

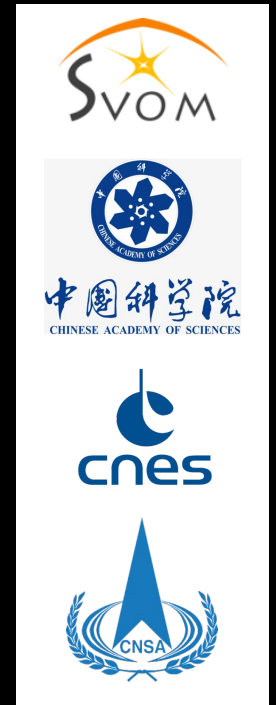
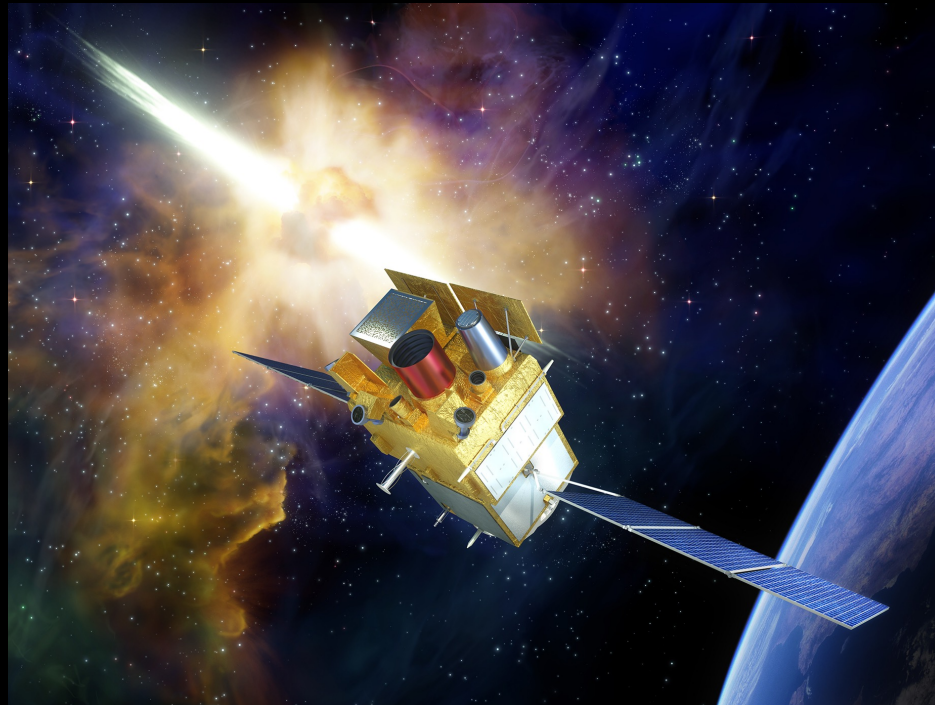


Institut
d'Astrophysique
de Paris



FIRST GAMMA-RAY BURST OBSERVATIONS WITH SVOM

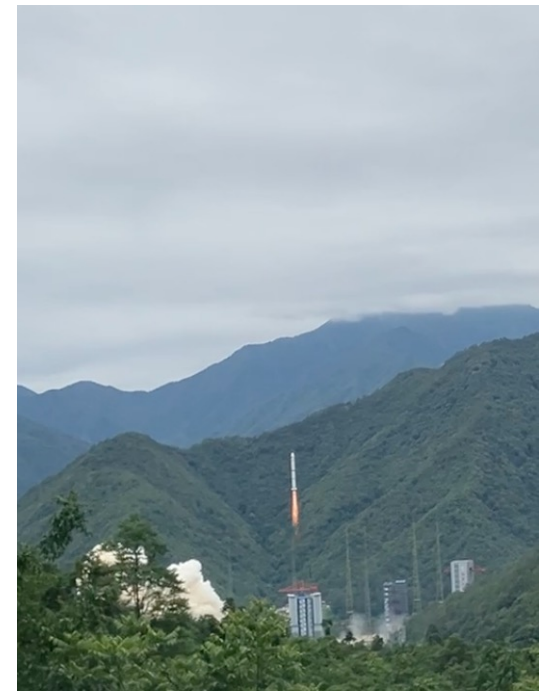
Frédéric Daigne & Bing Zhang,
on behalf of the SVOM collaboration



SVOM GRB FIRST DETECTIONS

- **SVOM Launch: 22 June, 2024**
- Since the launch: commissioning and validation phases
- April 2025: beginning of the nominal phase of scientific operations

- **SVOM Core Program: Gamma-Ray Burst Studies**



Since the launch: **80 GRBs detected on-board SVOM**

including:

32 GRBs also detected by Fermi/GBM

15 GRBs also detected by Swift/BAT

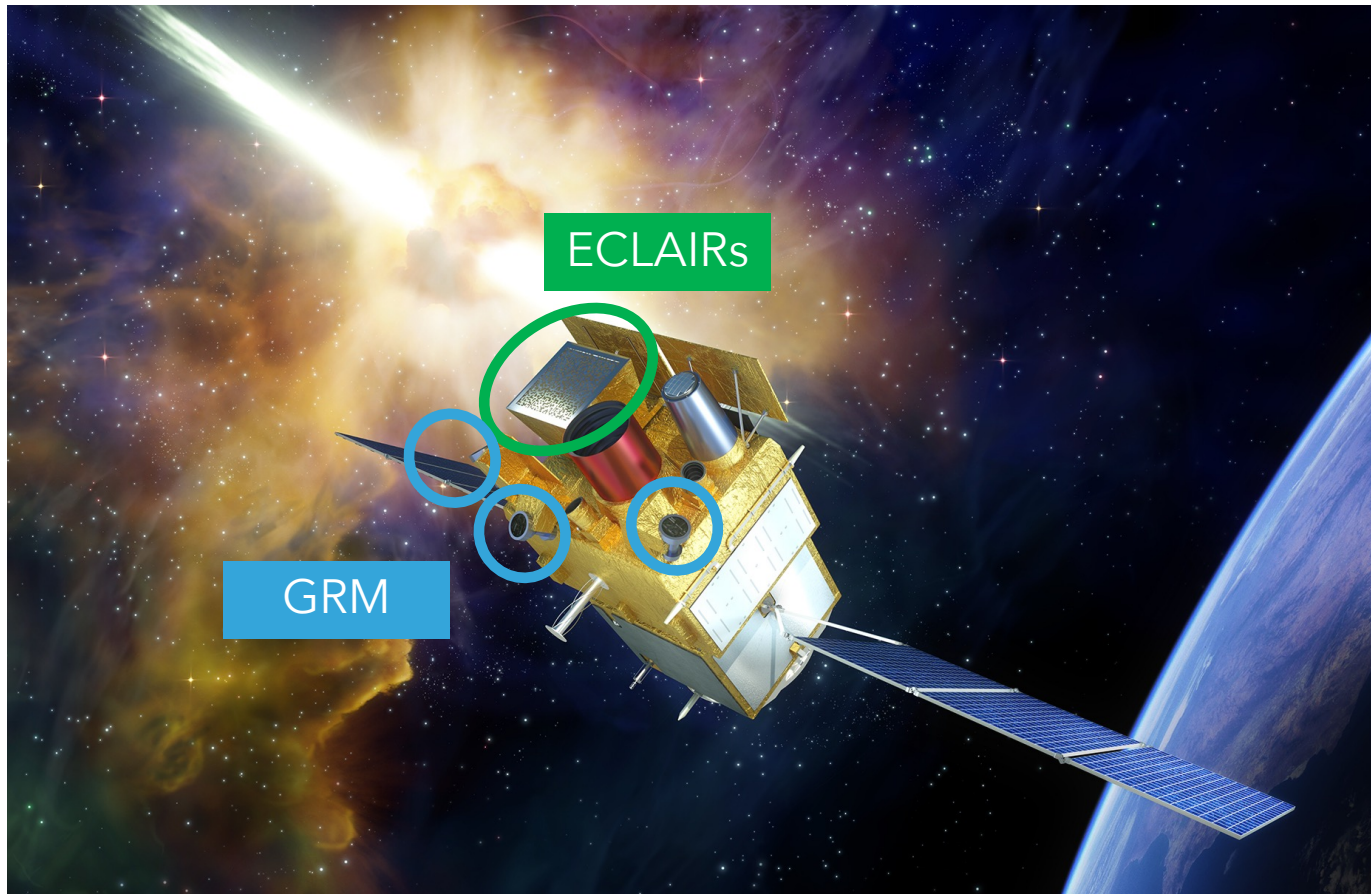
8 GRBs also detected by Konus-WIND

7 GRBs also detected by EP/WXT

1/3 are SVOM-only GRBs

+19 on-ground detections

SVOM: TWO TRIGGERING INSTRUMENTS

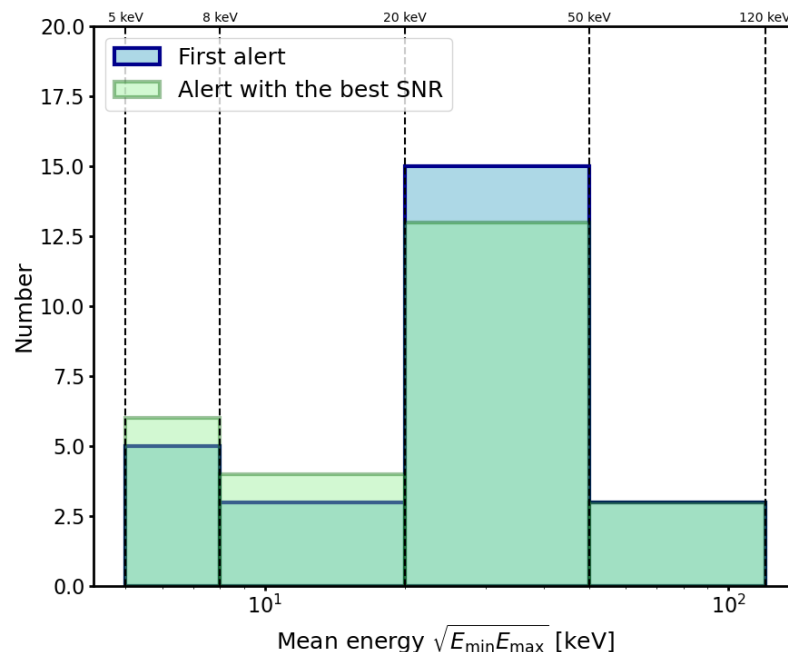
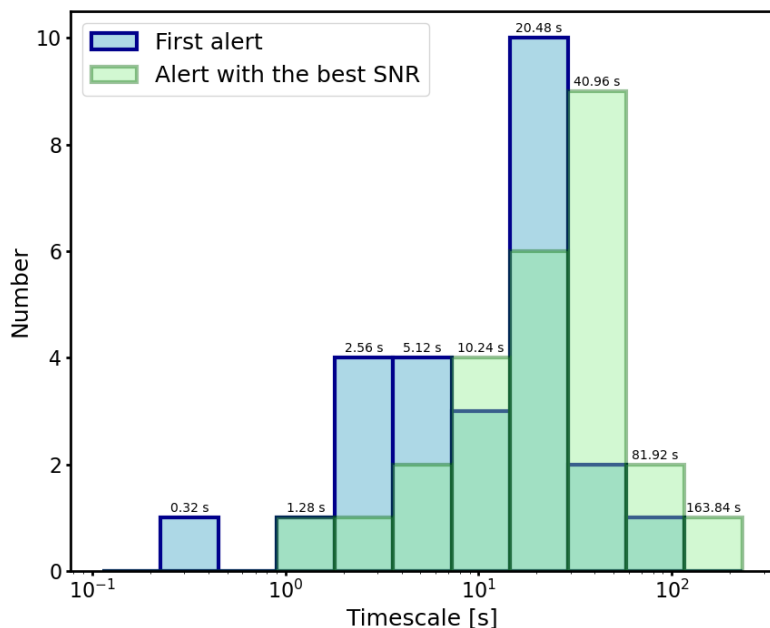


SVOM: TWO TRIGGERING INSTRUMENTS

ECLAIRS:

- Coded-mask telescope, **4-150 keV**, 2 sr, photon counting mode
- Can trigger on many combinations of timescales, energy bands and zones in the detector plane, either on the count rate (**CRT**) or on images (**IMT**)

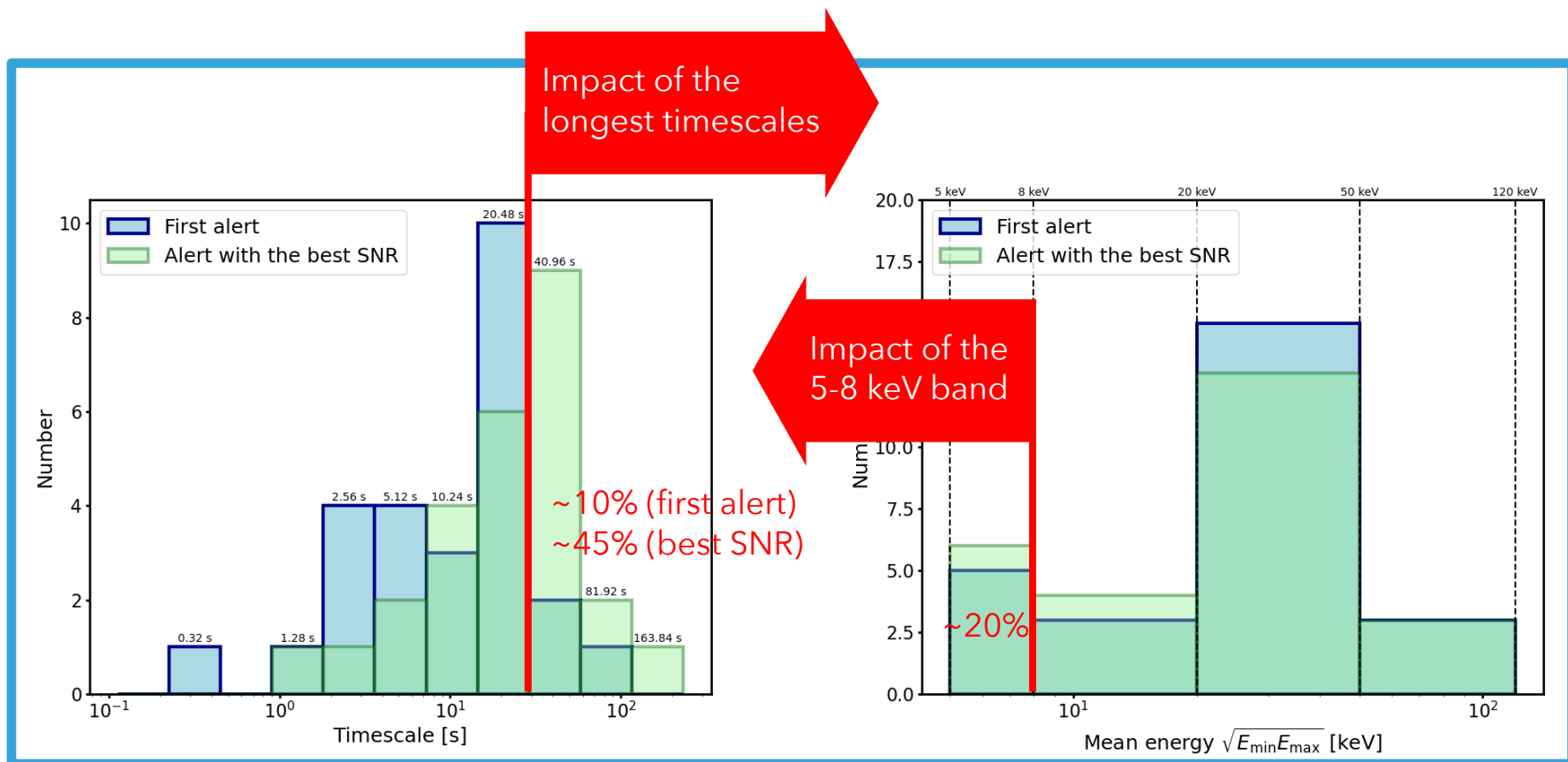
*First 26 GRBs with an on-board detection by ECLAIRs:
timescales and energy bands used to trigger*



- IMT: from **20 s to 20 min**
CRT: from **10 ms to 20 s** (always followed by an image giving the reported SNR)

SVOM: TWO TRIGGERING INSTRUMENTS

*First 26 GRBs with an on-board detection by ECLAIRs:
timescales and energy bands used to trigger*



15 SVOM-only triggers
among the 26 first GRBs detected on board by ECLAIRs (58%)

SVOM: TWO TRIGGERING INSTRUMENTS

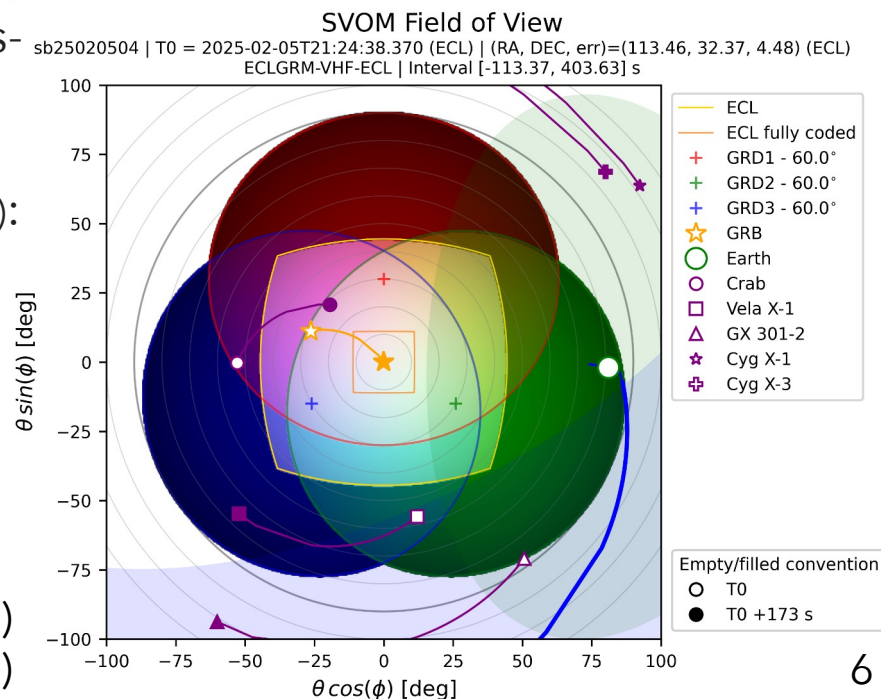
ECLAIRS:

- 26 GRBs detected on-board in 8.7 months ~ 36 GRB/year
- % of time with active on-board trigger: 45% (July-Nov. 24) → 76% (Dec. 24-March 25)
- **Expected rate during scientific operations: at least ~45-50 GRBs detected and localized on-board per year**
- **Localization in a few arcmin** (current median: 7.1' (stat) + 2' (sys))

GRM:

- **15 keV-5 MeV, three detectors (GRD) with a f.o.v. of 2.6 sr per detector**
- Can trigger on three timescales: 0.1, 1 and 4 s, only if the signal is above threshold in at least 2 GRDs
- 70 GRBs detected on-board since launch (~23% also detected by ECLAIRS): **~ 100 GRBs/yr detected on board**
- No localization, except on-ground localization for bright GRBs seen in the 3 GRDs (within ~5°)

Navigation plot of GRB250205A (slew) (ECL+GRM field of view)



SVOM: AUTOMATIC SLEW & FOLLOW-UP

Automatic slew: 54% of GRBs since launch ; **85% since Dec. 24** (lowered threshold)

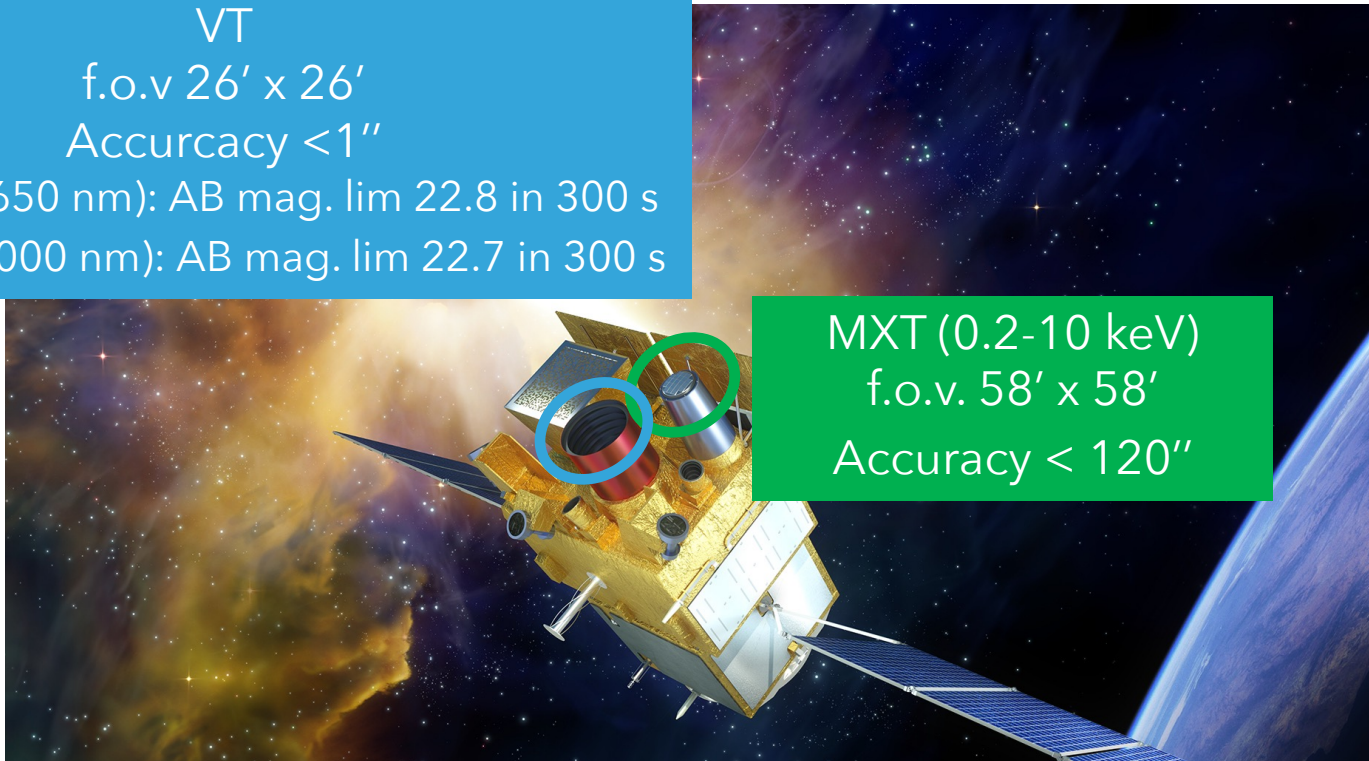
VT

f.o.v. 26' x 26'

Accuracy < 1''

Blue (400-650 nm): AB mag. lim 22.8 in 300 s

Red (650-1000 nm): AB mag. lim 22.7 in 300 s



MXT (0.2-10 keV)

f.o.v. 58' x 58'

Accuracy < 120''

VHF network: alert received on ground with a median delay of 7.6 s

- **GCN: public alert**
 - notice (since early Feb. 2025)
 - first circular (detection, localization for ECLAIRs triggers)
- **SVOM telescopes on ground: GWAC, C-GFT, F-GFT (Colibri) + partners**
- **ECL triggers: automatic ToO request for Swift/XRT** (since mid Feb. 2025)

SVOM GRBS: AFTERGLOW DETECTION & REDSHIFT MEASUREMENT

(since Dec. 24: 85% of GRBs detected on-board by ECLAIRs triggered an automatic slew)

	GRM-only on-board-triggers: first 54 GRBs	ECLAIRs on-board triggers: first 26 GRBs	ECLAIRs on-board triggers: first 14/26 GRBs with auto. slew
X-ray afterglow	17% (9/54)	81% (21/26)	100% (14/14) SVOM/MXT: 5 detections Swift/XRT: 14 ; EP/FXT: 6
Optical/NIR afterglow	13% (7/54)	58% (15/26)	71% (10/14) SVOM/VT: 8 det. + 4 early deep UL SVOM/CGFT+FGFT: 3 det. + 3 early UL
Redshift	11% (6/54)	35% (9/26)	43% (6/14) Special thanks to SVOM partners: NOT, Stargate, ...

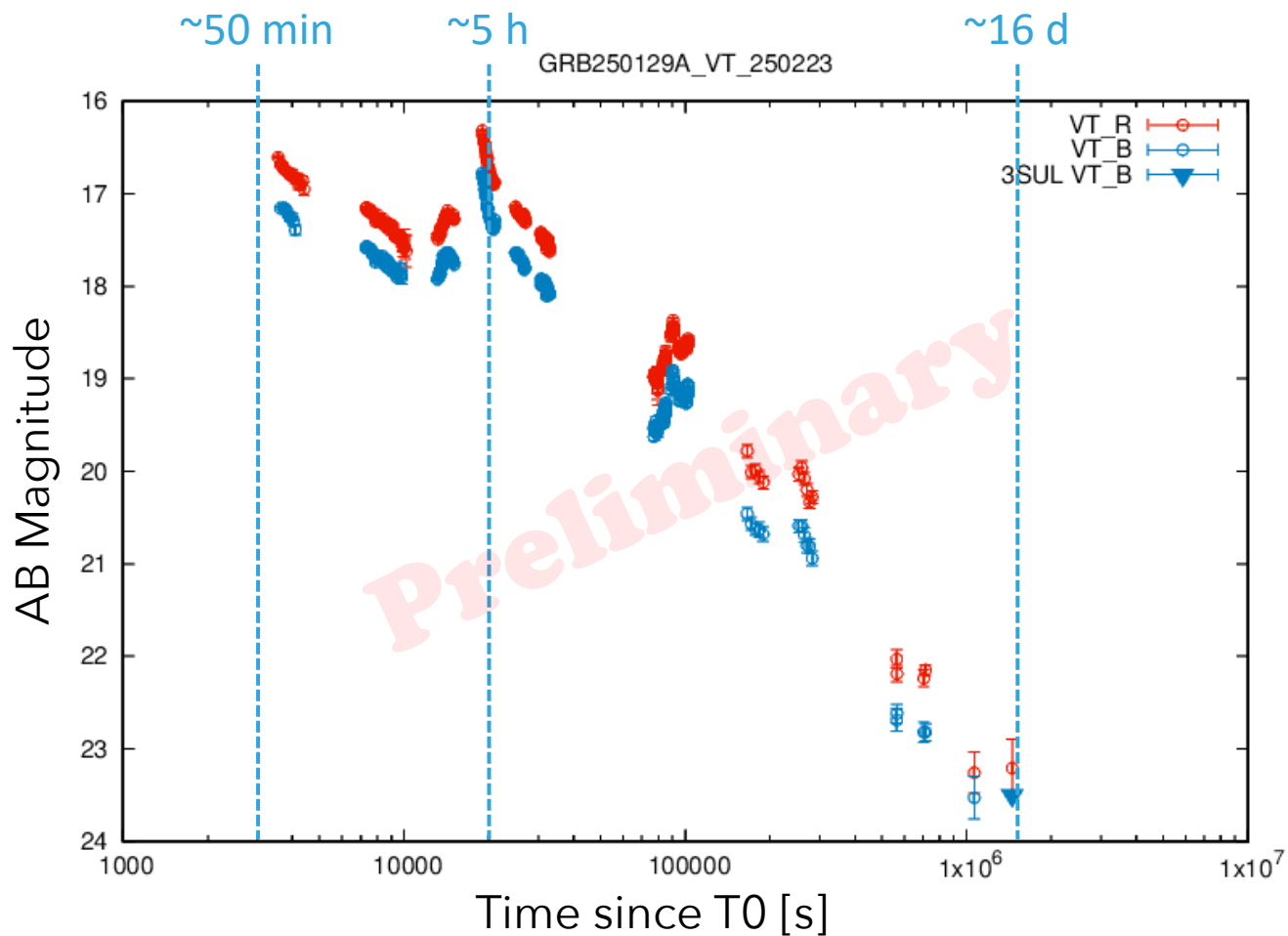
= common triggers with Swift/BAT (6) or EP/WXT (3)

SVOM instruments contribute to the follow-up of these GRBs.

Already an excellent efficiency for the follow-up of GRBs detected on board SVOM with ECLAIRs

SVOM FOLLOW-UP OF SWIFT/BAT GRBS

SVOM/VT follow-up of **Swift/BAT GRB250129A** at $z = 2.151$ (GCN#39071)

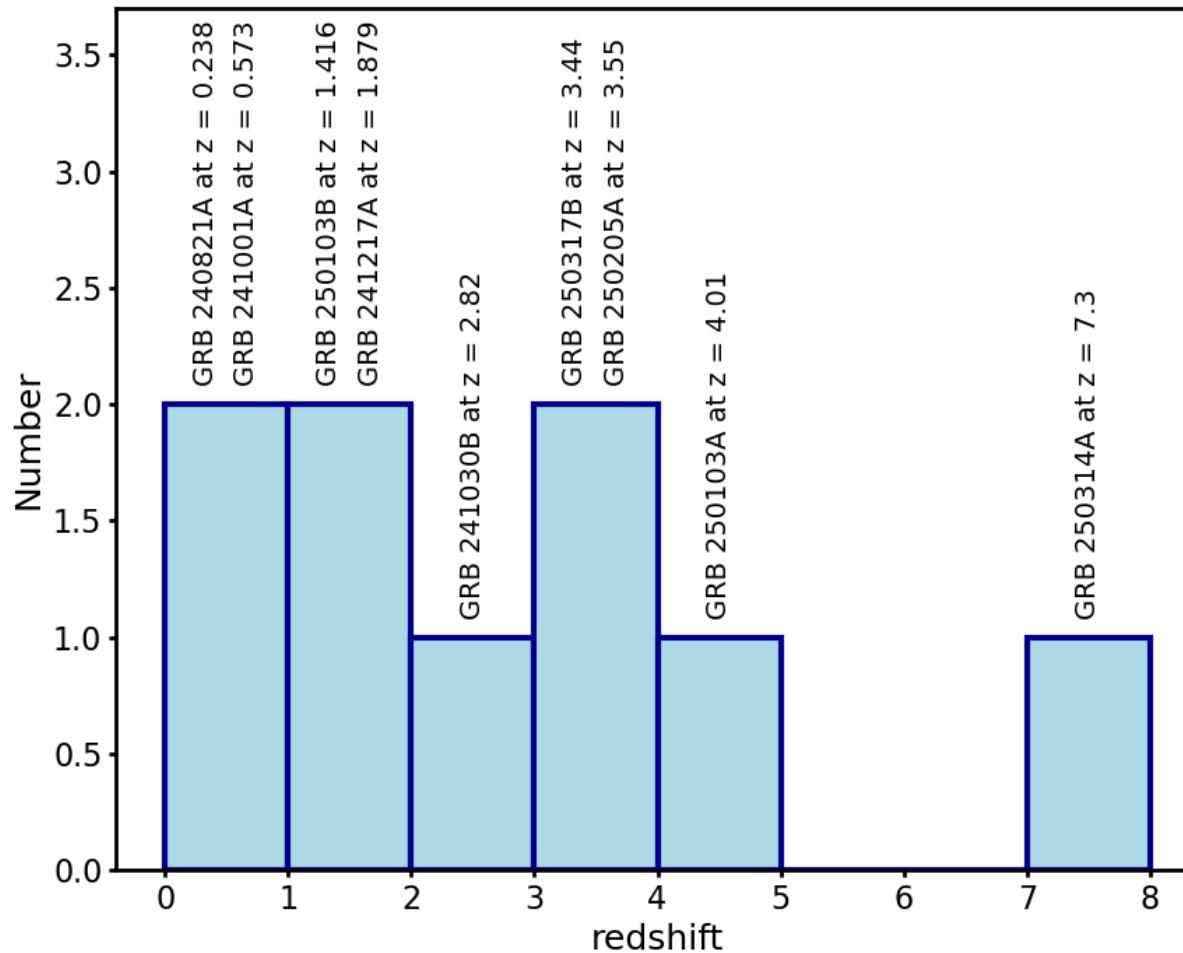


SVOM GRBS: AFTERGLOW DETECTION & REDSHIFT MEASUREMENT

- **Already more than 1/3 of ECLAIRs GRBs with a measured redshift !**
- **The efficiency of the redshift measurement should still increase:**
 - SVOM still on a learning curve...
 - The **nominal pointing law avoiding the Galactic plane** was not followed for most of the time during the first months.
 - Since Dec. 2024, **increased fraction of automatic slew** following ECLAIRs triggers
 - Since Feb. 2025: **automatic Swift/XRT ToO request** following ECLAIRs triggers, to come soon: **automatic EP/FXT ToO request**
 - Ratio $\#redshift/\#opt. \text{ afterglow} = 9/15 = 60\%$: some additional redshifts may be measured via **late host galaxy spectroscopic observations**.
 - **Delay to identify optical candidates** in early VT images may be reduced.
 - A new camera (CAGIRE) will be installed in coming months, allowing **observations in J,H bands with SVOM/F-GFT (Colibri)**.

SVOM ECLAIRS GRBS: REDSHIFT DISTRIBUTION

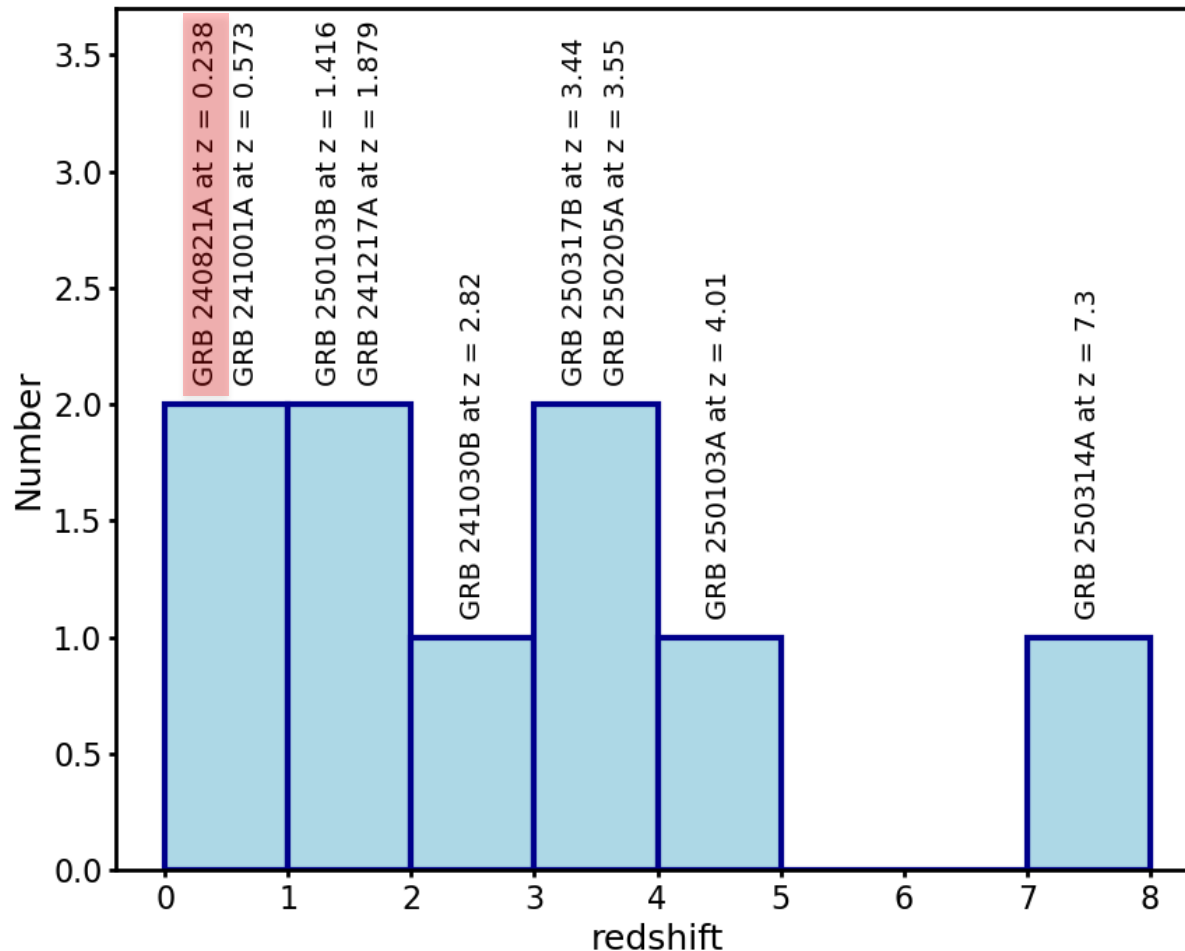
- **First 9 ECLAIRS GRBs with a measured redshift:** ECL+GRM = 7 ; ECL-only = 2
- **$z = 0.238$ to 7.3 ; Median = 2.8**



SVOM ECLAIRS GRB SAMPLE (1) SHORT GRBS

Better understanding the **short GRB-merger connection** and the **physics of ejection/emission in the post-merger phase**: SVOM can contribute to build a **sample of fully characterized short GRBs**, including the properties of the host galaxy.

GRB 240821A = a short GRB with extended soft emission



SHORT GRBS & THE MERGER SCENARIO: GRB240821A

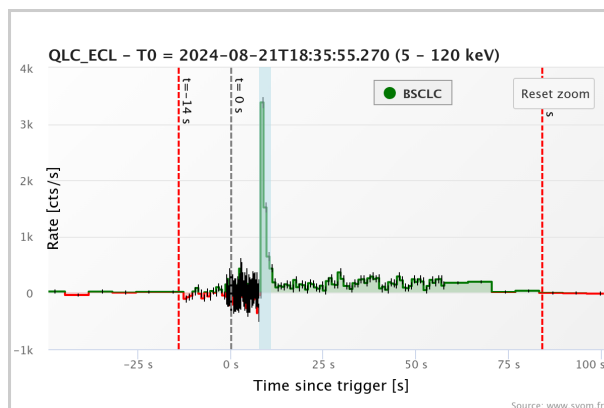
- **A first example: GRB240821A** (during SVOM commissioning phase)

GRB240821A ECLAIRs and GRM lightcurves:

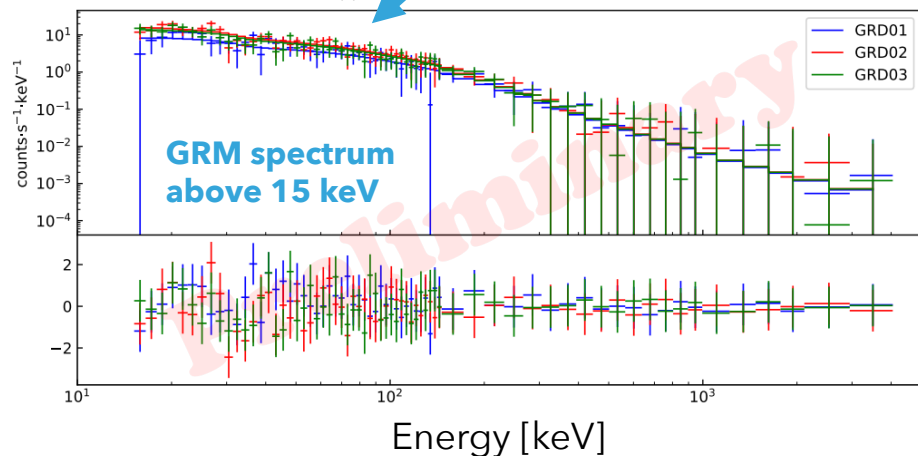
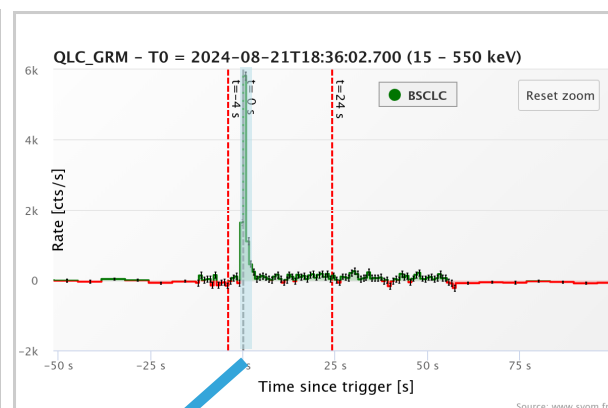
T90 = 52.2 ± 0.2 s (4-120 keV)

Short spike + ext. emission

ECLAIRs (5-120 keV)



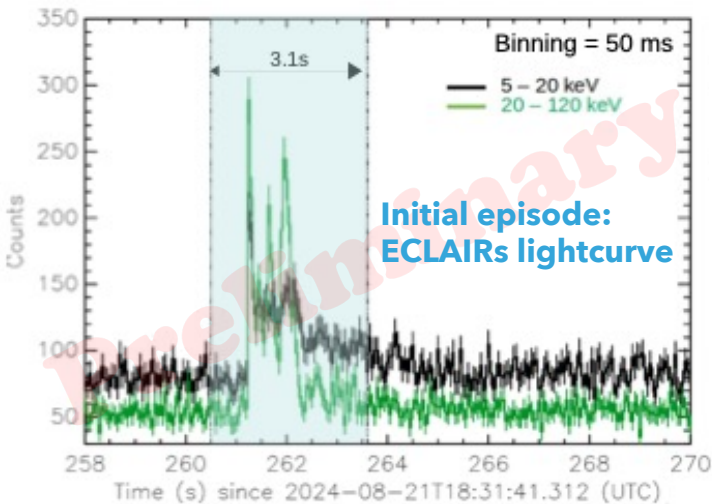
GRM (15-550 keV, 3 GRDs combined)



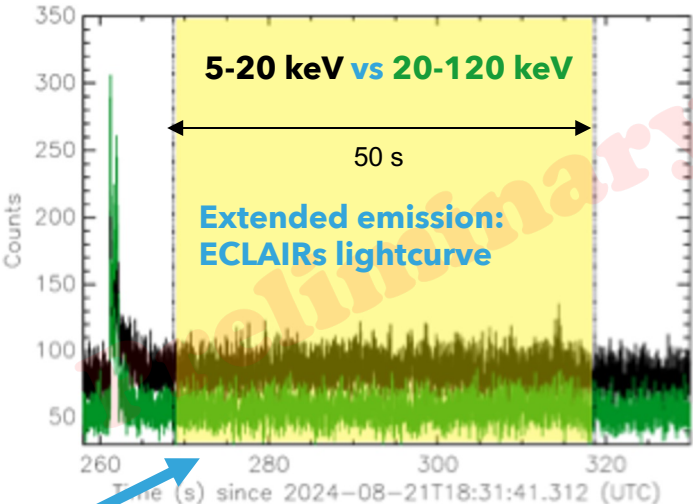
(data-model)/error

GRM above 15 keV:
fit of the initial spike with BAND $\alpha = -0.57$; $E_{\text{cut}} = 89$ keV

ECLAIRs-GRM cross-calibration to be completed soon:
next step = ECLAIRs+GRM joint fit to better constrain
the low-energy slope



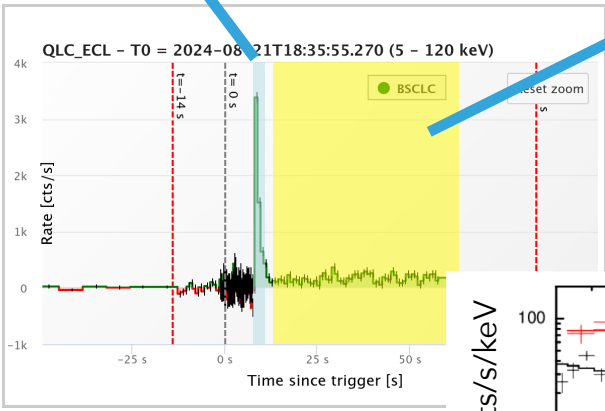
Initial episode
= short hard spike
(variable) detected
by ECLAIRs+GRM



GRB240821A
ECLAIRs lightcurve:

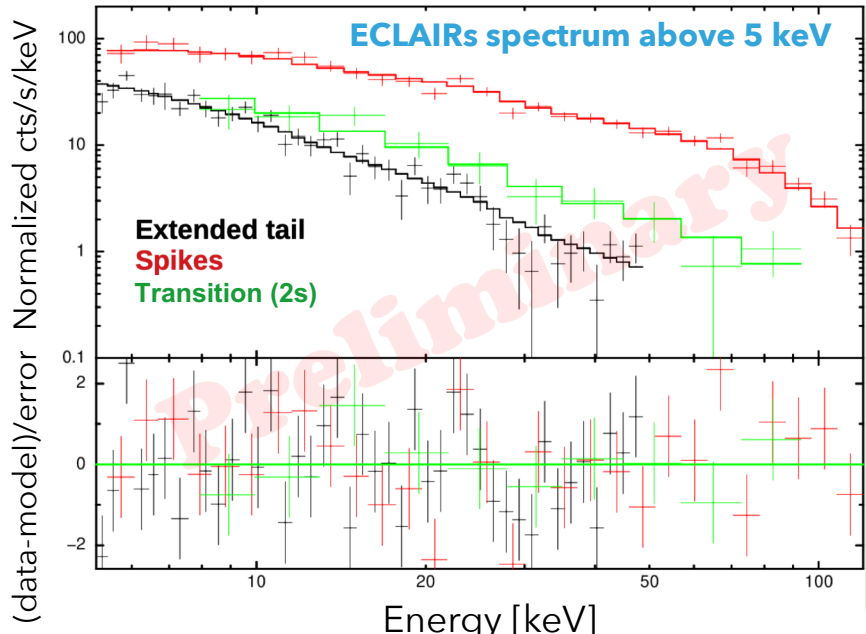
T90 = 52.2 ± 0.2 s (4-120 keV)

Short spike + ext. emission



Extended emission

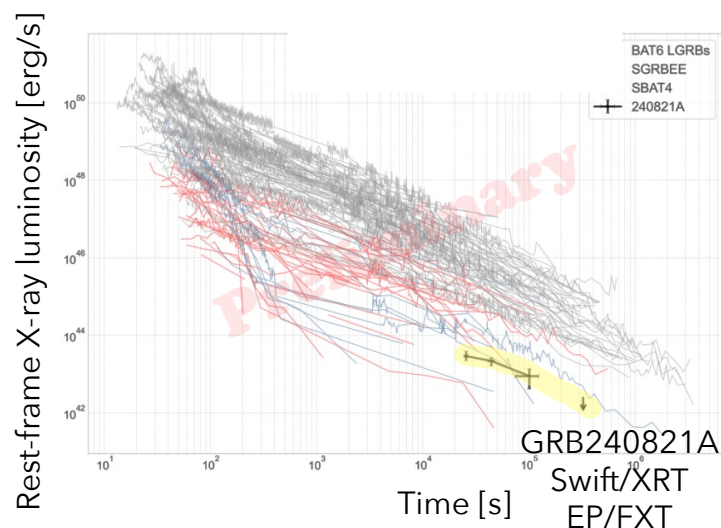
- plateau-like emission
- softer = not detected above 50 keV
- non-thermal emission
- (to be compared to the analysis by Chang+24 of a Fermi/GBM sample of 36 SGRB+EE)
- no strong spectral evolution



SHORT GRBS & THE MERGER SCENARIO: GRB240821A

■ A first example: GRB240821A

Red: short GRBs without extended emission / Blue: short GRBs with extended emission / Black: GRB240821A
X-ray afterglow = consistent with other sGRBs with EE but faint in X-rays



BAT6, [Salvaterra+12](#)

S-BAT4, [d'Avanzo+14](#), see [Riccardo Brivio yesterday's talk](#)
with a sub-sample of SGRB-EE, see poster by [M.M. Dinatolo](#)

- Optical AG detected by Gemini and GRANDMA/SOAR
- **Host galaxy: phot. & spectr. (GTC, VLT, Keck)**
- Preliminary analysis (spectroscopy only): $z = 0.237$
Metallicity: $12 + \log(\text{O}/\text{H}) = 9.1 \pm 0.1$
SFR = $0.05^{+0.05}_{-0.02} \text{ M}\odot/\text{yr}$ (to be updated with phot.)
- **Host gal. properties would be very unusual for a LGRB host but are consistent with SGRB hosts**

- **The low-energy threshold of ECLAIRs (4 keV) should help in the future to constrain the fraction of SGRBs with EE** (see also [Kisaka+17](#))

Paper on GRB240821A in preparation, led by [F. Daigne](#) & [B. Zhang](#)

SHORT GRBS & THE MERGER SCENARIO

- **Another example: GRB241105A = SGRB with EE (Fermi/GBM & SVOM/GRM)**
 - Tail less soft than in GRB240821A
 - **Multi- λ follow-up including SVOM/VT**
 - VLT: $z = 2.681$ (GCN#38097) = would be the highest redshift for a SGRB
 - Host galaxy: JWST photometry (GCN#38654)
= massive host, star-forming, at low-metallicity, similar to other collapsar hosts at this redshift.
 - **Collapsar origin favored**

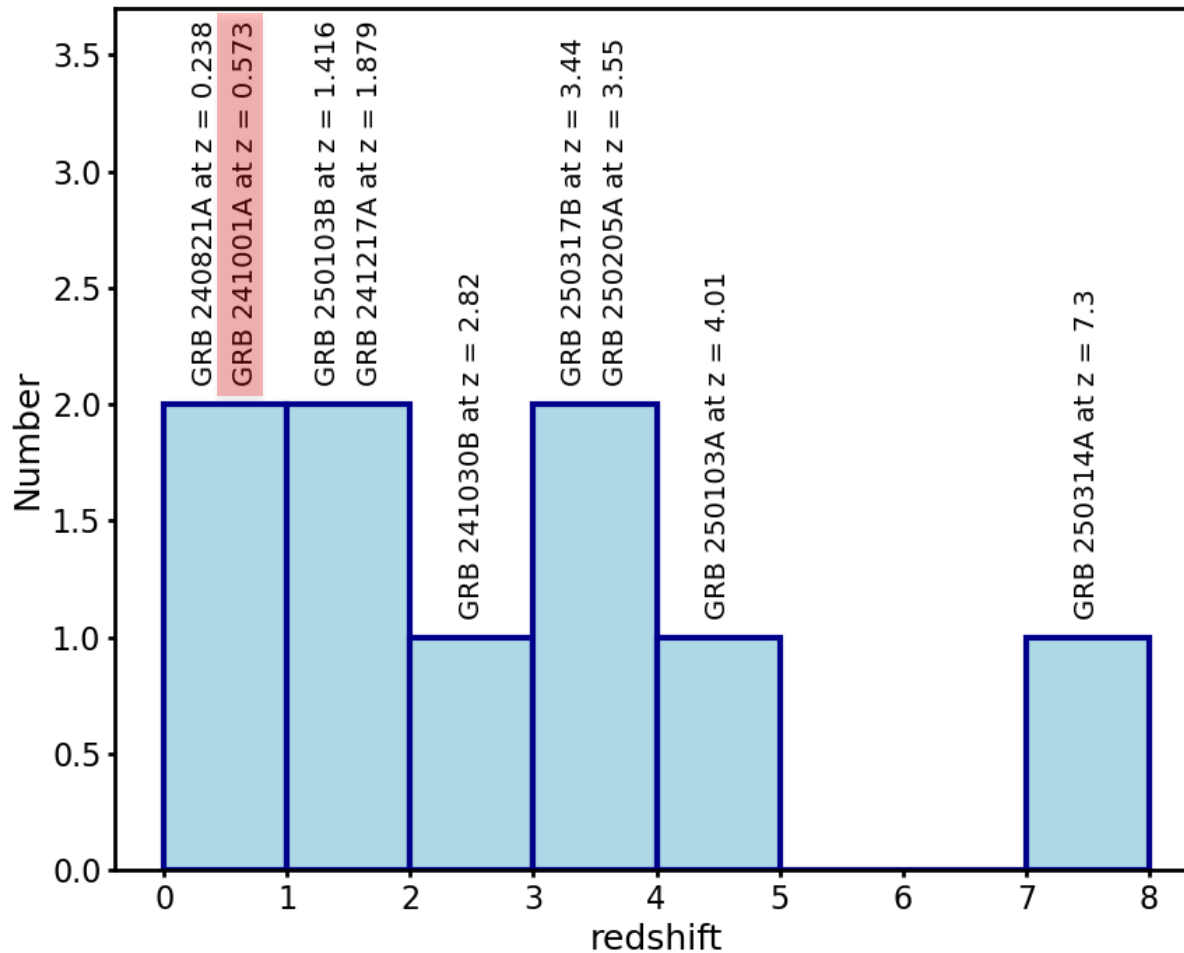
Paper on GRB241105A in prep., led by D. Dimple - Contact on SVOM side: J. Palmerio

SVOM ECLAIRS GRB SAMPLE (2) SOFT GRBS

SVOM/ECLAIRs detect many soft or very soft events. The characterization of these events (AG, redshift, host) allows to explore the **underlying diversity**.

GRB 241001A

= a very soft event detected only by ECLAIRs



Three other soft GRBs:

GRB240819A

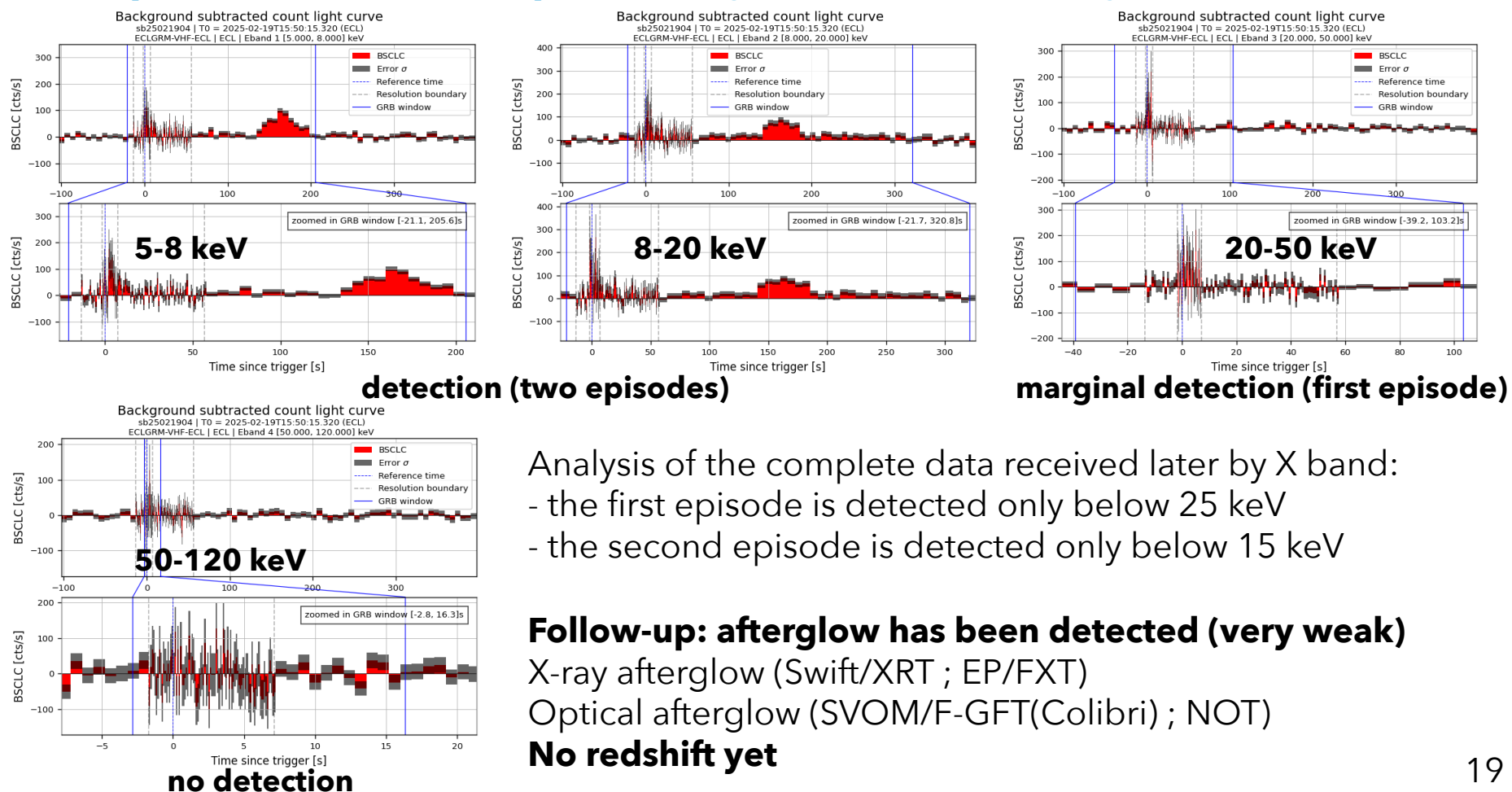
GRB240828B

GRB250219A

SOFT GAMMA-RAY BURSTS: EXPLORING THE DIVERSITY

Our first look at the soft GRBs detected by ECLAIRs on board SVOM: results of the pipelines developed for the quicklook analysis of ECLAIRs and GRM VHF data.

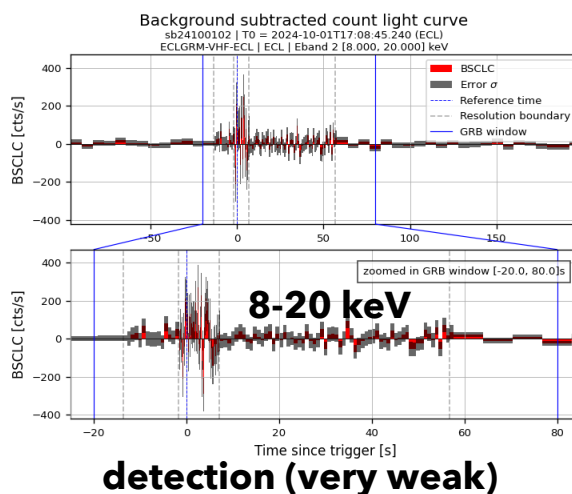
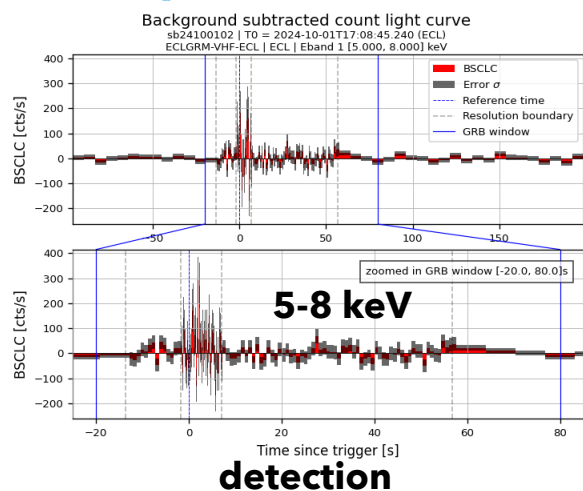
Example 1: GRB250219A (preliminary classification: X-ray rich GRB)



SOFT GAMMA-RAY BURSTS: EXPLORING THE DIVERSITY

Our first look at the soft GRBs detected by ECLAIRs on board SVOM: results of the pipelines developed for the quicklook analysis of ECLAIRs and GRM VHF data.

Example 2: GRB241001A



GRB241001A

Full characterization:
X-ray and optical AG, redshift

Two more cases: already four soft GRBs detected on board by ECLAIRs

- GRB240819A: X-ray AG (Swift/XRT), Opt. AG (**SVOM/VT**, **SVOM/F-GFT** (Colibri))
 - GRB240828B: X-ray AG (Swift/XRT, EP/FXT)
- (These two events were detected in August 2024, during the commissioning phase, with a long delay before the validation of the trigger and the alert)

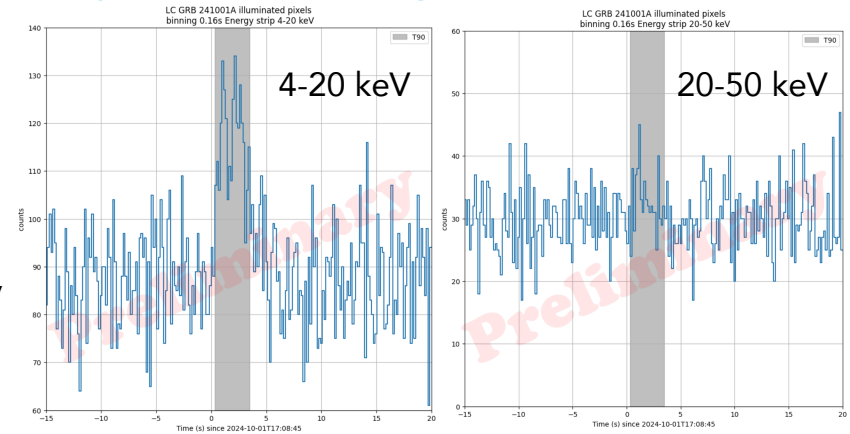
SOFT GAMMA-RAY BURSTS: EXPLORING THE DIVERSITY

GRB241001A ECLAIRs lightcurve:

T90 ~ 10 s

Faint in 20-50 keV band, not detected > 50 keV

Preliminary classification = **X-Ray Flash**



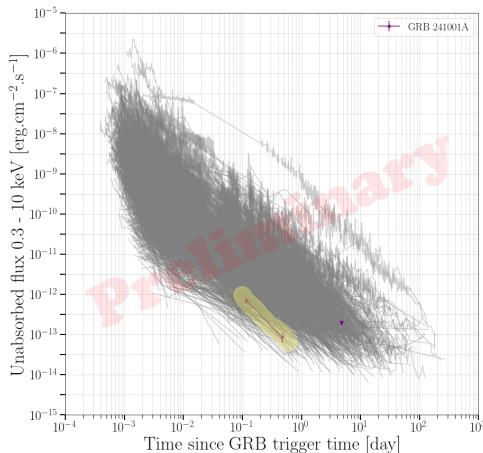
ECLAIRs spectrum well fitted with BB, also consistent with BPL, but PL rejected
 $E_{\text{iso}} = 8.4 \cdot 10^{49}$ erg ; $E_p = 7.1$ keV ($kT = 1.9$ keV) ; subluminal at its redshift

Paper on GRB241001A in preparation, led by B. Schneider

Faint X-ray afterglow

(Swift/XRT and EP/FXT)

241001A vs Swift/XRT sample

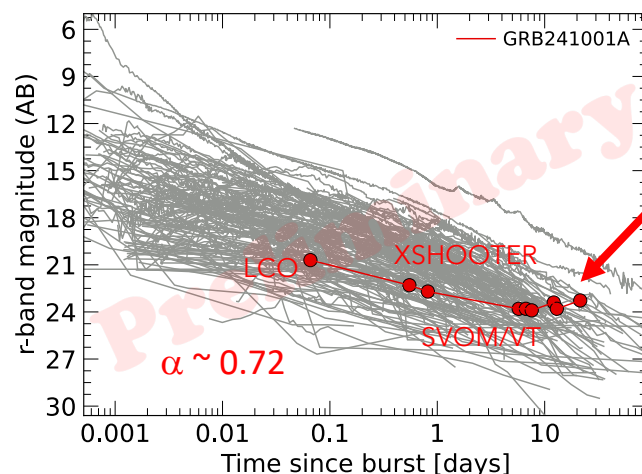


Optical afterglow: limited dataset

SVOM/VT and from GCN:

LCO (GCN#37667) & VLT/XSHOOTER (GCN#37677)

vs Kann+10 sample.



Redshift: $z = 0.573$

VLT/XSHOOTER (GCN#37677)

JWST: associated type IcbI SN

(NIRSpec spectrum @21.5 days)
(GCN#37867)

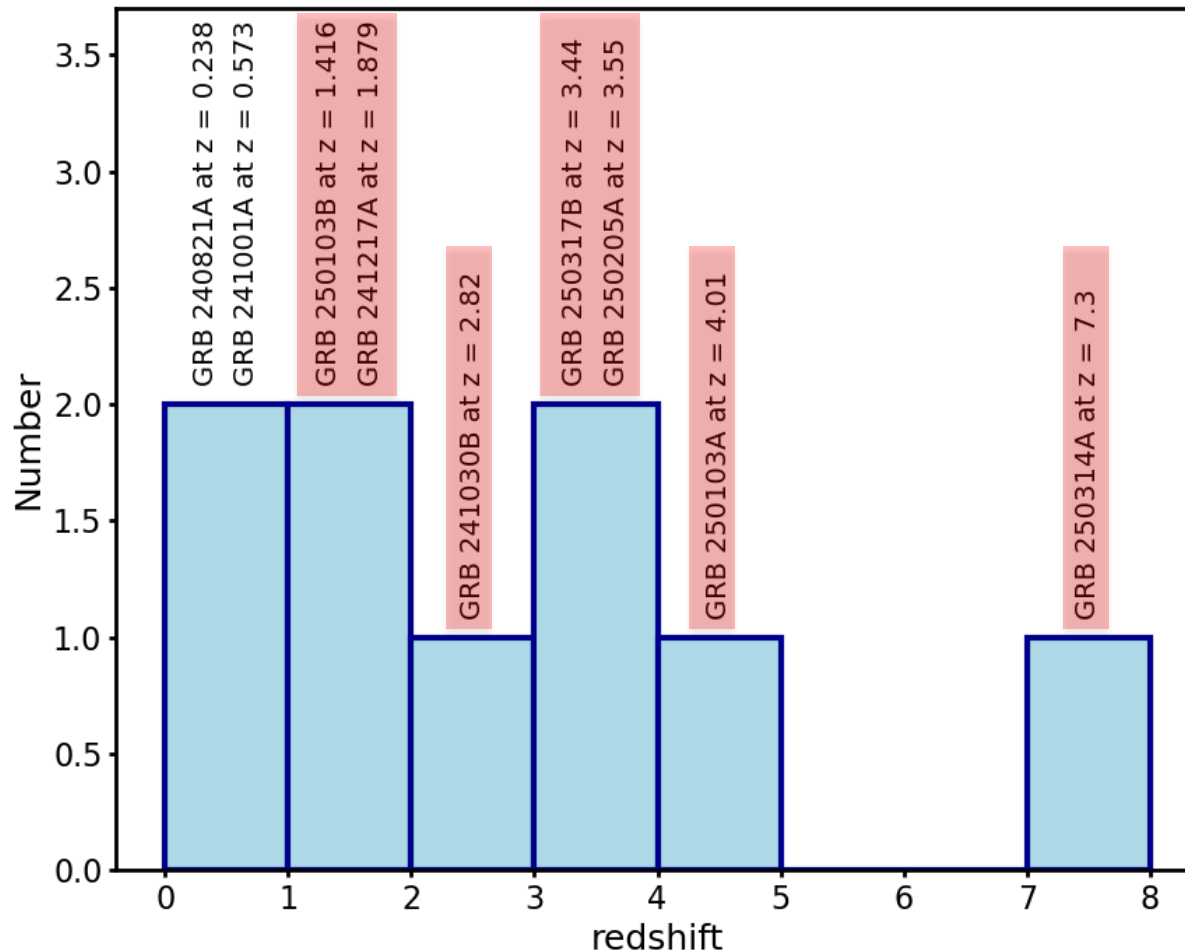
Late rise observed by SVOM/VT
in red filter = very likely the supernova

**Possible scenarios:
shock breakout?
off axis GRB?**

SVOM ECLAIRS GRB SAMPLE (3) LONG GRBS

The population of long GRBs is already better understood but SVOM can build a sample of **well characterized long GRBs** (prompt, AG, z, host) and especially better constrain the **prompt spectrum** (ECLAIRs+GRM), the **early afterglow** (MXT,VT,GFTs), or the population at **high redshift**.

7 long GRBs with $z = 1.42$ to 7.3 (median: 3.4)



14 other long GRBs:

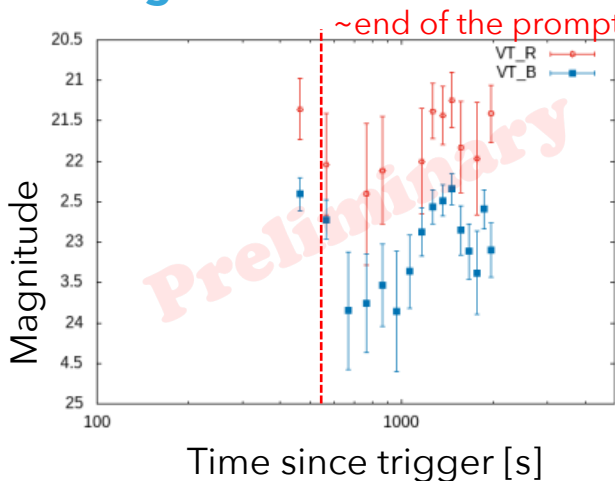
GRB240713A
GRB240914A
GRB241009A
GRB241017A
GRB241018A
GRB241108A
GRB241112B
GRB241113B
GRB241209B
GRB241212A
GRB241229A
GRB250106A
GRB250108A
GRB250127A

LONG GRBS: LATE PROMPT & EARLY AFTERGLOW (V,X, γ)

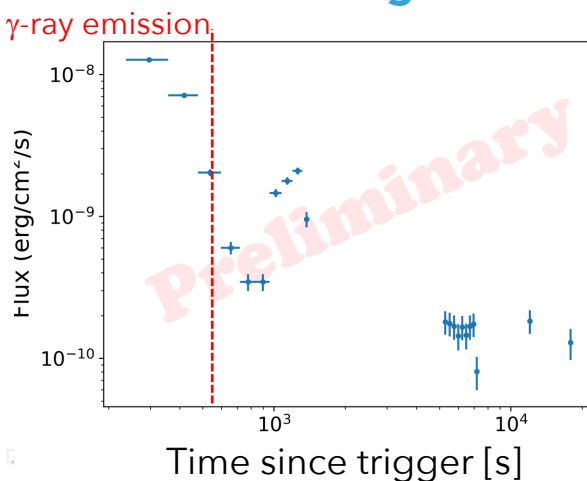
GRB241217A at $z = 1.879$

- **A very long GRB detected by the four instruments on board SVOM**
 - a precursor detected by SVOM/ECLAIRs, triggering a slew (also detected by GRM)
 - main episode detected by the four instruments on-board SVOM
- **Emission in ECLAIRs lasts ~550 s**
- **MXT and VT start observing 263/240 s after ECLAIRs trigger**
 - **observation of the late X-ray and optical prompt emission**
 - **rise of the afterglow, peaking at ~ 1400 s !**
- Detailed analysis on-going: [paper in preparation, led by Marius Brunet & He Gao](#)

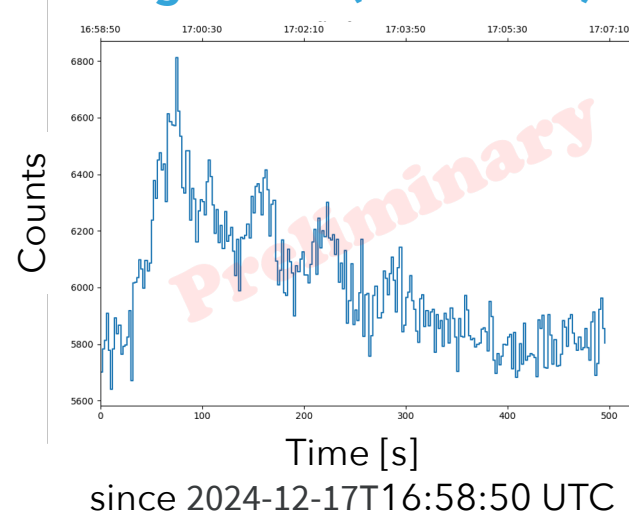
Early VT lightcurve



MXT lightcurve



ECLAIRs lightcurve (4-120 keV)



LONG GRBS: EARLY AFTERGLOW

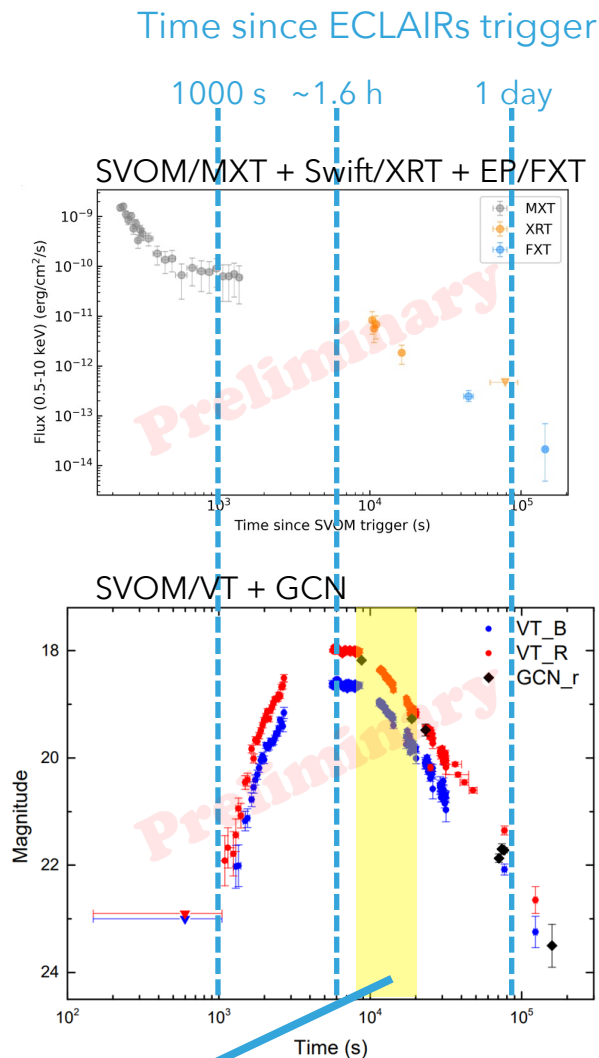
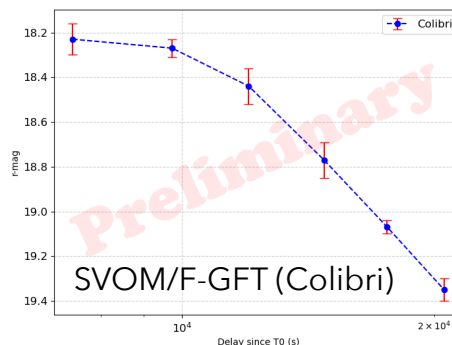
GRB250317B at $z=3.44$

- **An event detected only in ECLAIRs mostly in the 5-8 and 8-20 keV bands**
- $T_{90} \sim 15$ s (4-120 keV)
- **Very weak in GRM**
- **X-ray AG detected by SVOM/MXT**
Follow-up with Swift/XRT and EP/FXT
- **Optical AG detected by SVOM/VT**
Follow-up by many telescopes, including **SVOM/VT and SVOM/F-GFT (Colibri)**

Peculiar behavior: peak@1.6h !

- Redshift: $z = 3.44$
GTC (GCN#39769)

- **Nature of this event?**
X-ray rich GRB?
Something else?
Origin of the achromatic behavior of the AG?



X-ray lightcurve
Optical lightcurve (red)

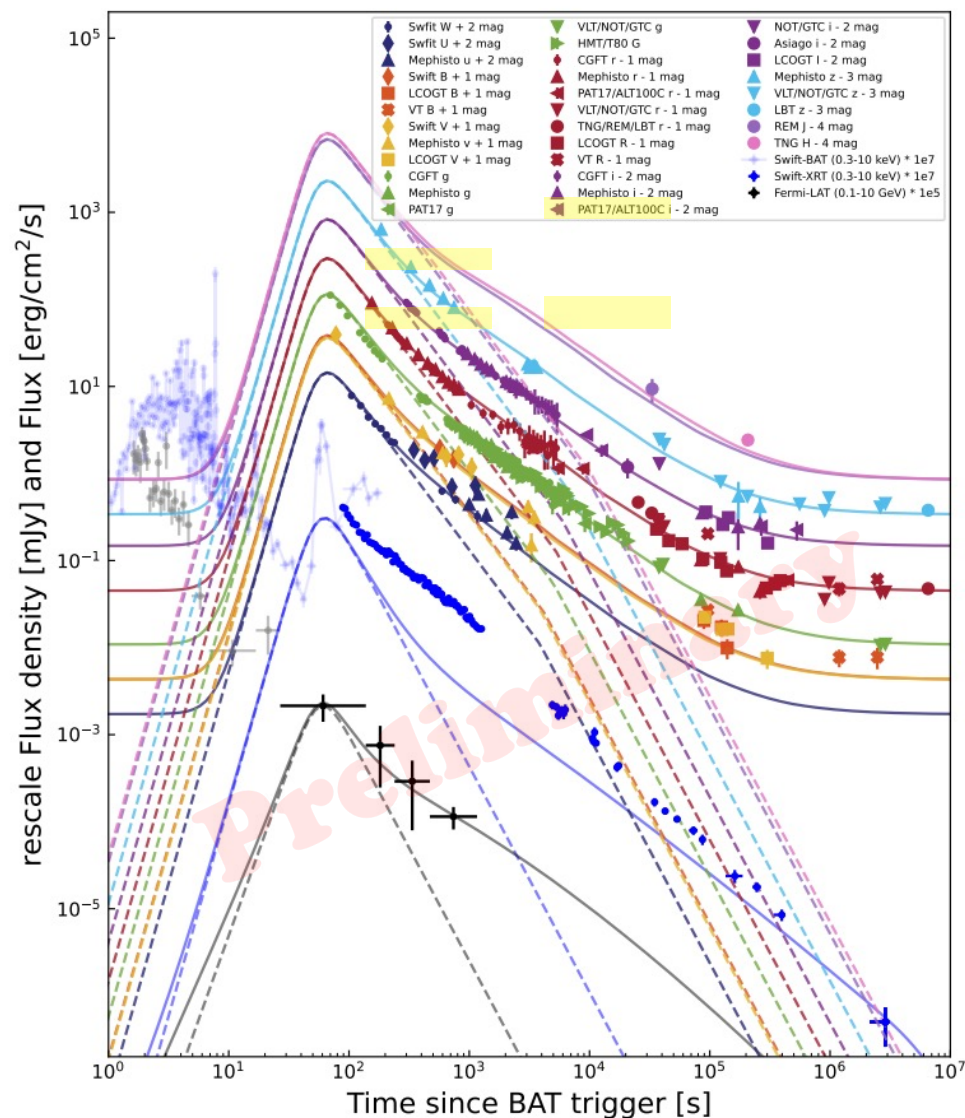
- LCOGT (GCN#39757, GCN#39759)
- OHP/T193 (GCN#39767, GCN#39777)
- NOT (GCN#39770)
- Mondy (GCN#39772, GCN#39790)

LONG GRBS: EARLY AFTERGLOW

GRB240825A at $z = 0.659$

- **A Swift/BAT & Fermi/GBM+LAT long GRB ($T_{90} \sim 4$ s in 50-300 keV)**
- **SVOM/C-GFT: AG detection 66 s after the trigger, follow-up for ~ 1.5 h**
- **SVOM/VT (SVOM ToO): detection at 1.1, 13.8 and 28.6 days**
- **An excellent early multi- λ dataset allowing a detailed modelling of the reverse and forward shock.**

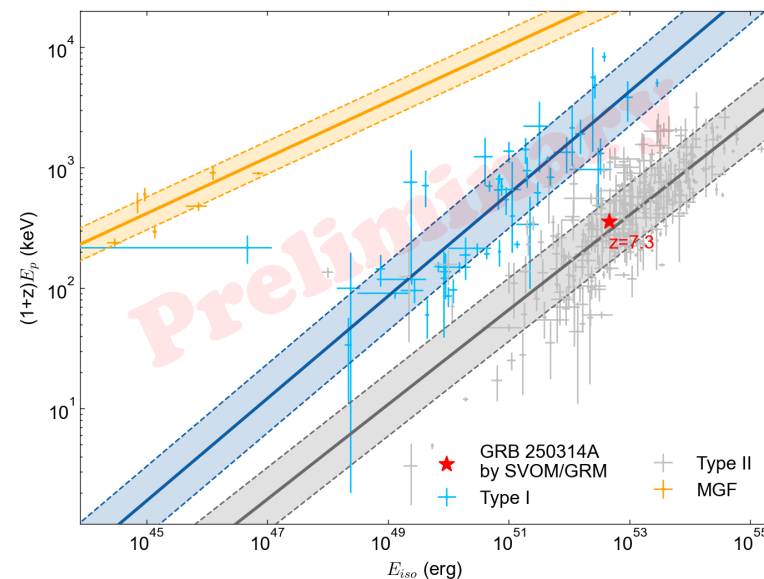
Paper on GRB240825A in preparation, led by Chao Wu



LONG GRBS AT HIGH REDSHIFT

GRB250314A at $z = 7.3$

- **A long GRB detected by ECLAIRs (T90 ~20 s) and GRM (T90 ~10 s) on-board SVOM**
- Lightcurve shows a main episode
- **Preliminary spectral analysis of GRM data:** located with other classical long GRBs in E_p - E_{iso} diagram.



- X-ray afterglow detected by Swift/XRT and EP/FXT
- **Optical afterglow: no detection by SVOM/VT despite an automatic slew**
Upper limits (3σ): $VT_R > 23.3$ @ 2.2 h (exposure time: 2.85 ks)
 $VT_B > 23.3$ @ 2.2h (exposure time: 3.30 ks)
- **NIR afterglow discovered by the NOT:** $J = 20.85 \pm 0.15$ @ 12.3 h (GCN#39727)
In a few months, the new camera CAGIRE will be installed at **SVOM/F-GFT (Colibri)**, allowing observations in **J and H filters**
Photometric redshift (Lyman alpha break) **with VLT/X-shooter** (GCN#39732)
See yesterday's talk by A. Saccardi

CONCLUSIONS

- **SVOM has started to explore the GRB diversity** with a clear impact
 - of the **4 keV low-energy threshold of ECLAIRs**:
 - **soft GRBs**
 - **long GRBs at high redshift**
 - **to come: characterization of the soft γ -ray spectrum by ECLAIRs+GRM**
 - of the optimization of the follow-up sequence (especially: **anti-solar pointing, VT sensitivity, GFTs, partners**):
 - crucial role of **Swift/XRT** and **EP/FXT** for the observation of the X-ray AG
 - already **high Opt. AG detection/redshift measurement rate** (still increasing, to come in a few month: JH filters on F-GFT)
 - **several cases of well characterized events at the prompt/early afterglow transition in X-rays and optical with MXT and VT**
- **Cross-calibration (ECLAIRs/GRM, ECLAIRs/MXT) to be completed soon: joint spectral analysis of the first detected GRBs**
- **Several papers in preparation on the first detected GRBs.**
- **Still on a learning curve, but SVOM works already very well. Thanks to SVOM partners and the whole community for the support!**

SVOM GRB PAPERS IN PREPARATION

- Paper on [GRB240821A](#) (SGRB-EE), led by F. Daigne & B. Zhang
- Paper on [GRB241001A](#) (XRF at $z=0.237$ with associated SN), led by B. Schneider
- Paper on [GRB241217A](#) (LGRB at $z = 1.879$ with late prompt/early AG simultaneous V/X/ γ observations), led by Marius Brunet & He Gao
- Paper on [GRB240825A](#) (LGRB at $z = 0.659$ with very early SVOM/CGFT detection and excellent multi-l early afterglow follow-up), led by Chao Wu
- Paper on [GRB241029A](#) (LGRB at $z = 1.072$ common to Fermi/GBM and SVOM/ECLAIRs+GRM), led by Wenjin Xie
- Paper on [GRB241030A](#) (a bright LGRB at $z= 1.41$ common to Swift/BAT, Fermi/GBM, SVOM/GRM with early AG absorption spectroscopy at Keck), led by Jing Wang & Weikang Zheng
- Paper on [GRB241105A](#) (SGRB-EE), led by D. Dimple
Contact on SVOM side: J. Palmerio

SVOM: SEVERAL POSTERS TO KNOW MORE

- **Learn more on ECLAIRs on-board trigger:**

See poster « *SVOM/ECLAIRs Gamma-Ray Burst Trigger In-Flight Commissioning* » by S. Schanne

- **There is also an ECLAIRs on-ground trigger!**

See poster « *The SVOM/ECLAIRs offline trigger pipeline for the detection of γ /X-ray transients* » by M. Brunet, H. Yang et al.

- **Want to know more on the (mostly automatic) quicklook analysis of ECLAIRs and GRM data received by the VHF network?**

See poster « *The GRB quick analysis pipeline of SVOM ECLAIRs & GRM* », by T. Maiolino et al.

- **Results of the on-going ECLAIRs-GRM spectral cross-calibration:**

See poster « *In-flight spectral cross-calibration of ECLAIRs and GRM on board SVOM* » by M.-G. Bernardini et al.

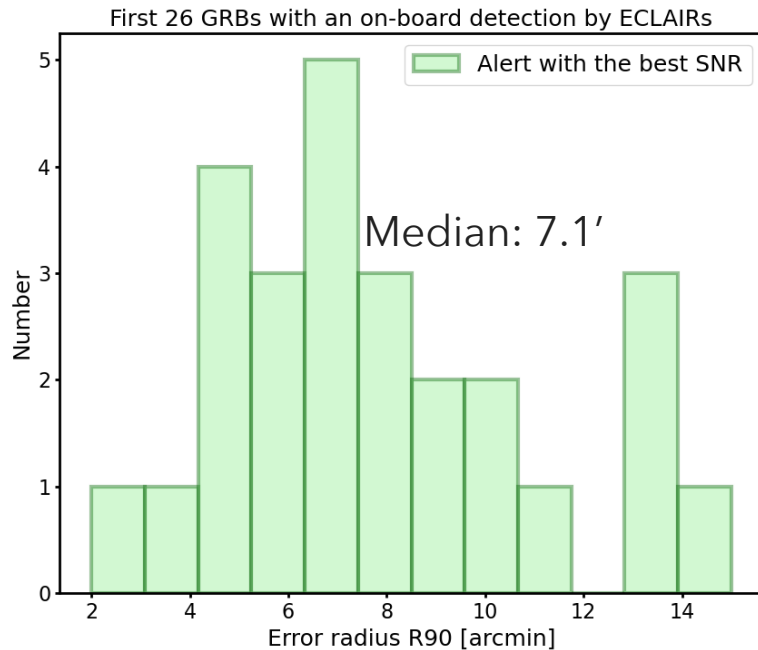
- **Want to know more on SVOM/F-GFT (Colibri) and the soon-to-come CAGIRE camera (J,H)?**

See poster « *From Swift/GROND to SVOM/COLIBRI to study the GRB afterglow* » by N.A. Rakotondrainibe

SVOM/ECLAIRS: GRB DETECTION RATE – LOCALIZATION – SLEW

■ ECLAIRS:

- 26 GRBs detected on-board in 8.7 months ~ 36 GRB/year
- % of time with active on-board trigger: 45% (July-Nov. 24) → 76% (Dec. 24-March 25)
- **Expected rate during scientific operations:**
~45-50 GRBs detected and localized on-board per year



Statistical error on ECLAIRS localization
Systematics: 2'

Field-of-view of the follow-up instruments on board SVOM:

- MXT: 58' x 58' (Swift/XRT: 24'x24')
- VT: 26' x 26'

Automatic slew:

- 54% of GRBs since Launch
- **85% of GRBs since Dec. 24**
(lowered threshold)