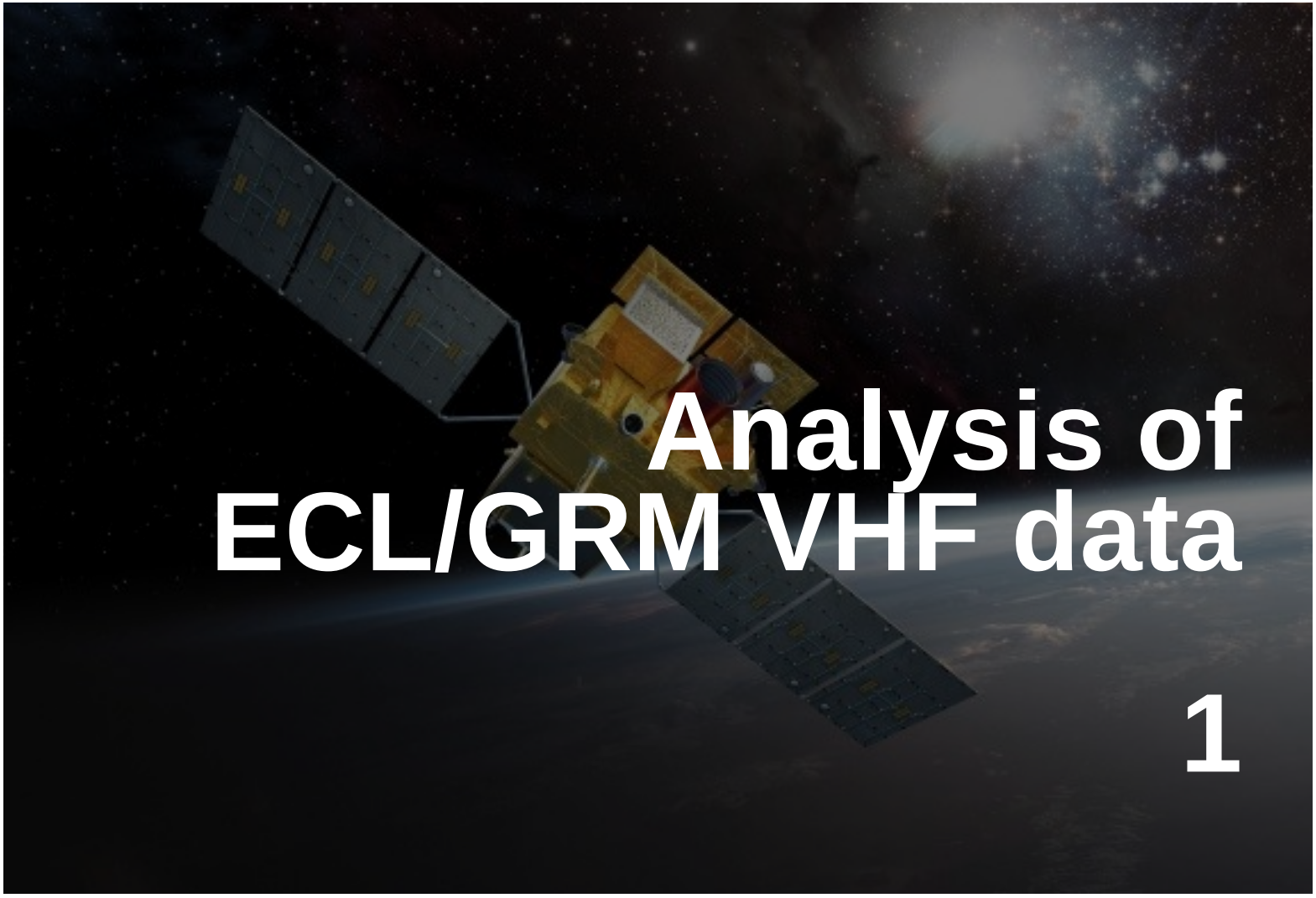
ECLAIRs science meeting - 08/01/2026



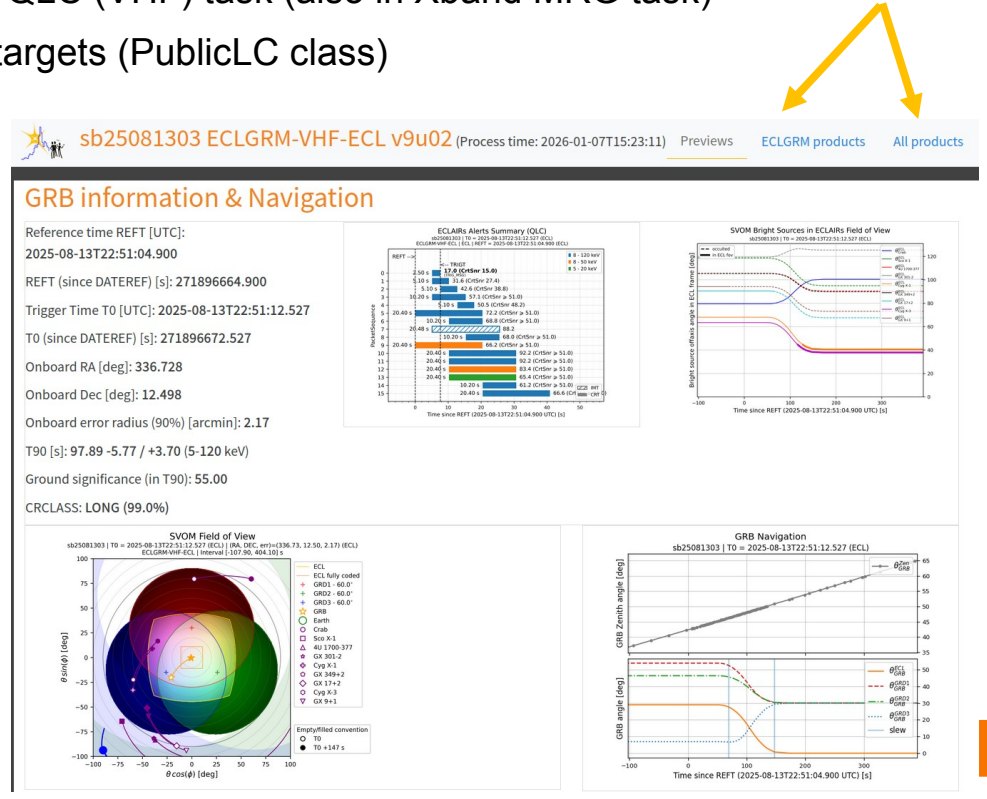
Analysis of ECL/GRM VHF data

1

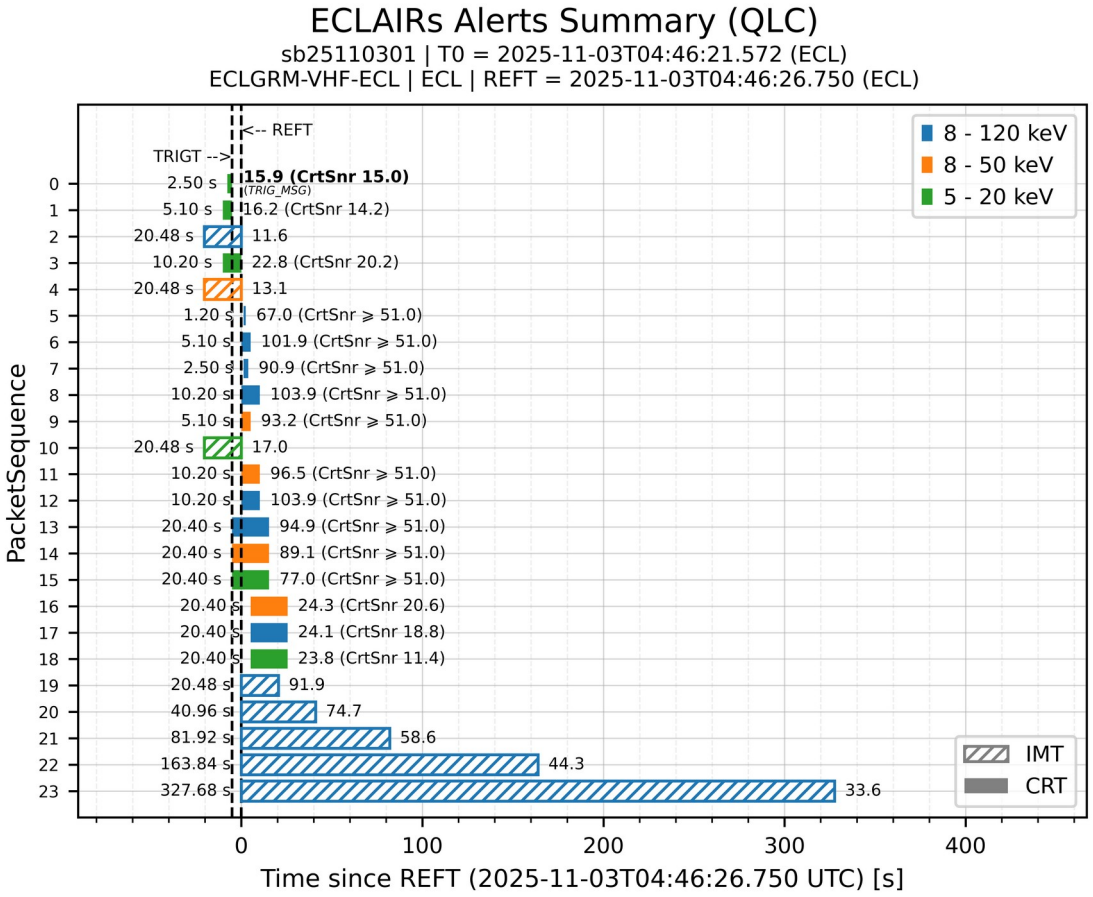
Recent developments: pipeline and user interface

- ECLGRM-VHF pipeline: v1.5.1 in production since December 8 (eclgrm-tools v1.10.1)
  - 4 upgrades since KP-2 (v1.2.0)
  - New summary plot of all ECL alerts in QLC (VHF) task (also in Xband MRG task)
  - Public light curves for ECL and GRM targets (PublicLC class)
    - ECL+GRM ongoing

- ECLGRM User Interface
  - Finalized VHF dashboards



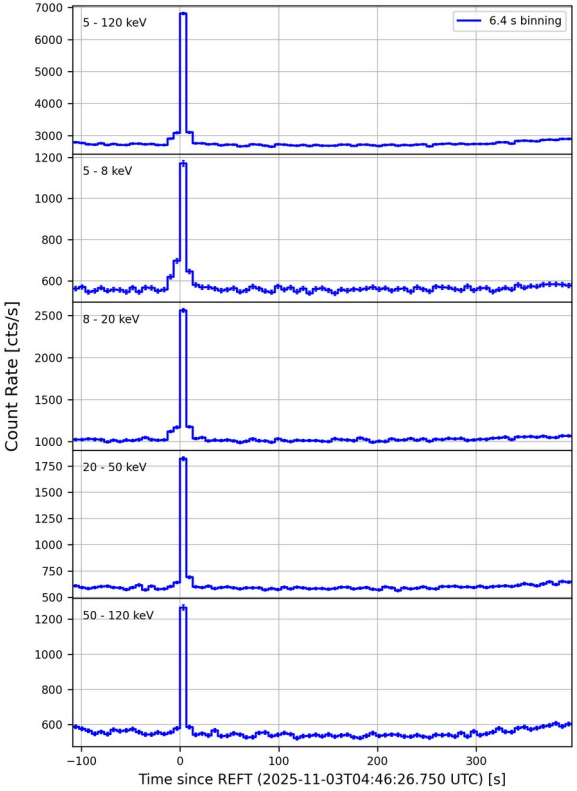
Summary plot of ECLAIRs alerts



Public light curves (ECLAIRs)

SVOM/ECLAIRs on-board lightcurve (VHF data)

sb25110301



SVOM/ECLAIRs on-board lightcurve (VHF data)

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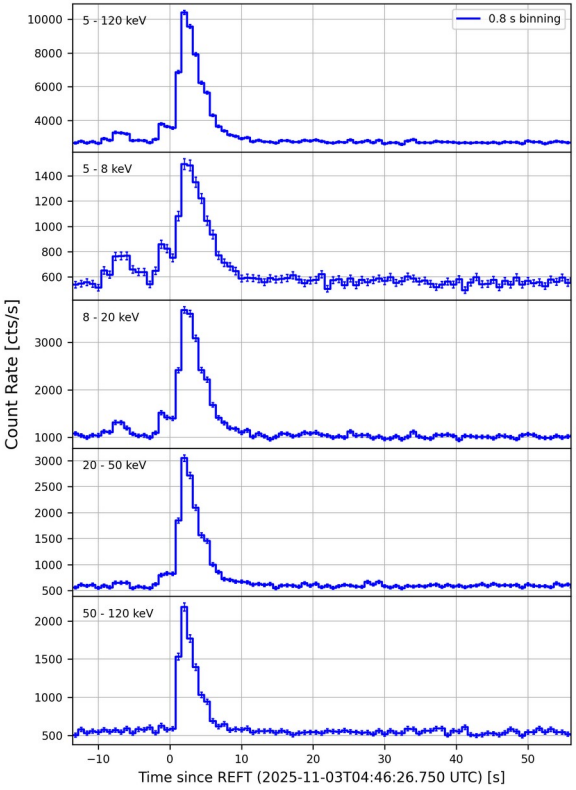

SVOM/ECLAIRs on-board lightcurve (VHF data)

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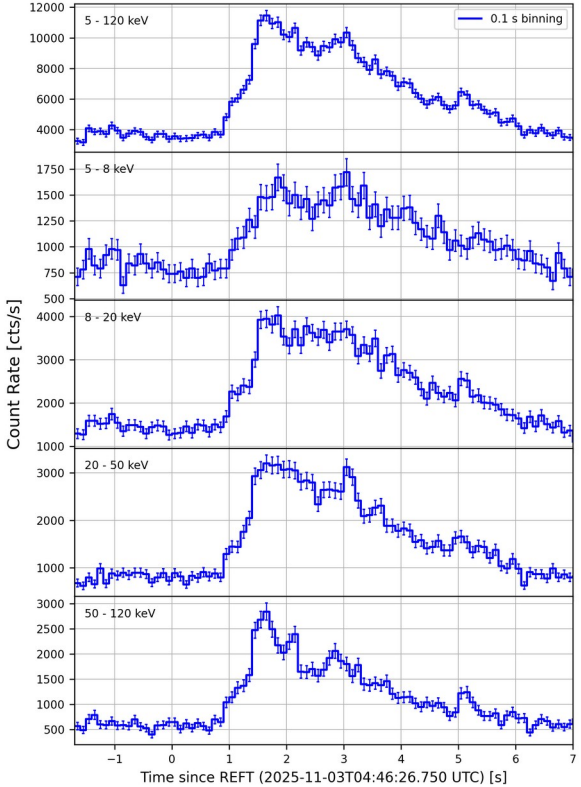

Public light curves (GRM)

SVOM/GRM on-board lightcurve (VHF data)

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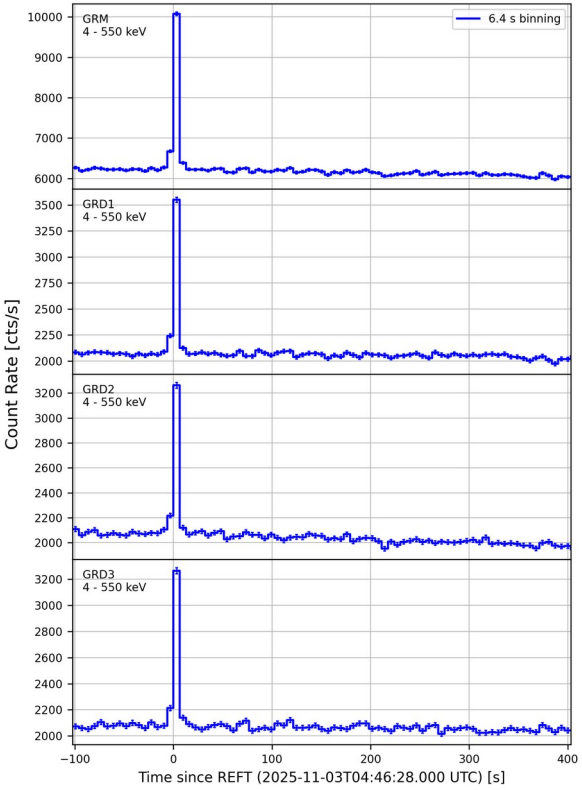

SVOM/GRM on-board lightcurve (VHF data)

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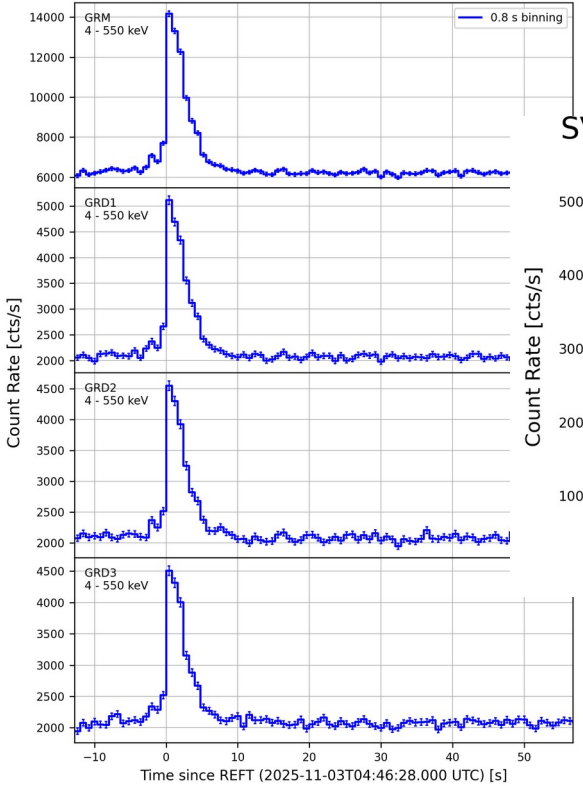

SVOM/GRM on-board lightcurve (VHF data)

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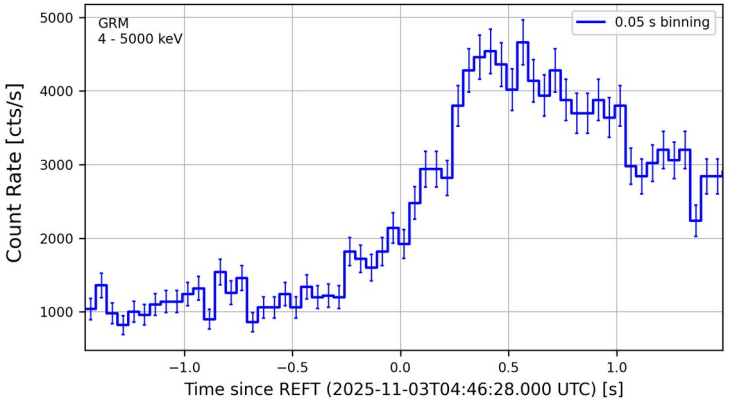


Future developments (1/2)

- Increase performance and speed
  - Bkg fit with modelT (polynomial function of time) instead of modelE in the no-slew case
  - Less simulations (n_draw=100 instead of 300) to compute QT90 error if incomplete LC

- Improved QLC
  - Passage in SAA-EXT: just display the information for diagnosis (to drive possible reprocessing)
  - GRM 1-ms LC saturation at 15 counts/bin: to be rebinned & dedicated QT90
  - New bkg components? (bright source occurring during the VHF sequence); post-SAA deactivation?
  - Weighted light curves (slew)? ECL coding fraction, GRD cos(Θ) (if position known)

- QPO_GRM & QSP_GRM: in standby
  - Quick localization: IHEP code implemented, bad performance → waiting for IHEP update
  - Quick spectrum: useless (trigger window) + circular problem as both products are interdependent

- CRCLASS in standy: to be trained on homogeneous VHF sample of triggers with post-launch energy bands (from April 2025 meeting)

Future developments (2/2)

- Reprocessing of all ECLAIRs and/or GRM validated GRBs
  - Important in view of opening the GRB public table
  - Need OBLC reprocessing (vhf-preproc) to apply bug fixes and onboard config changes since launch
  - Need a strategy for eclgrm-vhf reprocessing
    - Mechanism to tag (and then reuse) the analysis configuration if manually optimized
    - Distribute the work / the list of GRBs in the ECLAIRs IS team

- Post-processing of eclgrm-vhf results
  - Statistical analysis of GRB population seen through VHF data
  - Reference distributions of QT90, QPF, QHR
  - QHR vs. QT90 correlation for quick classification
  - etc

GRM Xband data transfer (CSC→FSC)

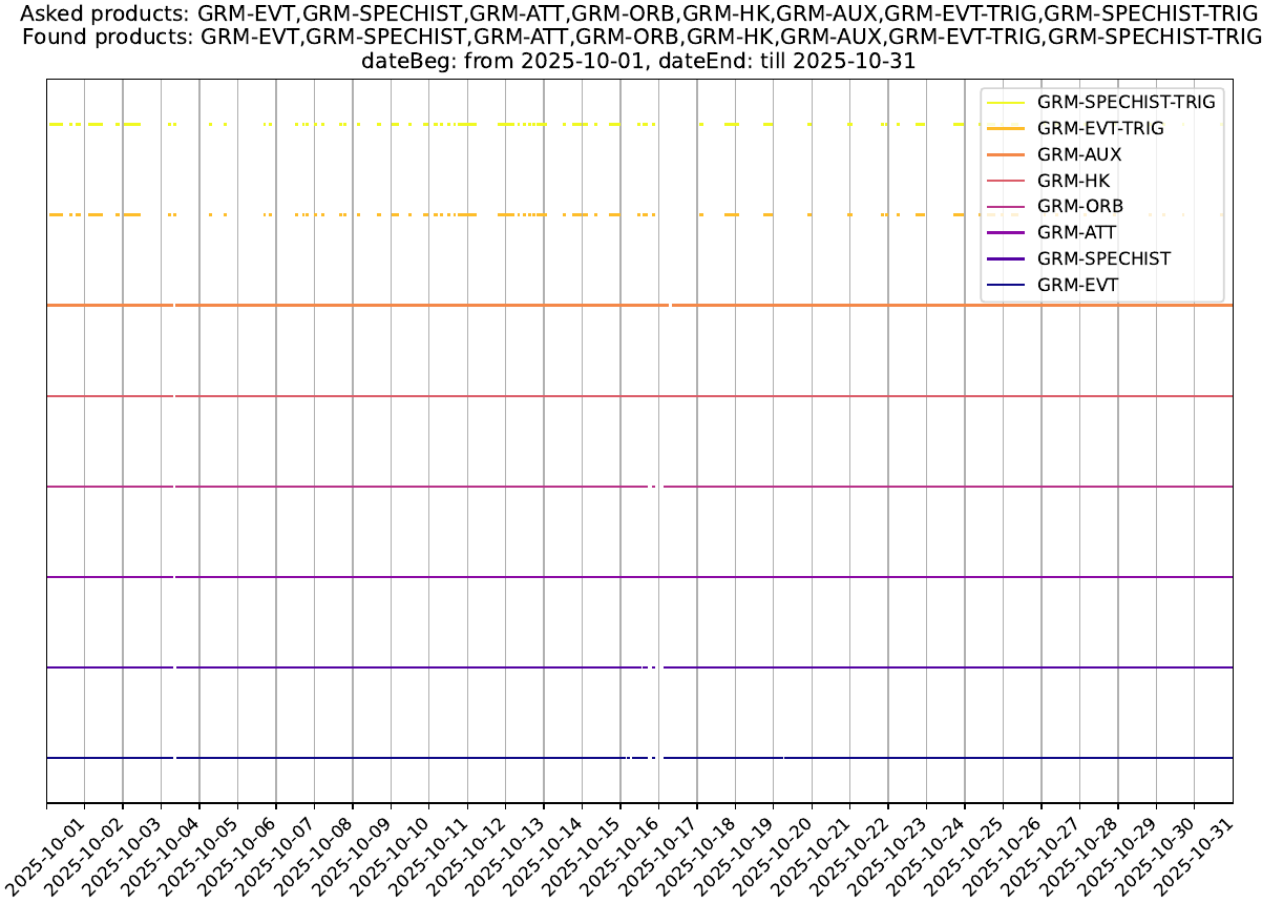
2

GRM data transfers from CSC to FSC

- GRM L1 data (Xband data): regular checks and requests to IHEP
  - Burst data: our priority, for valided GRBs
  - Obs-id data: gaps in the transferred data, less since this Spring
  - Ongoing test to transfer ~8 TB of GRM reprocessed data (new calibration)

- GRM L2 data (Xband scientific products): final DM and transfer tests pending
  - F/C ongoing work to freeze the data model of L2 SP produced by the FSC and GRM-IC pipelines
  - To be followed by transfer tests of GRM-only L2 SP from GRM-IC to FSC SDB via CSC

GRM L1 data transfers from CSC to FSC



Availability of GRM “continuous” (obsid) data in SDB@FSC

GRM L2 data model harmonization

- Ongoing discussions with IHEP
  - Data model harmonization (structure of FITS templates + can the SDB import GRM pipeline products)
  - Discussions on content and example results (how FITS templates are filled by the GRM pipeline)

Task	Product(s)	DM harmonization	Content
CLC	CLC_GRM	ok	ok
T90	T90_GRM	ok	ok
PO	PO_GRM	ok	ok
CSP	CSP_GRM_GRD1, CSP_GRM_GRD2, CSP_GRM_GRD3	ok	ongoing
BCSP	BCSP_GRM_GRD1, BCSP_GRM_GRD2, BCSP_GRM_GRD3	ok	ongoing
DRM	DRM_GRM_GRD1, DRM_GRM_GRD2, DRM_GRM_GRD3	ok	ongoing
SP	SP_GRM	pending	pending
MCSP	MCSP_GRM_GRD1, MCSP_GRM_GRD2, MCSP_GRM_GRD3	pending	pending
HR	HR_GRM	ok	ok
LAG	LAG_GRM	ok	ok

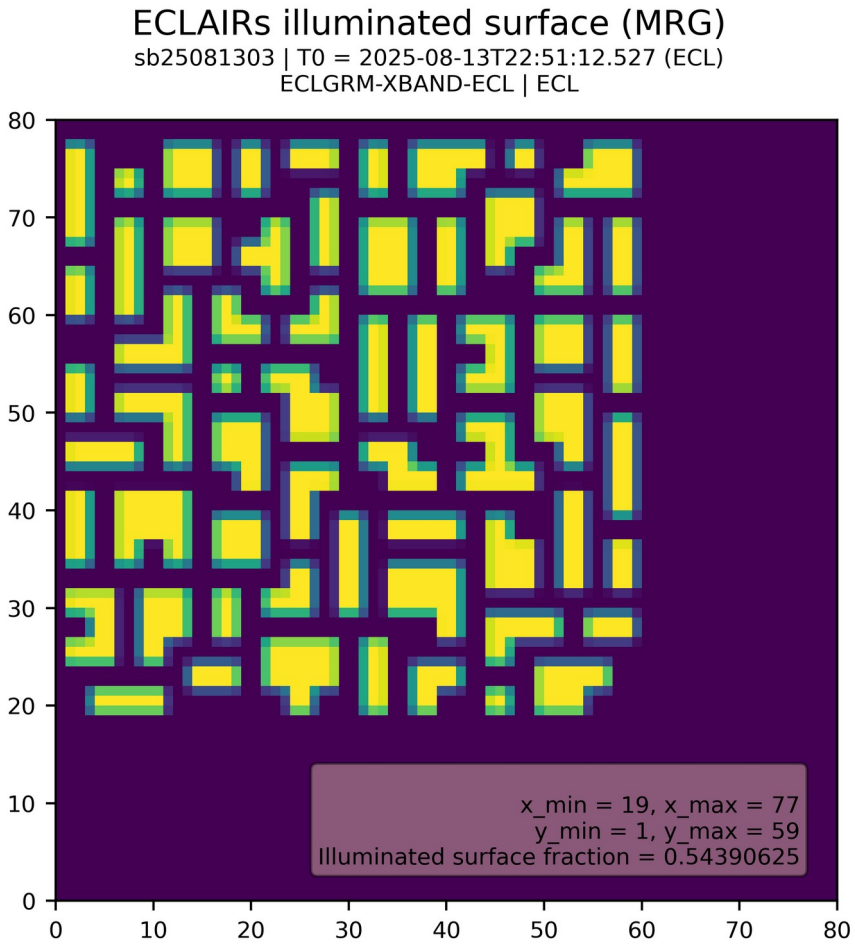
Analysis of ECL/GRM Xband data

3

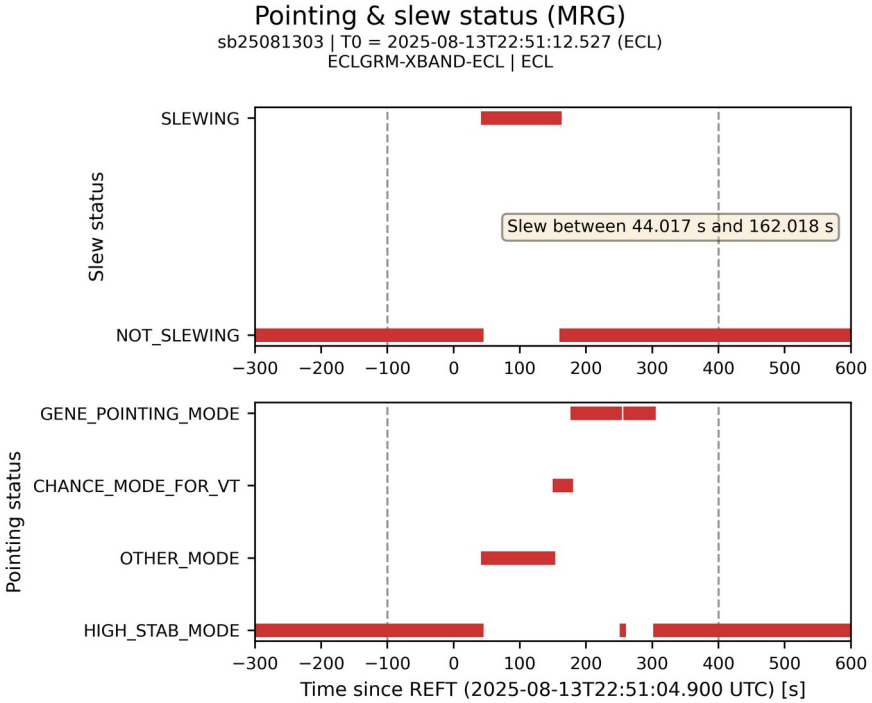
Recent developments: pipeline and user interface

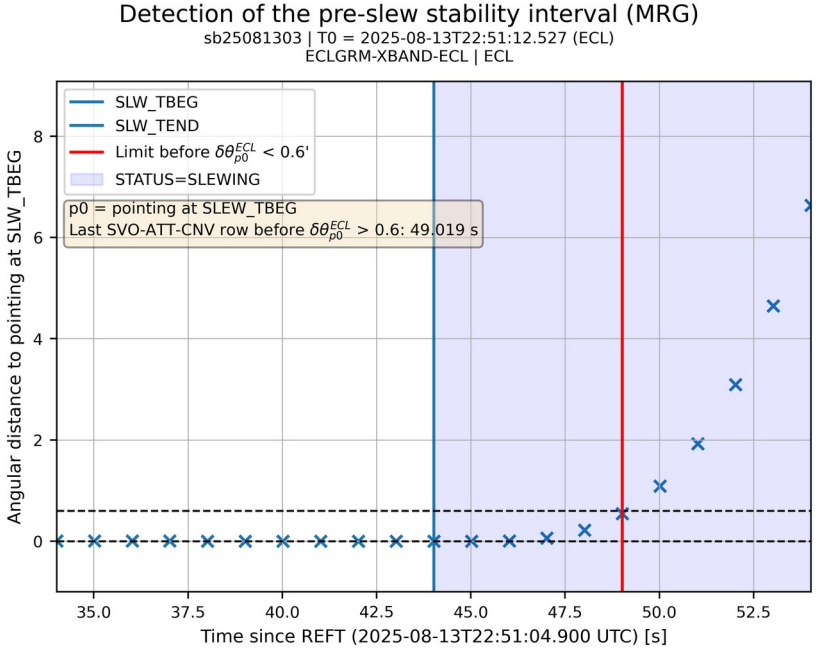
- ECLGRM-XBAND pipeline: v2.8.1 in production since December 8 (eclgrm-tools v1.10.1)
  - 4 upgrades since July 2025 (v2.5.0)
  - Coverage of eclgrm-xband increased from 14% to 80% + Sonarqube passed (coverage & code quality)
  - Pipeline modularization to select the tasks to run, useful for local usage
    - Useful to skip time-consuming tasks that have been already performed
  - MAIN: new task to download onboard products at the very beginning of the pipeline (OBALERT & OBLC), to either retrieve VHF-dependent data or to set user-selected values
    - Useful in the future to analyse new sources found by the OFTG
  - MRG: new control plots (illuminated surface, slew)
  - Selection of ECL DPIX illuminated pixels with configurable threshold: flagged in MRG,
    then filter enabled in CLC on a time interval set before the slew (criterion based on GRB angular distance stability)
  - DRM ECL: apply ARF correction to account for illuminated surface fraction
  - SP: improved ‘delchi’ plot (including 2-sigma upper limits), Epeak computation (for Xspec grbm model)
  - Several bug fixes (mostly minor), more config options for user
    - Ecut soft max increased from 150 keV to 1 MeV
  - Documentation completed
- ECLGRM User Interface: first complete version of XBAND dashboards

Recent developments: additional information



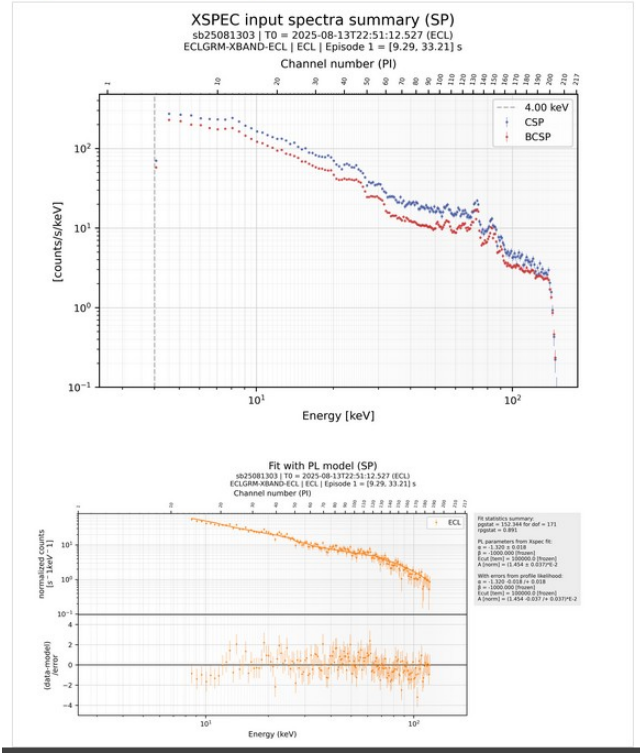
Recent developments: additional information

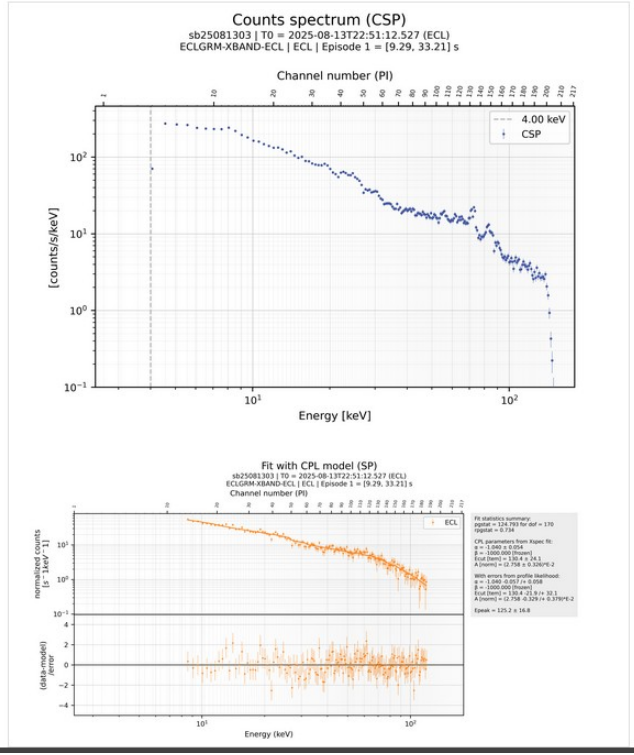


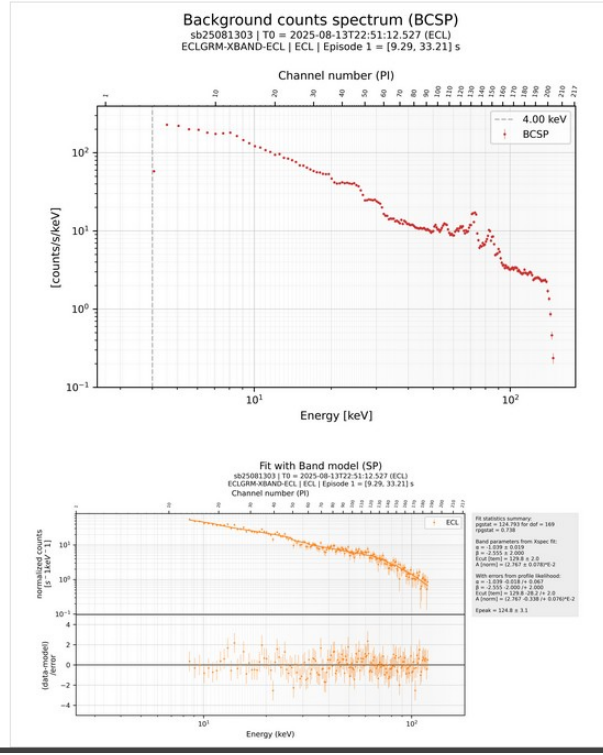


Recent developments: Xband dashboards of eclgrm-ui

Spectral analysis episode1







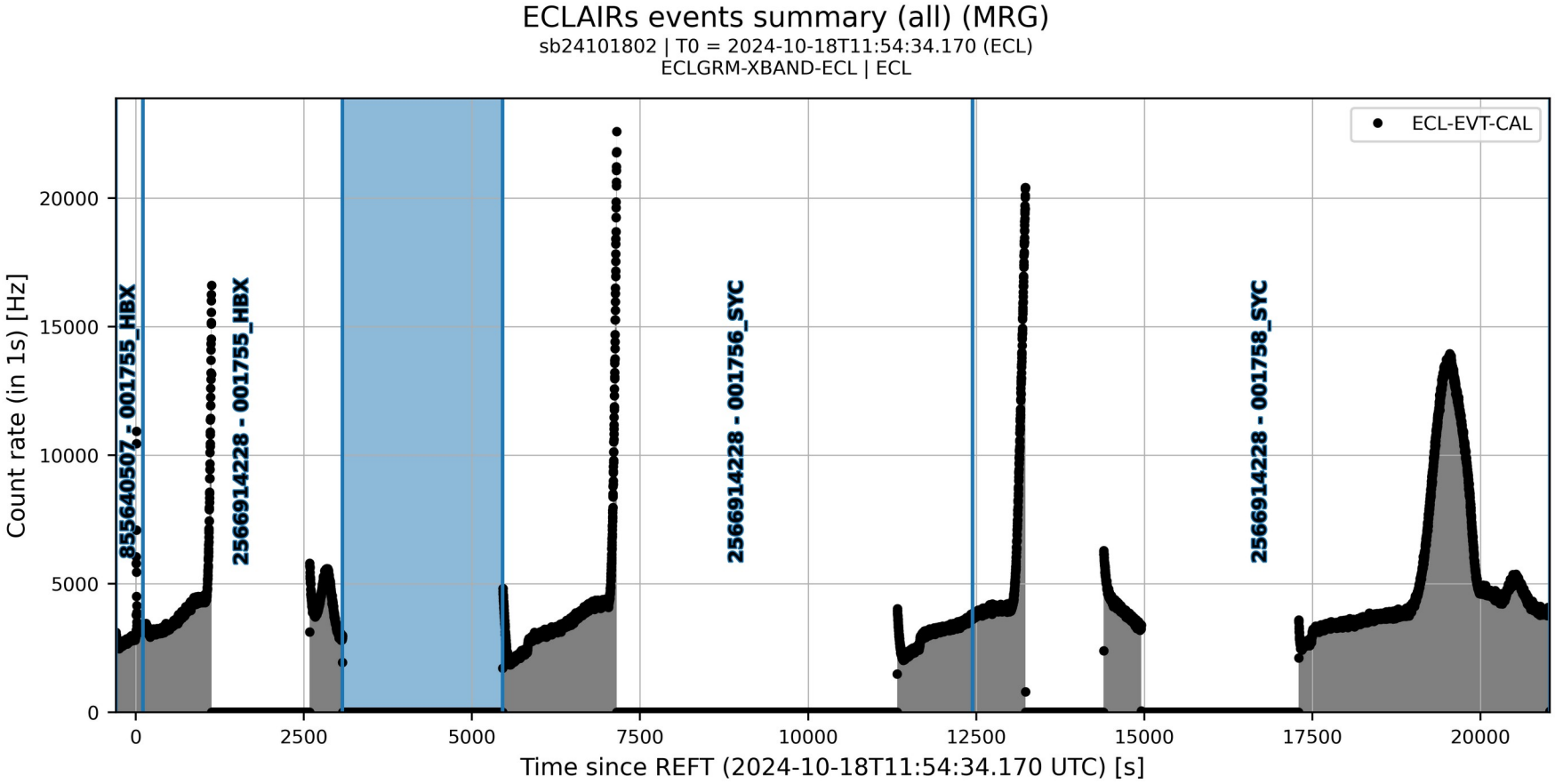
Recent developments: eclgrm-xband v3.0.0 in integration

- Needs eclgrm-tools v1.11.0
- Needs Xspec fix (HEASOFT version >=6.35)

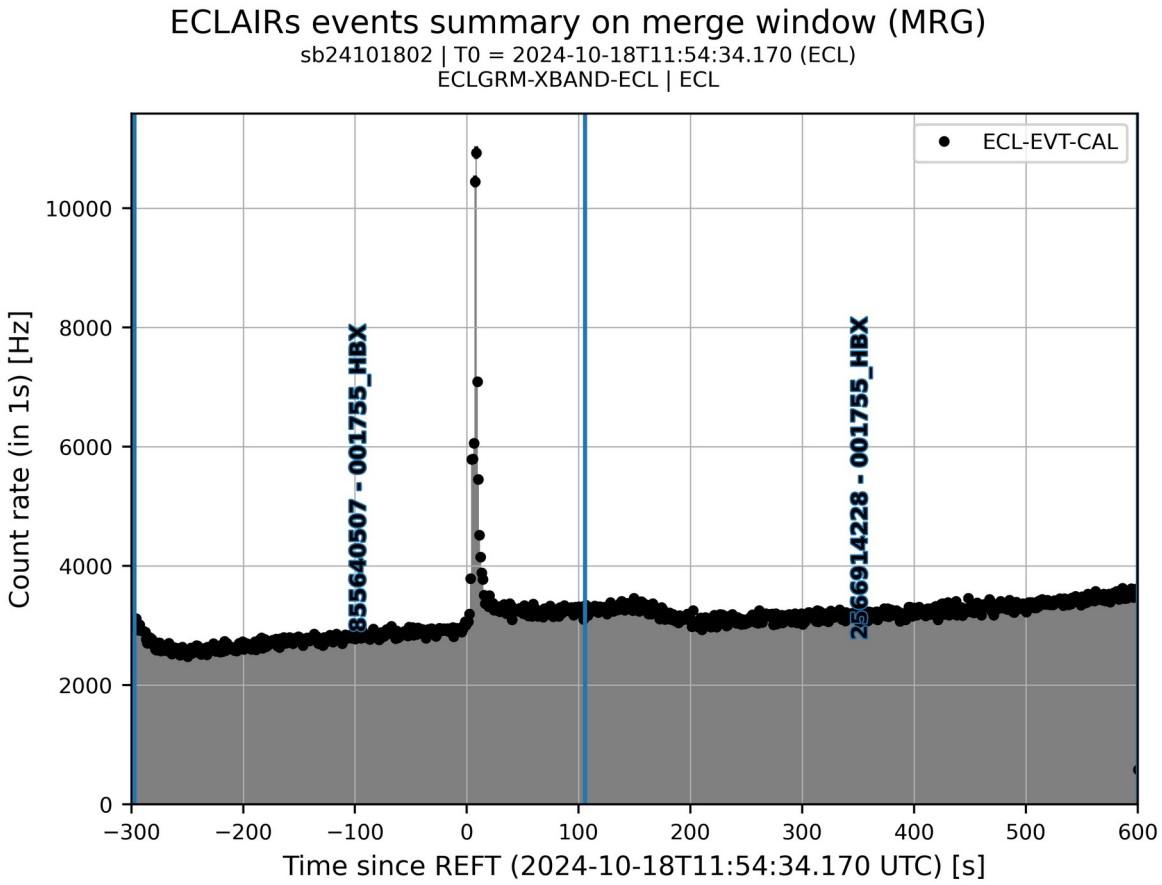
- MRG: new control plots of count LC for ECL-EVT-CAL-MRG (on merge window) and all ECL-EVT-CAL input files
- Spectral analysis
  - Run ECPI inside eclgrm-xband pipeline (counting technique still default)
  - Fill PI channel numbers dynamically in CSP/BCSP/DRM/ICSP/IDRM from 0 to n-1 (instead of 1 to n) everywhere (agreed with EIC and ECPI teams)
  - Added the grbm model init parameter values to the SP user configuration
  - Display both symmetrical errors (from Xspec fit) and asymmetrical errors (from profile likelihood) on model parameters in the SP delchi plot

- Documentation to come (installation with Xspec fix, ECPI usage)

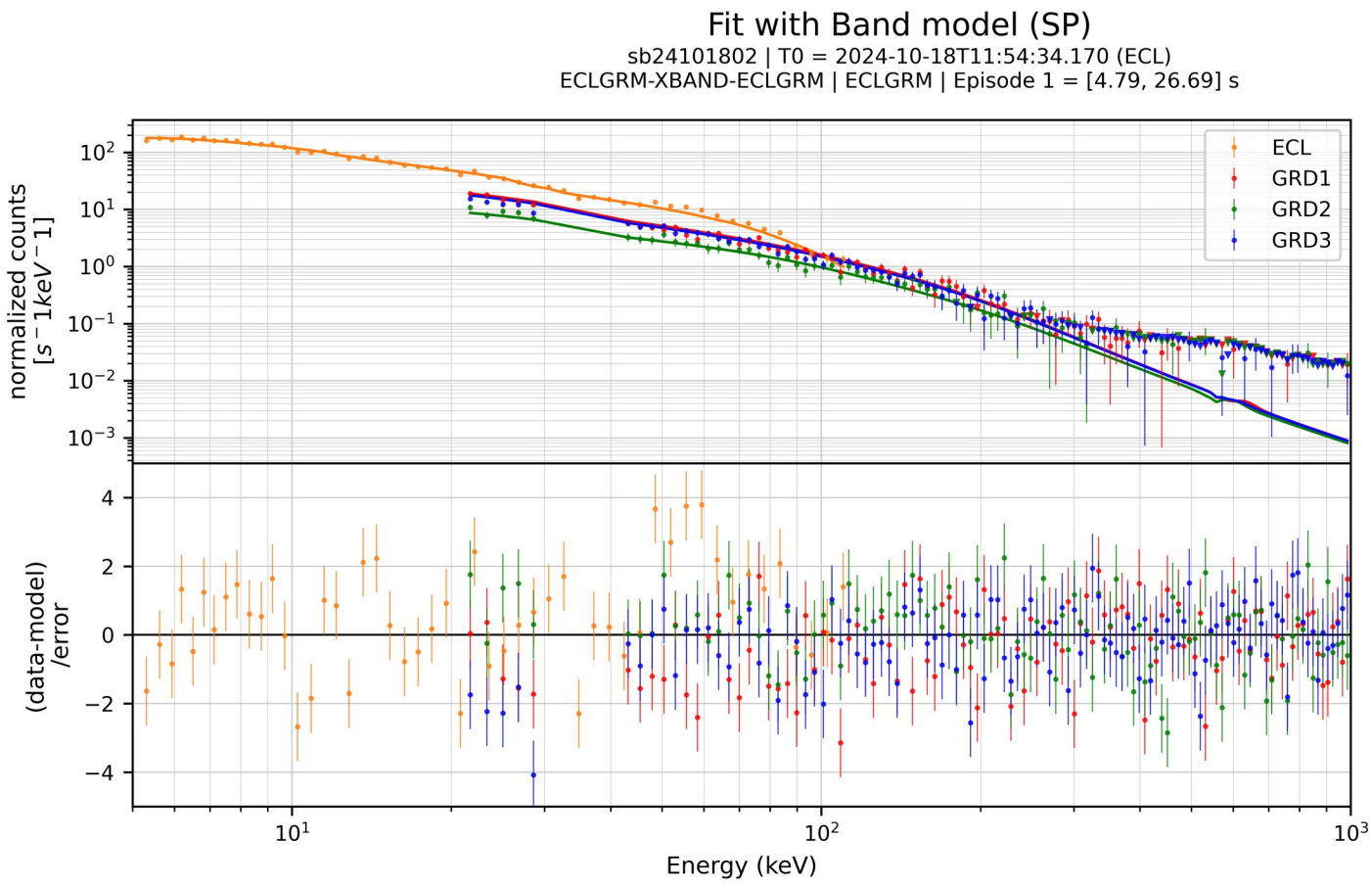
Recent developments: additional information



Recent developments: additional information



Recent developments: running ECPI in ECLGRM-XBAND



Fit statistics summary:
c-pgstat = 491.640 for dof = 377
rc-pgstat = 1.304

Fit statistics details:
-- ECL: Chi-Squared = 129.227 using 51 bins
-- GRD1: PG-Statistic = 132.411 using 110 bins
-- GRD2: PG-Statistic = 111.413 using 110 bins
-- GRD3: PG-Statistic = 118.589 using 110 bins

Band parameters from Xspec fit:
α = -1.241 ± 0.023
β = -2.452 ± 0.098
Ecut [tem] = 100.1 ± 7.0
A [norm] = (2.244 ± 0.125)*E-2

With errors from profile likelihood:
α = -1.241 -0.022 /+ 0.021
β = -2.452 -0.115 /+ 0.086
Ecut [tem] = 100.1 -6.3 /+ 7.1
A [norm] = (2.244 -0.117 /+ 0.121)*E-2

Epeak = 75.9 ± 5.8

Future developments

- Pipeline & algorithms
  - ECPI: optimized usage of spectrum extraction (SPEX) for fully automated analysis
  - Add local spectral models: empirical (PL, CPL, Band) & physical (ISSM, BB, etc)
  - Add SED contour plot, luminosity energetics (if z known) → standalone code available
  - DRM: averaging method in case of slew
  - SP/HR: Time-resolved spectra / HR: automated search for emission episodes
  - LAGs: Tune spectral lags
- Local execution mode for offline triggers (no burstid)
- Update the documentation
- Resume scientific validation
  - ECLGRM-XBAND-ECL vs. ECPI: some differences for limited SNR (different bkg spectra?)
  - ECLGRM-XBAND-GRM vs. GRM-IC results on benchmark GRBs (started)

About the imaging technique

- General workflow
  - ICSP task = get the GRB spectra with ecpi
    - get GRB spectrum (PHA) for each episode
      - a. run ecpi (auto)
        - run ecpi to extract the GRB spectrum with SPEX
        - retrieve the GRB spectrum from ECL-SPS-SOE, conversion to PHA
      - b. can set **“custom_pha”** to inject standalone (converted) ecpi outputs in the eclgrm-xband imaging technique
        - need to properly set the episodes in the rest of the pipeline (e.g., for combined analysis)
    - reformat the data to create ICSP product (PHAII)
  - IDRM task = get the corresponding spectral response
    - IDRM = ARF * RMF (standard response files in CALDB)
    - Rebinned to match the energy channels

Current v3.0.0 (integration) : semi-automated imaging technique [ICSP task]

1. Find relevant sources in ECL FoV

- run ecpi (part 1/2) : (DPCO - CALI) - BUBE - IMAG
  - default config (**“ecpi”/”ecpi_conf”** in ICSP config) including the BUBE **“energy_channels”** (default: 32 channels)
  - **pipeline override of BUBE “usr_gti”** with current episode t_start, t_stop
    - **override can be disabled with “ecpi”/”override_ecpi_conf_in_pipeline”/”usr_gti”**

2. Detect which source to retrieve from SPEX (i.e., if ecpi found a source and which one is the GRB)

- 2a. source id given by user (**“ecpi”/”src_extraction”/”src_id” = “manual”**)
- 2b. source id to be automatically detected by the pipeline (**“ecpi”/”src_extraction”/”src_id” = “auto”**)
  - retrieve the full list of detected sources from IMAG, for all energies
  - for all ‘unknown’ sources, compute the angular distance between (RA_FIN, DEC_FIN) and the onboard GRB position
  - the source id to extract is the closest source to the onboard position

3. *Extract the GRB spectrum*

- Run ecpi (part 2/2) : IMAG - SPEX
  - default config (**“ecpi”/”ecpi_conf”** in ICSP config) including the BUBE **“energy_channels”** (default: 32 channels)
  - **pipeline override of SPEX “src_list”** depending on the user config/IMAG results
    - if no source has been identified : force onboard position with **“src_list” = [[“GRB”, RA_OBJ, DEC_OBJ, 0.000001]]**
    - if a source has been identified as the GRB : force an empty list
    - **override can be disabled with “ecpi”/”override_ecpi_conf_in_pipeline”/”src_list”**

Limitations: the user must properly tune BUBE **”energy_channels”**, IMAG **”snr_ths”** & SPEX **”snr_sth”** for proper source detection / spectrum extraction

Upcoming v3.1.0 : fully automated imaging technique [ICSP task]

1. Find all the sources to consider in SPEX

- run ecpi (part 1/2) : (DPCO - CALI) - BUBE - IMAG
  - default config (**“ecpi”/”ecpi_conf”** in ICSP config)
  - **pipeline override of BUBE “energy_channels”** to get larger bands to detect all the sources in ECL FoV
    - **how to choose the best energy channels?**
  - **pipeline override of IMAG “snr_ths”** with a low value = all relevant sources must be detected
- compute the best position for each source id
  - **averaging positions in different energy channels?**
  - **run ecpi on a broad energy band?**

2. Extract ecpi spectrum using all sources in the FoV

- run ecpi (part 2/2) : IMAG - SPEX
  - default config (**“ecpi”/”ecpi_conf”** in ICSP config)
    - including the BUBE **“energy_channels”** (default: 32 channels)
  - **pipeline override of IMAG “snr_ths”** with a very high value to prevent all sources from being detected and used automatically in SPEX
  - **pipeline override of SPEX “src_list”** to manually provide all the sources detected in step 1 (with their best position)

*3. Select the source to extract like in the current technique (**“ecpi”/”src_extraction”** in ICSP config)*

- 3a. source id given by user
- 3b. source id to be automatically detected by the pipeline
  - retrieve the full list of detected sources from IMAG, for all energies
  - for all ‘unknown’ source locations, compute the angular distance to the onboard GRB position
  - the source id to extract is the closest source to the onboard position

SVOM special review: ECLGRM pipeline article submitted

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Research in Astronomy and Astrophysics

The GRB joint scientific analysis pipeline of the ECLAIRs and GRM instruments on board SVOM

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Abstract The study of the prompt high-energy emission of Gamma-Ray Bursts (GRBs) with 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 on board 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 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 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: gamma-ray bursts — mission: SVOM — instruments: ECLAIRs, GRM – techniques: pipelines

1 INTRODUCTION

The SVOM (Space-based multi-band astronomical Variable Objects Monitor) observatory (Cordier et al. 2025a, Wei et al. 2025, Dong et al. 2025) is primarily dedicated to Gamma-Ray Burst (GRB) science (Wei et al. 2016). The two wide field-of-view instruments on board the satellite, the coded-mask camera ECLAIRs (4–150 keV, Godet et al. (2025)) and the Gamma-Ray Monitor (GRM, 0.015–5 MeV, Sun et al. (2025)), 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 fields of view of the instruments on board SVOM (Cordier et al. 2025a).

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 possibly thermal component superimposed to their non-thermal emission (Bernardini et al. 2017) or of spectral breaks distinctive of synchrotron emission (e.g. Oganesyan 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, as 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. (2025) already demonstrate the ability to characterize the GRB population in all its diversity.

In order to exploit the potential of combining ECLAIRs and GRM observations of GRBs, two data analysis pipelines (*eclgrm-vhf* and *eclgrm-xband*) have been developed and deployed in Docker containers running at the SVOM French Science Center (FSC, Louvin et al. (2025)). The pipelines use a common library of algorithms to create the scientific products (SPs hereafter, see Louvin et al. (2025); Claret et al. (2025)) 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:

- The GRB quick analysis pipeline (*eclgrm-vhf*) processes the ECLAIRs and/or GRM count rate light curves that are built on board following each GRB alert and quickly transmitted to the ground via VHF antennas (Cordier et al. 2025b). For each instrument, and also for the joint ECLAIRs and GRM analysis, the pipeline creates the related quick SPs, which are used to promptly characterize the source and help validate the trigger as a genuine GRB.
- The GRB complete analysis pipeline (*eclgrm-xband*) processes the ECLAIRs and GRM event data which are registered on board and transmitted to the ground via X-band antennas several times per day (Yurong et al. 2025). 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 SPs. The X-band SPs 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. 2025), using a similar methodology and a common SP data model (Louvin et al. 2025).
- The *eclgrm-ui* user interface is used by the ECLAIRs-GRM Instrument Scientist (ECLGRM-IS hereafter) on shift, who is an expert of 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 SPs (Claret et al. 2025).

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 *eclgrm-ui* functionalities and their use by the ECLGRM-IS. Section 6 presents our conclusions and the possible future pipeline improvements.

2 PIPELINE ARCHITECTURE AND ACTIVATION

The onboard trigger and observation scenarios (ECLAIRs and/or GRM trigger, satellite autonomous slew to place

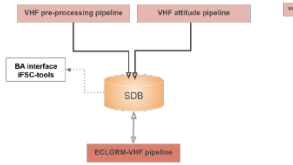

Fig. 1 Functional diagram of the *eclgrm-vhf* pipeline. The two FSC pipelines in pink color generate SPs that are retrieved and used by the *eclgrm-vhf* pipeline through the FSC SDB.

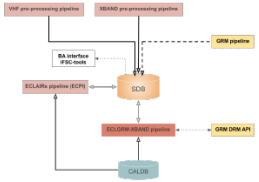

Fig. 2 Functional diagram of the *eclgrm-xband* pipeline. The three FSC pipelines in pink color create SPs that are retrieved and used by the *eclgrm-xband* pipeline through the FSC SDB. The two services running at the GRM-IC (Wang et al. 2025; Zhao et al. 2025) are indicated in yellow color: the GRM 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.

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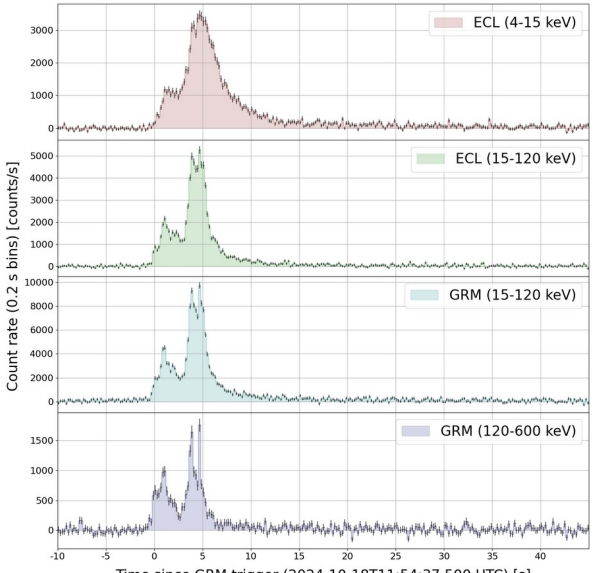

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