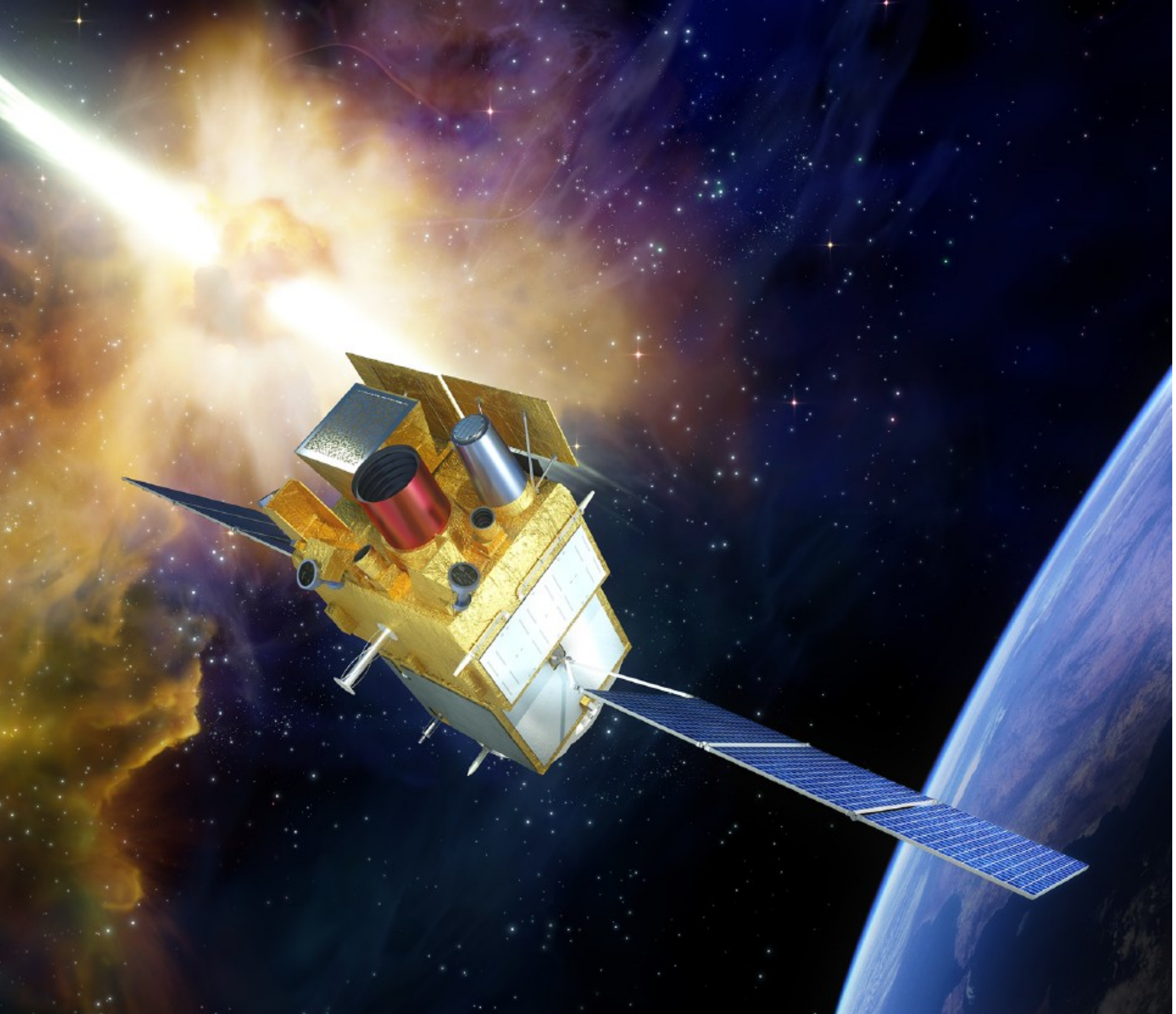


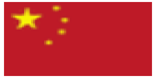
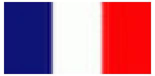
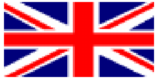
First results from the SVOM mission

Frédéric Piron

Laboratoire Univers et Particules
de Montpellier (CNRS/IN2P3/LUPM)

Sexten Workshop, 2025 July 3

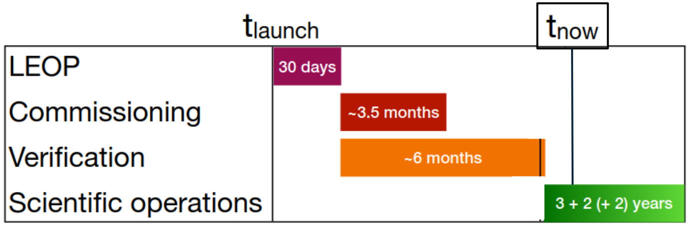
The SVOM consortium

- **China (PI J. Wei)** 
  - SECM Shanghai
  - Beijing Normal University
  - Central China University Wuhan
  - GuangXi University Nanning
  - IHEP Beijing
  - KIAA Peking University
  - Nanjing University
  - NAOC Beijing
  - National Astronomical Observatories
  - Purple Mountain Observatory Nanjing
  - Shanghai Astronomical Observatory
  - Tsinghua University Beijing
- **Mexico** UNAM Mexico 
- **France (PI B. Cordier)** 
  - CNES Toulouse
  - APC Paris
  - CEA Saclay
  - CPPM Marseille
  - LUX Meudon
  - IAP Paris
  - IJCLab Orsay
  - IRAP Toulouse
  - LAM Marseille
  - LUPM Montpellier
  - ObAS Strasbourg
- **United Kingdom** University of Leicester 
- **Germany** 
  - MPE Garching
  - IAAT Tübingen

Space-based Variable Objects Monitor

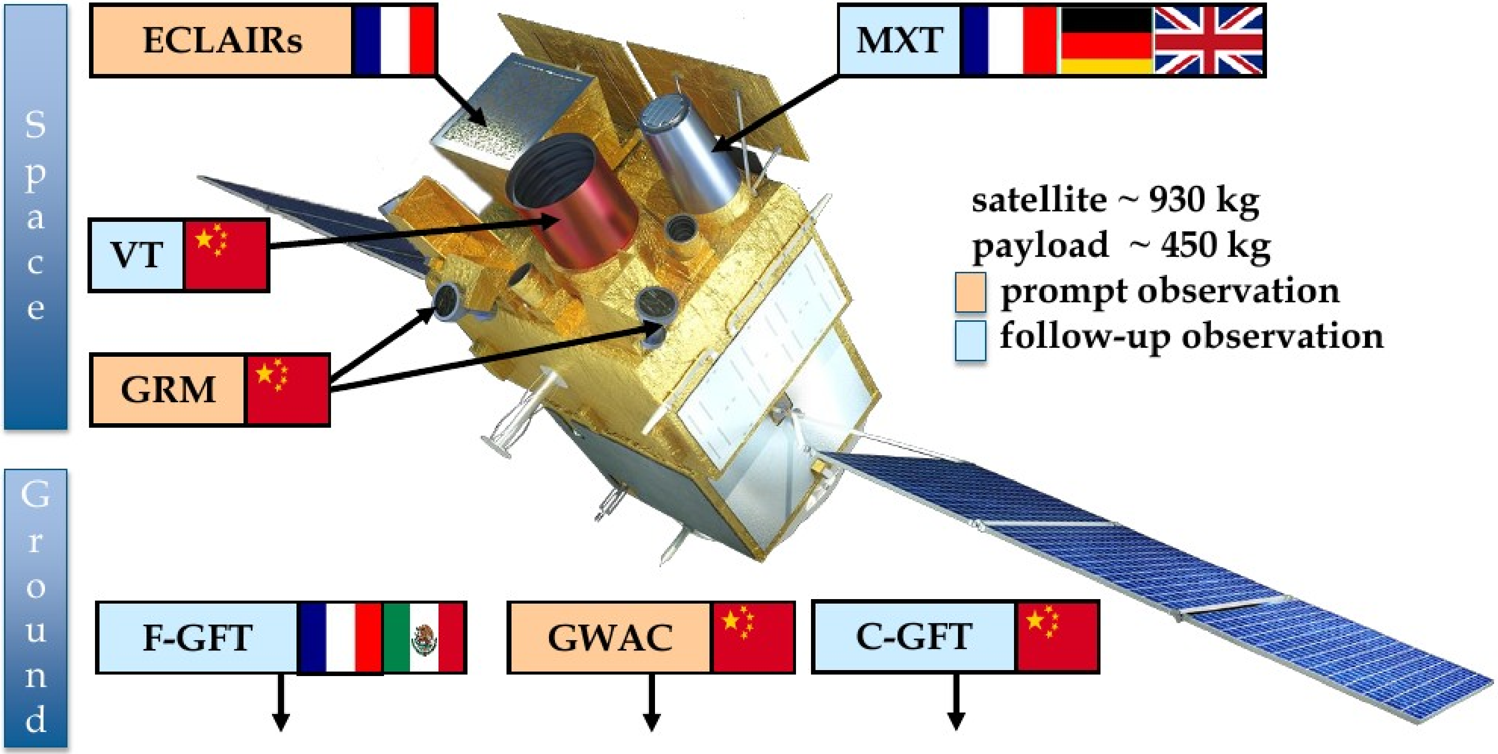
- **2024 June 22: launch from Xichang (Sishuan) by a LM-2C rocket**
- **2025 April: beginning of scientific operations**
- **3+2 years (+extension)**

Post-launch phases



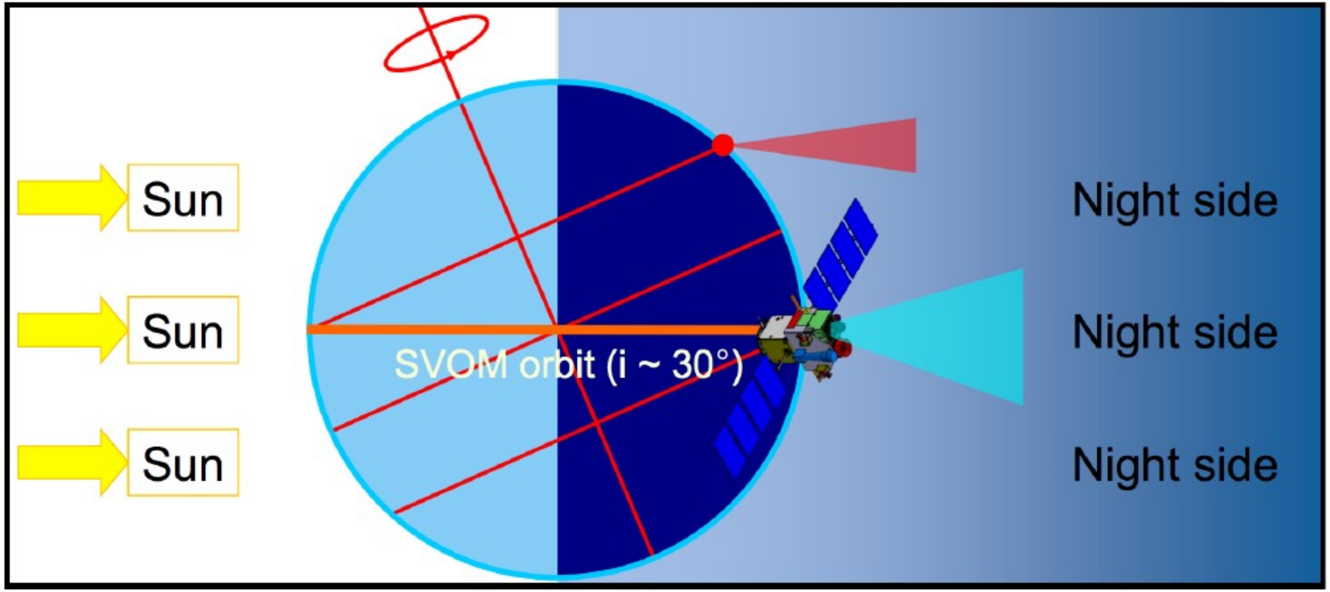
The SVOM system

- On board: 4 instruments (2 wide FoV, 2 narrow FoV), VHF antennas, slewing capability
- On ground: 3 telescopes for rapid follow-up observations, VHF stations

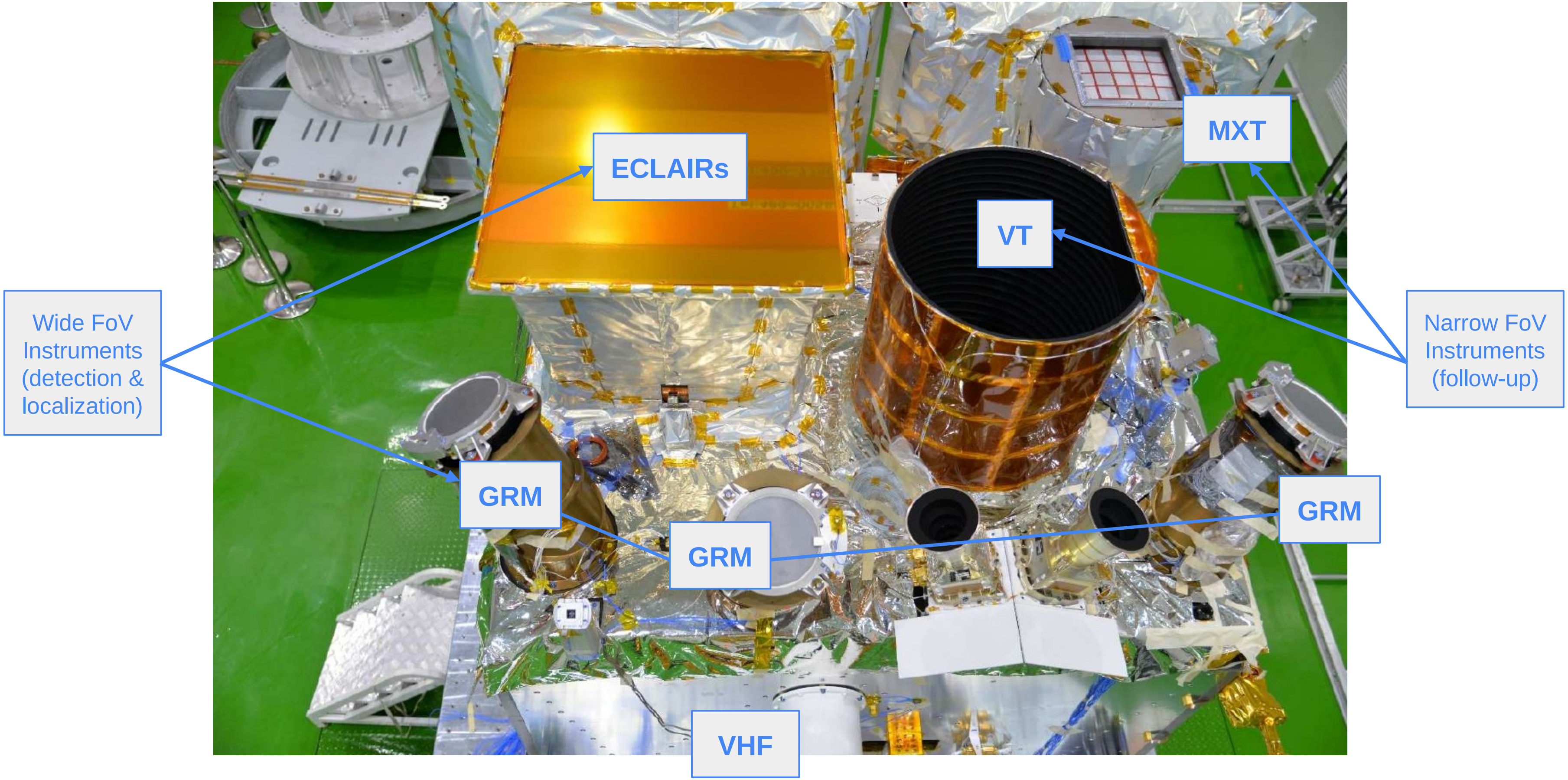


Orbit and pointing strategy

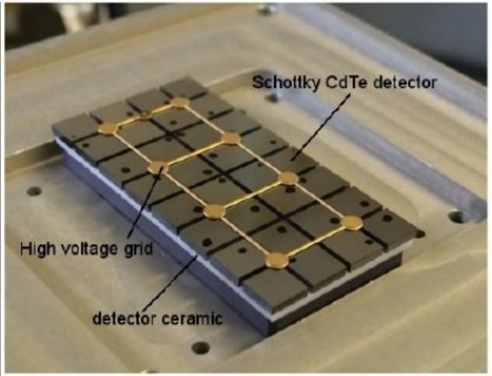
- **Low Earth Orbit: 650 km, 30° inclination, 1 orbit ~ 96 min**
- **Nearly antisolar attitude law to facilitate follow-up observations from ground**
  - Earth in the FoV: 65% duty cycle for ECLAIRs (50% for MXT and VT)
  - ECLAIRs FoV: avoidance of Galactic plane and Sco-X1

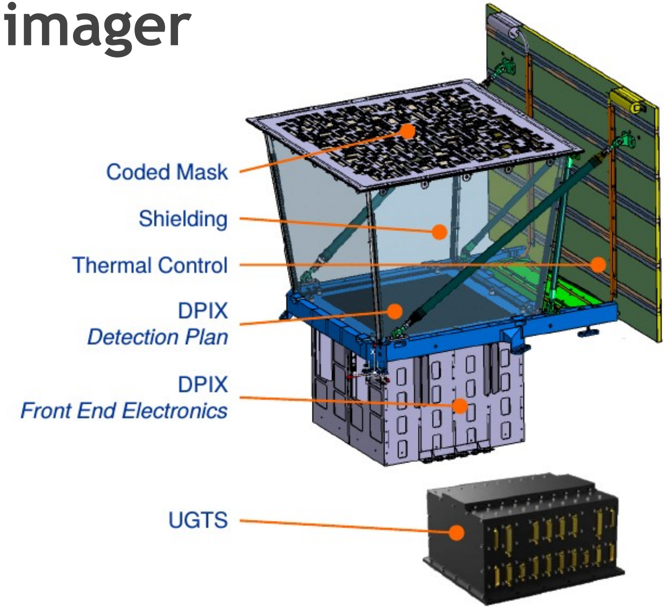


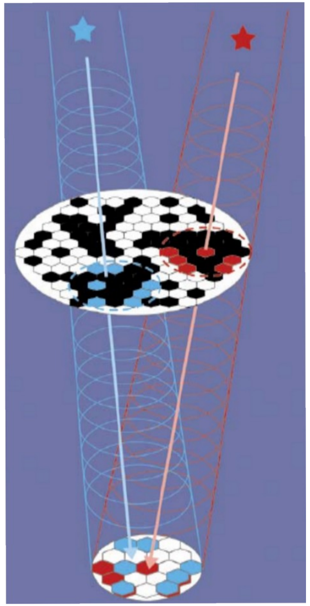
The SVOM payload



The ECLAIRs X/gamma-ray imager





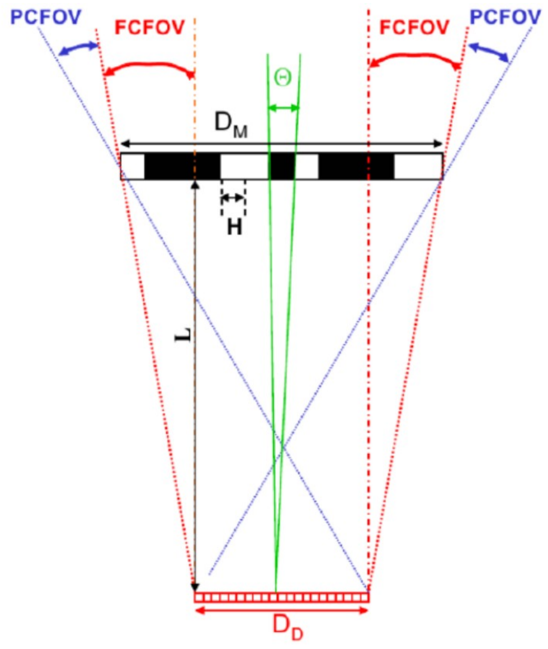


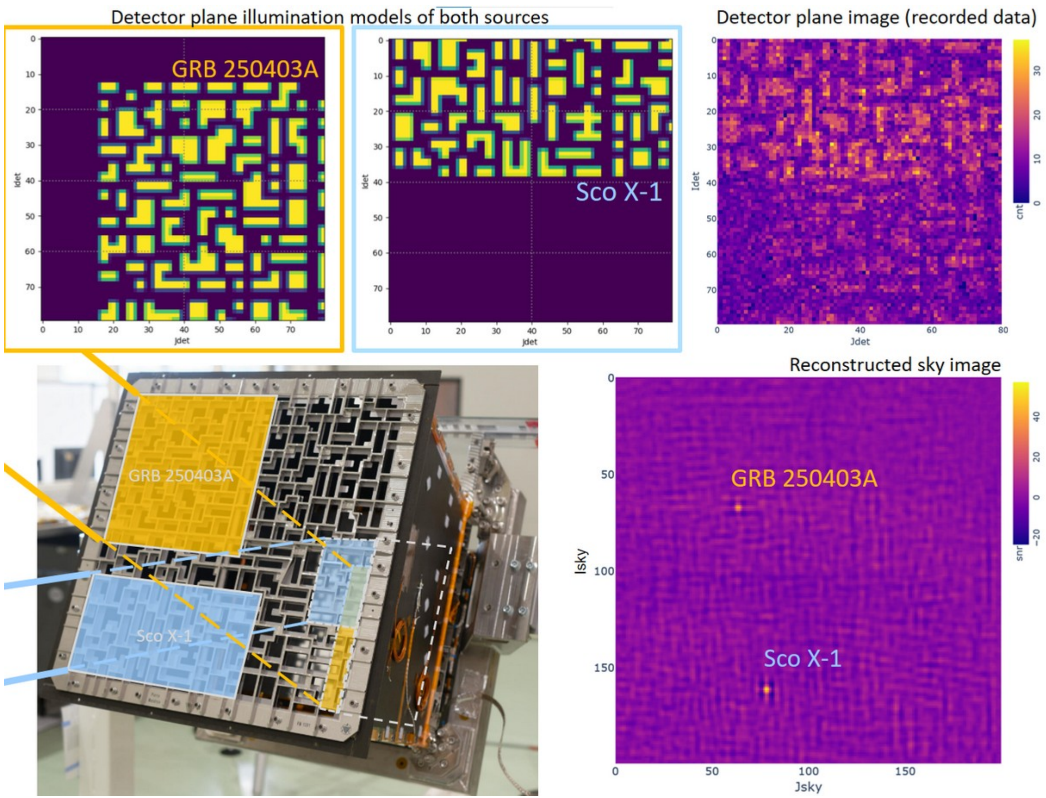
Field of view	2.05 sr
Energy range	**4**-150 keV
Energy resolution	<1.6 keV @60 keV
Effective area	200 cm² @6 keV
Localization accuracy	**<12 arcmin** (90% of sources at detection limit)

- **Coded mask 54x54 cm², 40% open fraction**
- **Detection plane area 1024 cm²**
  - 6400 CdTe pixels (4x4x1 mm3)
- **All photons are sent to the ground**
- **Onboard real-time trigger and localization**
  - Strongly varying background (Earth transit through FoV every orbit)
  - Time scales 10 ms to 20 min, 4 energy bands, 9 detector zones
  - Count Rate Trigger (CRT, <20 s) and Image Trigger (IMT, >20 s)

GRB 250403A with ECLAIRs

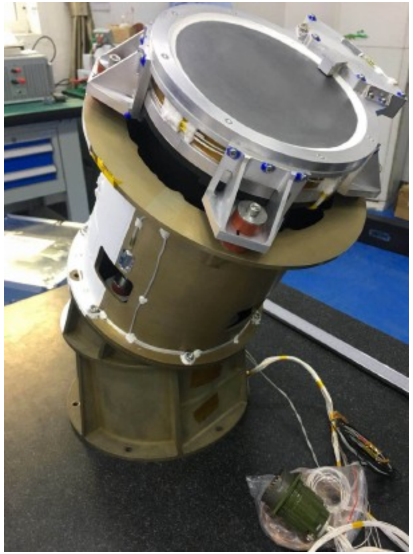
ECLAIRs partially and fully coded fields of view

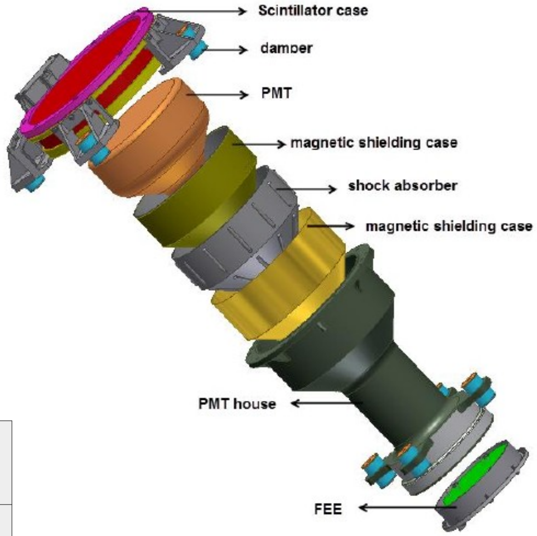


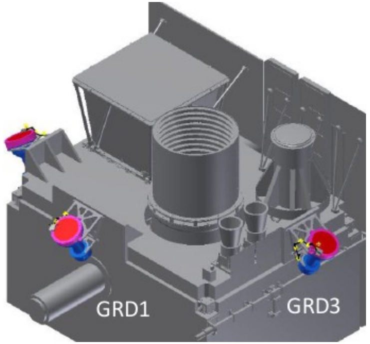


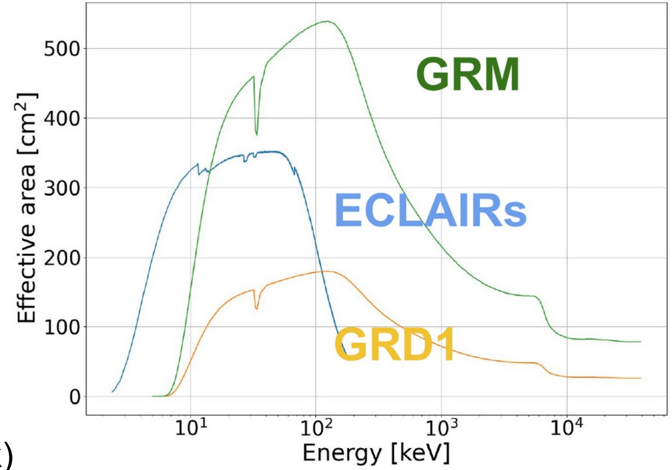
- **Scorpius X-1:** galactic LMXB (9000 l.y. from Earth), most powerful X-ray source
- **GRB 250403A at z = 1.857:** as intense as Sco X-1!

The Gamma-Ray Monitor (GRM)







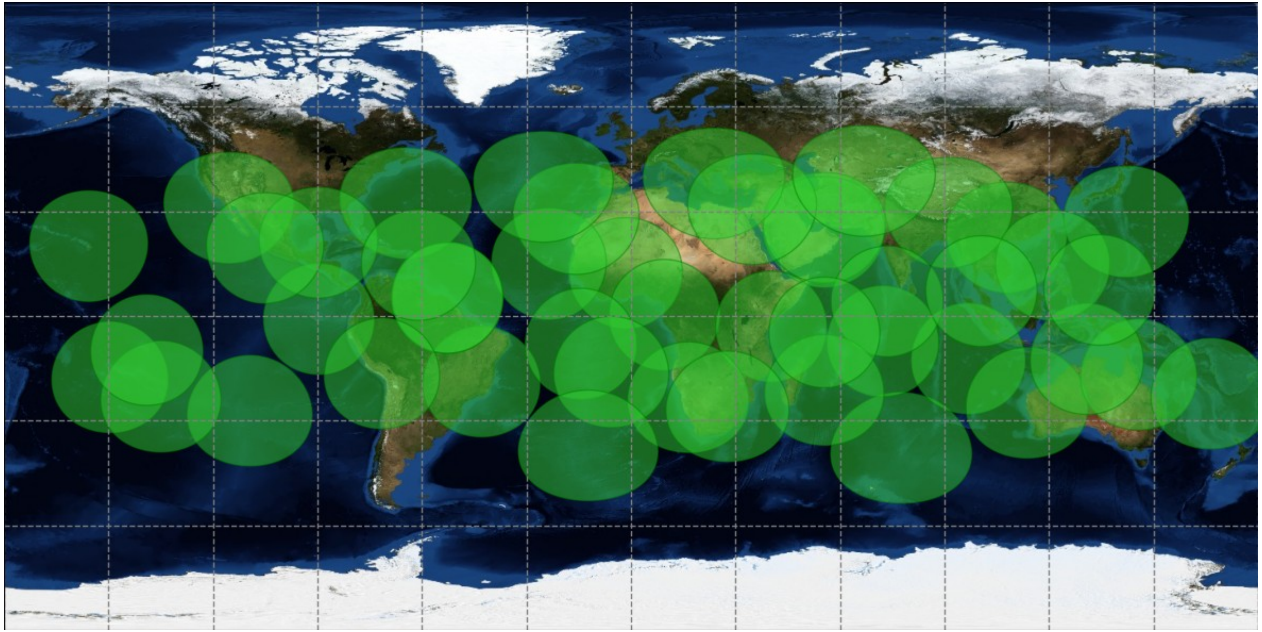


Field of view	5.6 sr (GRD ±60°)
Energy range	15-5000 keV
Energy resolution	<19% @60 keV
Effective area	190 cm² @peak for each GRD
Localization accuracy	Several degrees (under study)

- **3 Gamma-Ray Detectors (GRDs)**
  - NaI(Tl) (16 cm Ø, 1.5 cm thick)
  - Plastic scintillator (6 mm) to monitor particle flux and reject particle events
  - 30° inclination w.r.t. ECLAIRs optical axis
- **Count Rate Trigger (2 GRDs above threshold)**
  - Time scales 0.1 to 4 s, 4 energy bands

The VHF alert network

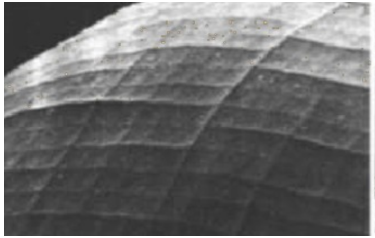
- **47 stations deployed under the satellite track**
- **Alerts are received on the ground (French Science Center) with a median delay of ~7.6 s**
  - Lost VHF packets are recovered via Beidou in case of coverage gap: median delay of ~81s

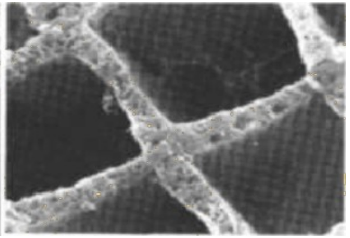


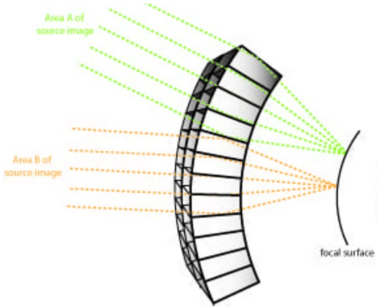
- **GCN public alerts**
  - Notice since February 2025
  - First circular (detection and localization in case of ECLAIRs trigger)

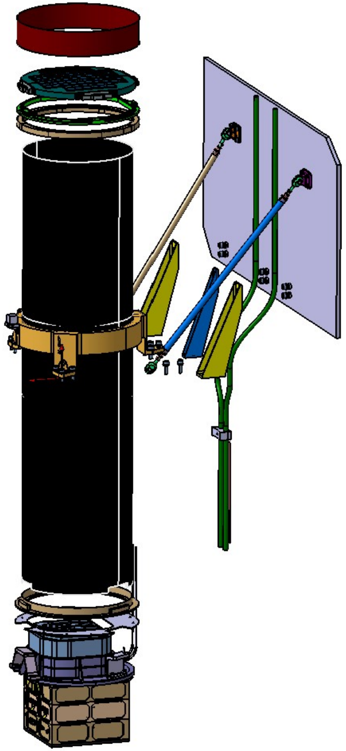
The Micro-channel X-ray Telescope (MXT)

Real vs. manufactured “lobster eyes”

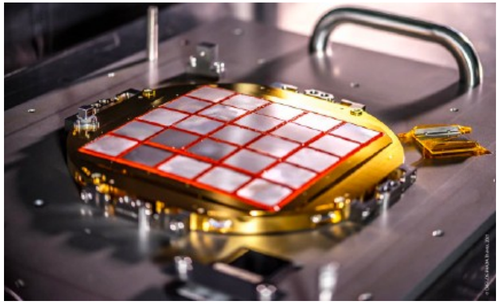








- **Micro-channel plate optics**
    - 20 micron size pores in a “lobster eye” configuration
    - Focal length: 1 m
    - pnCCD camera (256x256 pixels of 75 microns)

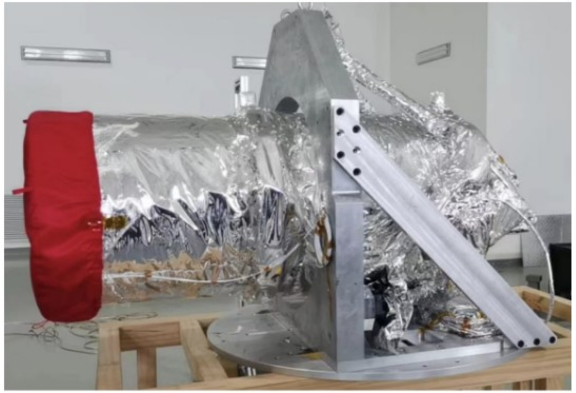


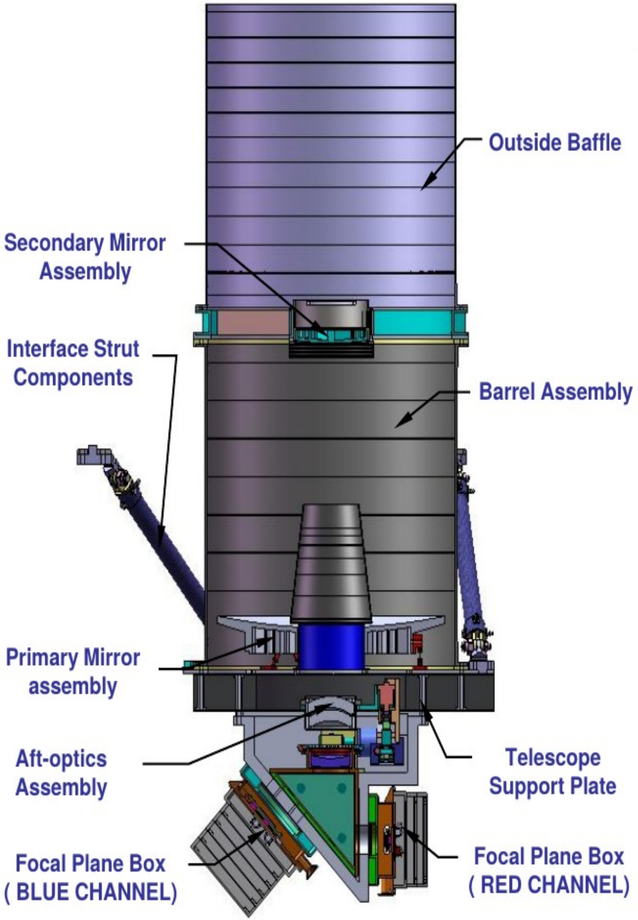
Field of view	58x58 arcmin²
Energy range	0.2-10 keV
Energy resolution	80 eV (FWHM) @1 keV
Effective area	27 cm² @1 keV (central spot)
Localization accuracy	<1 arcmin (50%) **<2 arcmin** (90%) Syst. under study

The Visible Telescope (VT)

- **Ritchey-Chretien telescope**
  - 40 cm Ø, f=9
  - Focal length: 3.6 m
  - 2 channels: blue (400-650 nm) and red (650-1000 nm)
  - 2k * 2k CCD detector each
- **FoV covering ECLAIRs error box in most cases**
- **Will detect 80% of ECLAIRs GRBs**

Field of view	26x26 arcmin²
Sensitivity	Mv=22.7 (B/R) (3σ, 300 s)
Localization accuracy	B: 80% @1.4 arsec R: 70% @0.9 arsec
Photometry accuracy	Blue: 1.3% Red: 0.5%





Ground segment telescopes

- **Ground-based Wide Angle Camera (GWAC)**
  - 36 camera units covering 5400 deg^2 (~1/2 ECLAIRs FoV)
  - Installed in Ali (China) and CTIO (Chile)
  - 500-800 nm; mlim=16-17 (10 s exposure)
  - Explore the prompt optical emission

- **Ground Follow-up Telescopes (GFTs)**
  - Robotic 1-m class telescopes (fast repointing, <30 s)
  - San Pedro Martir (Mexico) and Xinglong observatory (China)
  - **C-GFT**: 1.2 m, FoV = 21x21 $arcmin^2$, 400-950 nm
  - **F-GFT (a.k.a. Colibri)**: 1.3 m, FoV = 26x26 $arcmin^2$, multi-band photometry (400-1700 nm, 3 simultaneous bands)
    - A new camera (CAGIRE) to be installed in coming months, allowing observations in J,H bands

- **Accurate GRB localization → observations with large telescopes**

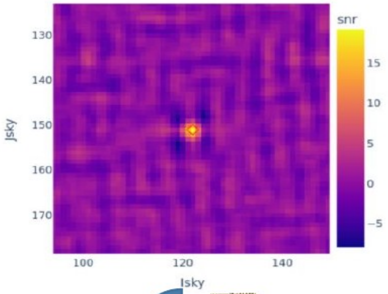
Boosting the synergy between space and ground-based telescopes

- **SVOM follow-up network: from 25cm to the 8m class telescope**
  - >75% of ECLAIRs GRBs immediately visible by one ground telescope (GFTs+LCOGT)
  - Early observation by large telescopes favored by pointing strategy → z measurement expected in ~2/3 of cases

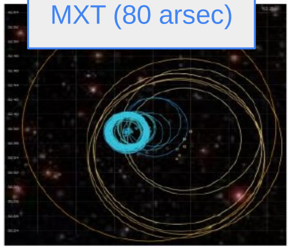
- **Synergies with Swift and Einstein Probe: ECLAIRs trigger → automatic ToO requests**
  - to Swift/XRT since February 2025
  - to EP/FXT since April 2025

GRB 250205A: a textbook case

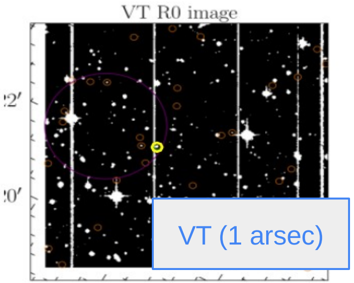
ECLAIRs (4.5 arcmin)



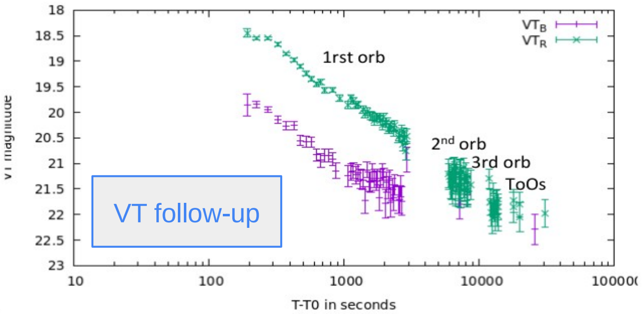
MXT (80 arsec)

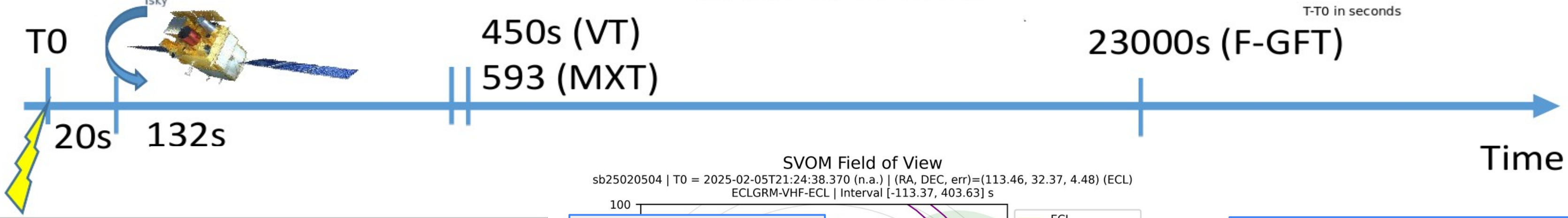


VT (1 arsec)

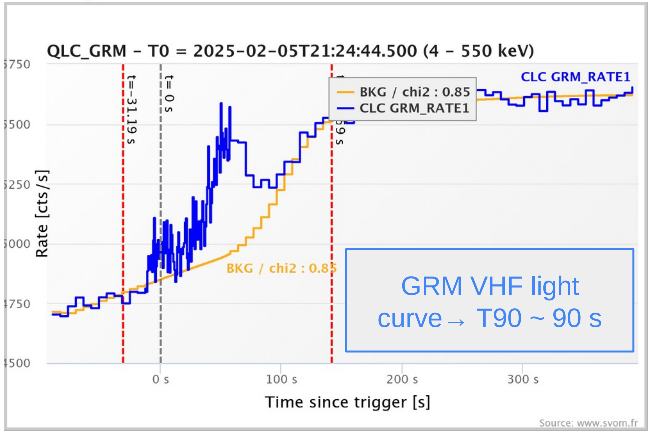


VT follow-up

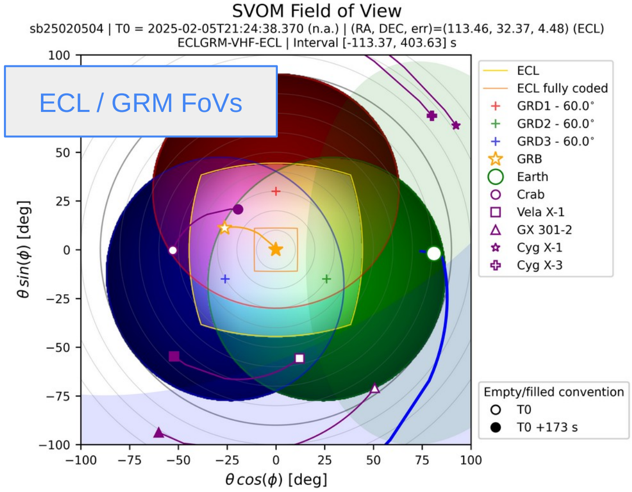




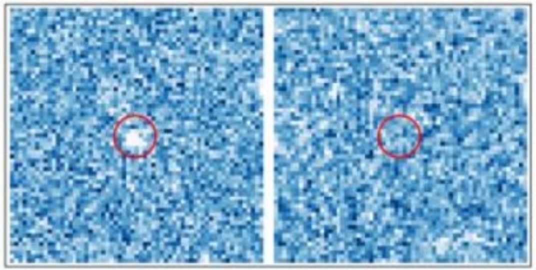
GRM VHF light curve → T90 ~ 90 s



ECL / GRM FoVs



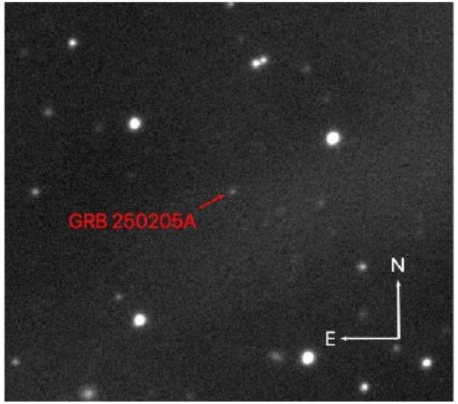
Colibri (F-GFT) at T0+6.4h
r = 22.89 + /- 0.11



GRB 250205A: a textbook case

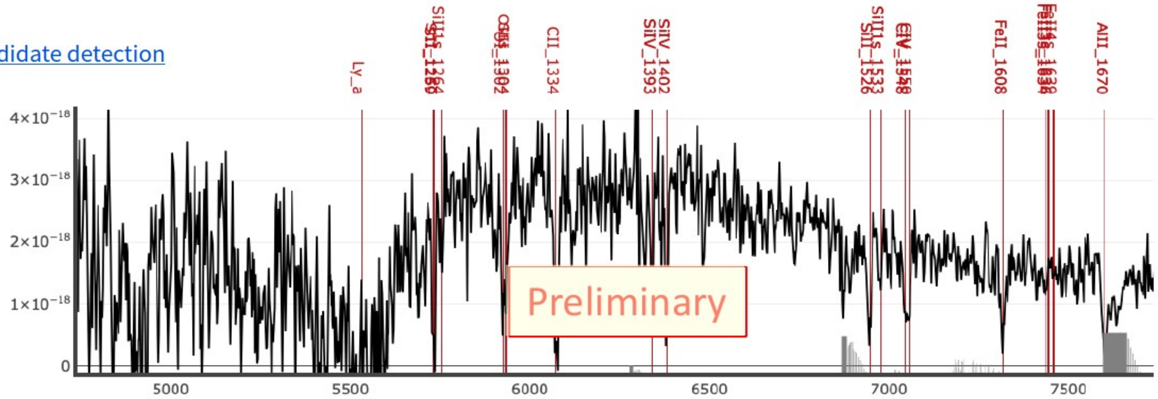
39520. GRB 250205A / EP250205A: further radio observations with the VLA
39315. GRB 250205A: VIRT Optical Upper Limit
39314. GRB 250205A: Leavitt Observatory optical upper limit
39302. GRB 250205A: Calapai Observatory, Massa S. Giorgio (Messina), upper limit
39289. GRB 250205A / EP250205A: radio detection with the VLA
39240. GRB 250205A: 1.3m DFOT optical upper limit
39171. GRB 250205A: Fermi GBM Observation
39170. GRB 250205A: REM NIR upper limit
39169. EP250205a/GRB 250205A: FTW optical and NIR observations of the counterpart
39168. GRB 250205A: Swift/UVOT Upper Limits
39166. EP250205a/GRB 250205A: correction to the source localization
39165. EP250205a/GRB 250205A: Einstein Probe observation
39162. GRB 250205A: COLIBRÍ/DDRAGO Optical Afterglow Detection
39161. GRB 250205A: Swift/XRT detection
39160. GRB 250205A: Redshift from OSIRIS+/GTC z = 3.55
39159. GRB250205A: SVOM/VT optical afterglow detection
39158. GRB 250205A: GOTO optical upper limits
39157. GRB 250205A: OHP/T193 optical counterpart candidate
39156. GRB 250205A: Liverpool Telescope optical counterpart candidate detection
39154. GRB 250205A: SVOM detection of a burst

GCN circulars



30-s acquisition in r-band

- **Mobilization of the GRB community**
- **At T0+1h45: OSIRIS+ on the 10.4 m GTC (La Palma) → z = 3.55**



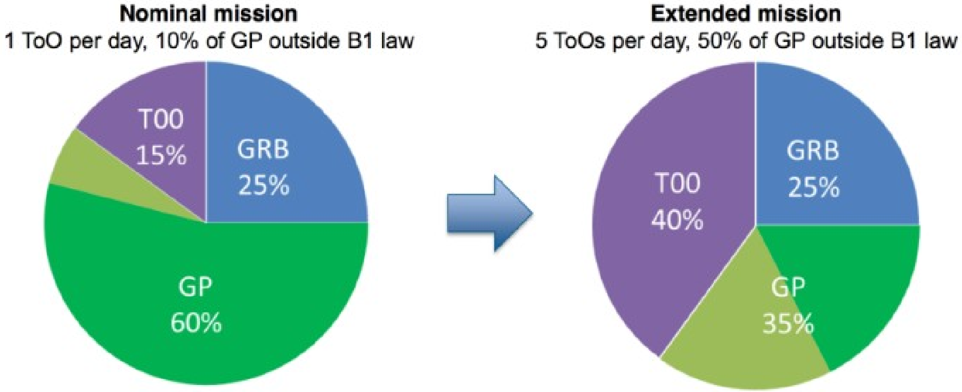
4x900s of spectroscopy using grism R1000B

Scientific Programs

The Core & ToO programs

reserved to SVOM Co-Is

Gamma-Ray Bursts



The General & ToO programs

GP obs (known sources): observation proposals awarded by a TAC (your proposal has to include a SVOM co-I).
ToO obs (not anticipated flaring sources): If you want a ToO, please contact the SVOM PIs

Magnetar Giant Flares

CVs, x-ray binaries

Flaring stars

AGN/Blazars

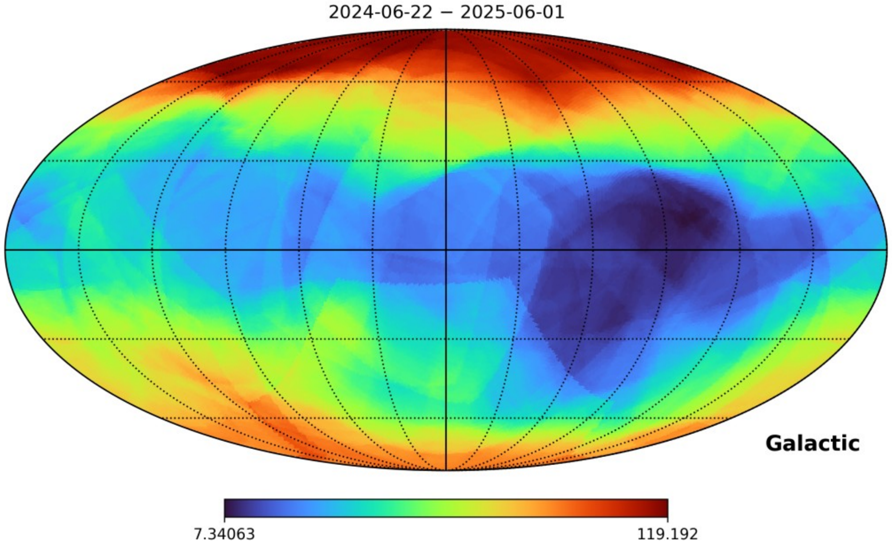
Supernovae

TDE, FRB, etc.

Exposure map and pointings (1st year)

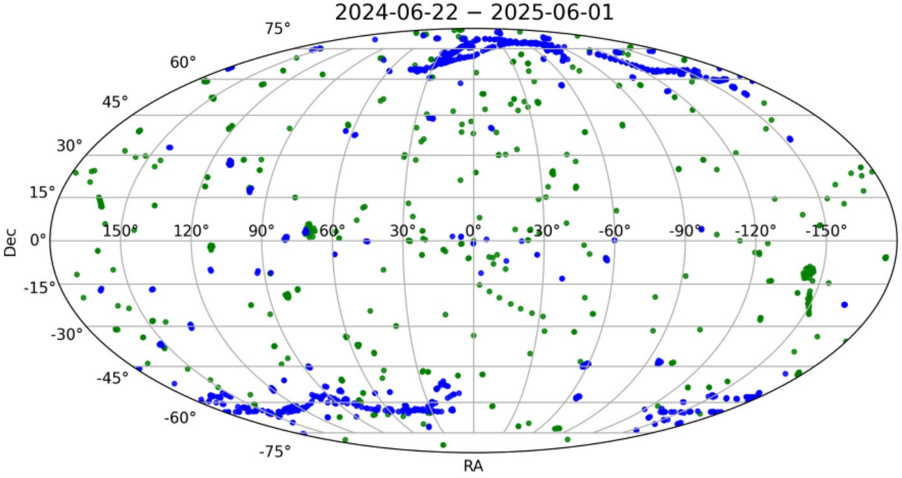
- **ECLAIRs sky exposure**
  - B1 attitude law → mostly towards galactic poles

ECLAIRs exposure map (in days) during 1st year



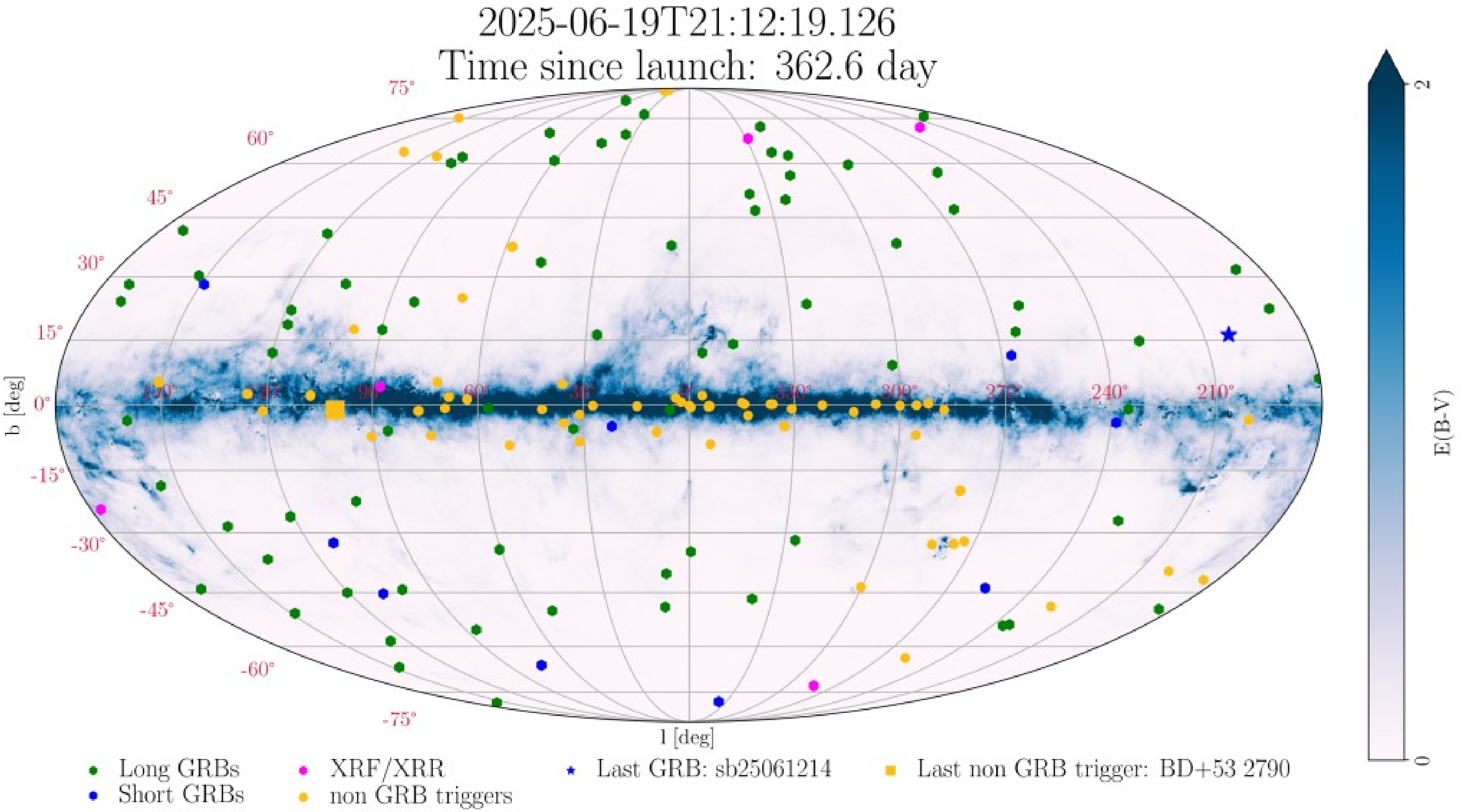
- **Platform pointing directions**
  - GP: predefined sky areas while awaiting GRBs
  - ToOs: known astrophysically interesting targets

MXT & VT pointing directions during 1st year



- **35% of available time devoted to ToOs, half of which for GRB revisits to build VT light curves**
  - >2/3 of these revisits were conducted for SVOM-detected bursts, <1/3 for Swift, EP and Fermi

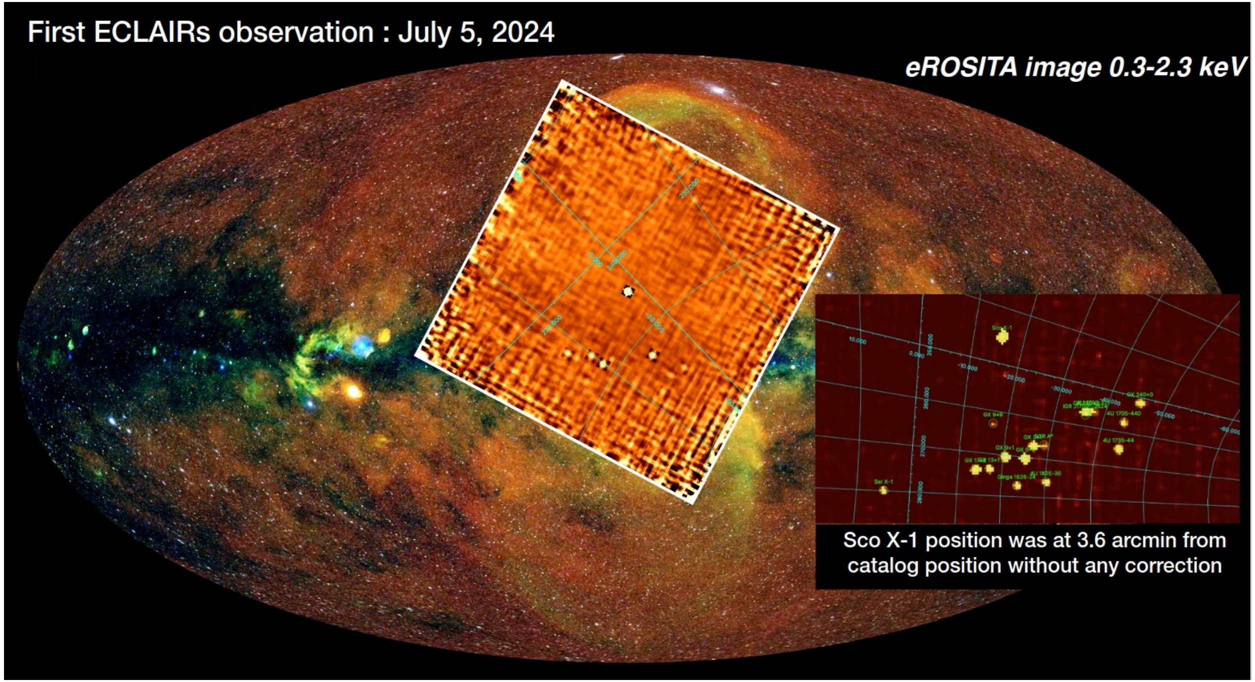
The SVOM X-ray/γ-ray transient sky after one year



SVOM transient statistics (1st year)

Preliminary

SGR	LMXB	HMXB	Variable / flaring star	AGN / blazar	unknown	Total
3 (4%)	~40 (54%)	~19 (24%)	4 (6%)	3/1 (4%)	6 (8%)	**~76**

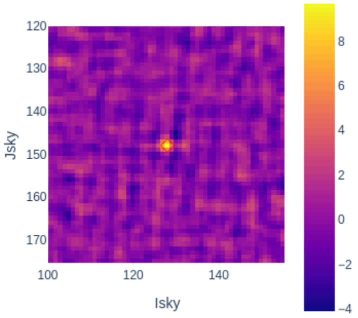


SVOM GRB statistics (1st year)

Preliminary

	GRM detection (Half time in commissioning)	ECL detection (Half time in commissioning)	Total ECL+GRM detection	Jointly detected by Swift / EP / Fermi	# z_{GRM}	# z_{ECL}
Observed	110	46	**131** 105 Long (80%), 18 Short (14%), 8 XRF (6%)	89 (68%)	10 (9%)	16 (35%)
Expected	>100	30 - 60	–	–	–	> 50%

ECLAIRs first GRB
(GRB 240713A)

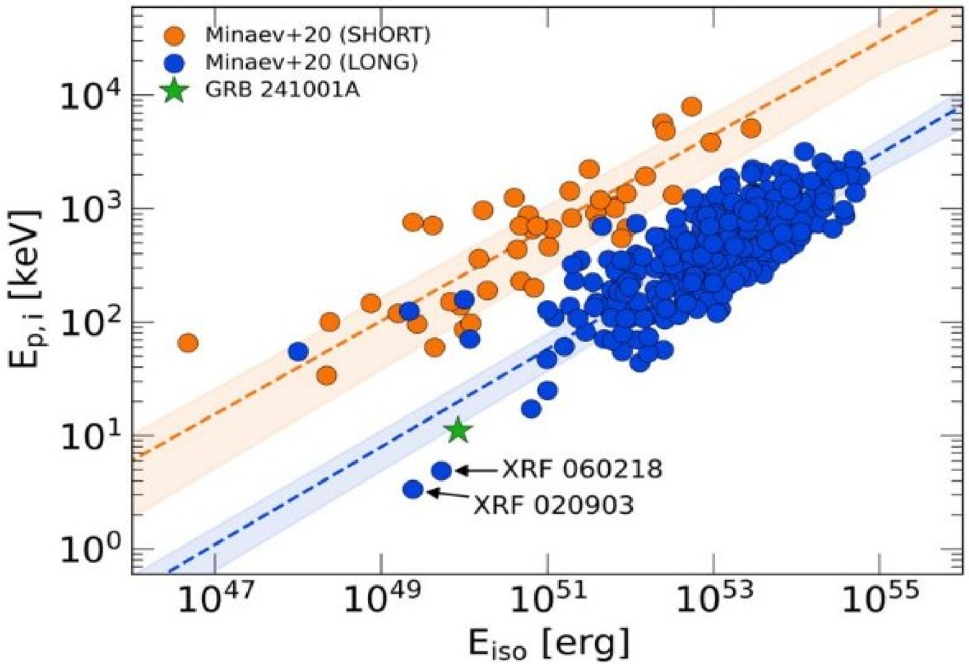


ECL median loc.	MXT median loc.	X-ray afterglows	Optical afterglows	Radio afterglows	z > 4
~7’	~40”	48 (36 ECL)	34 (27 ECL)	5	**4/26** (15%)

Soft Gamma-Ray Bursts

Goal: explore the diversity of long GRBs and the event continuum following the collapse of a massive stare → complete physical interpretation of the poorly known population of very soft X-ray bursts

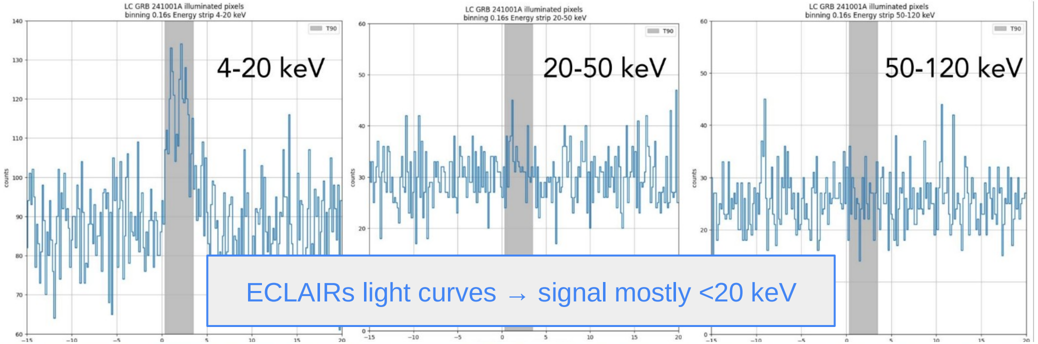
- Connection between classical collapsar GRBs and “failed” or low-luminosity GRB collapsars?
- Shock breakout emission?
- Geometry effect → off-axis jet?
- Low Γ jets?
- High redshift effect?



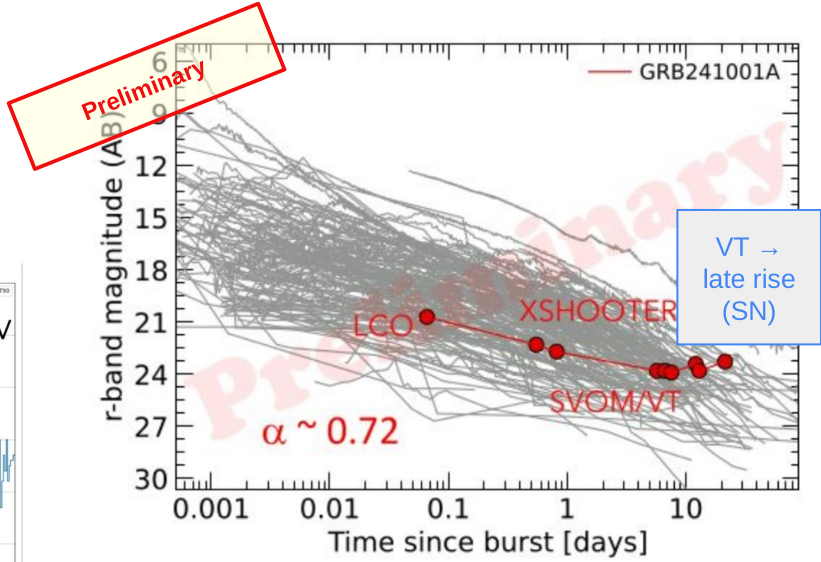
Soft Gamma-Ray Bursts

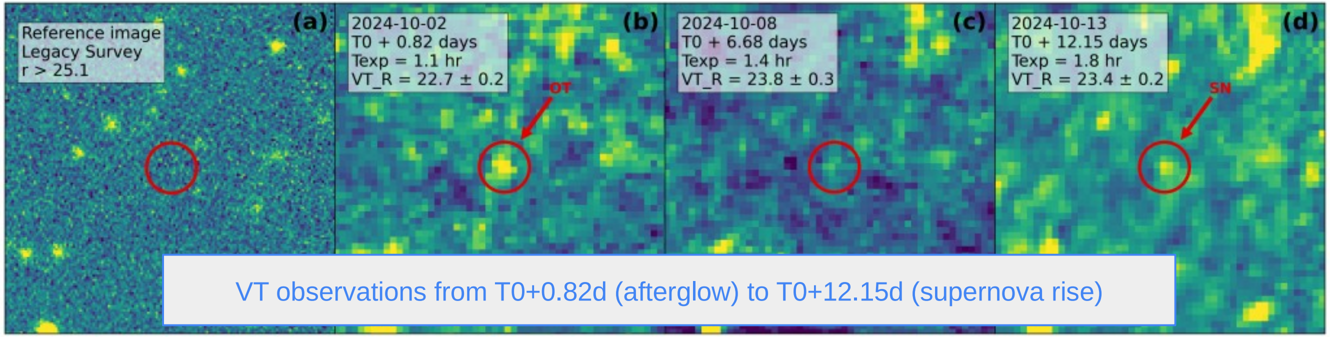
GRB 241001A (z = 0.573) Schneider et al. (in prep)

- Very soft burst associated with a type Ic SN (JWST at T0+24d)
- ECLAIRs spectrum: BB (1.9 keV) or BPL, PL rejected
- Faint X-ray afterglow, sub-luminous at its redshift
- X-Ray Flash: shock breakout? Off-axis GRB?



ECLAIRs light curves → signal mostly <20 keV





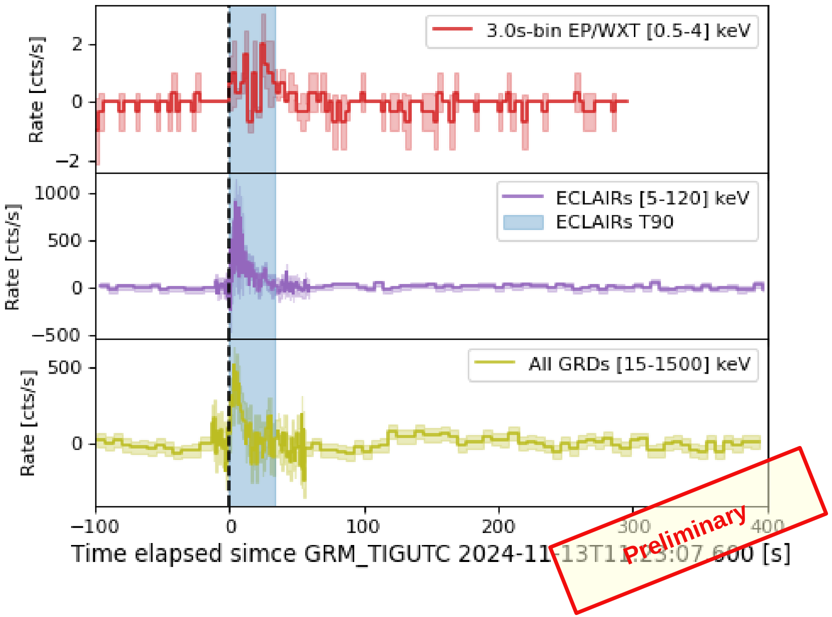
VT observations from T0+0.82d (afterglow) to T0+12.15d (supernova rise)

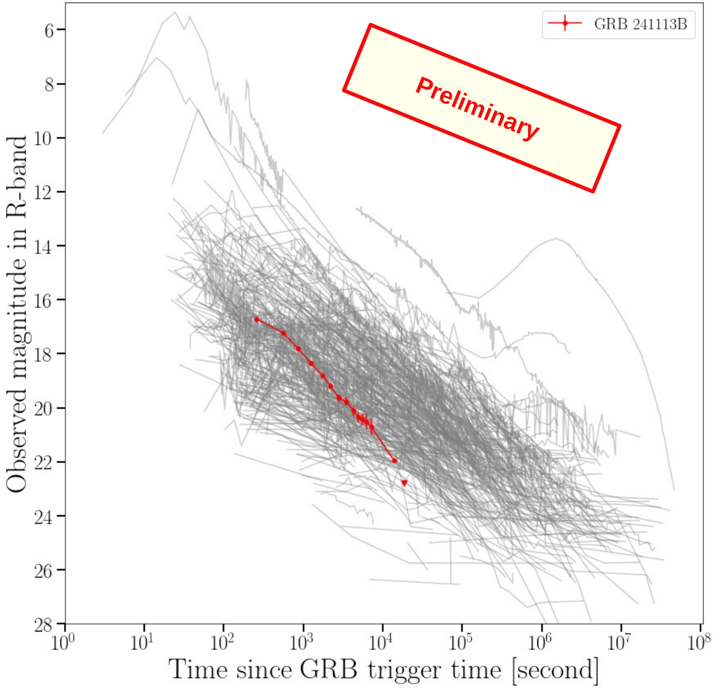
- **Other soft GRBs detected by ECLAIRs are under study:**
  240819A
  240828B?, 250219A?
  250317B Zhao et al. (in prep)
  250419A?
  sb25061207/GRB250612D

Soft Gamma-Ray Bursts

GRB 241113B Adrien et al. (in prep)

- A very soft X-ray burst jointly detected by SVOM and EP/WXT
- Good coverage of the optical afterglow: SVOM/VT, KAIT & Mephisto (associate partners)
- Faint X-ray afterglow also detected by EP/FXT



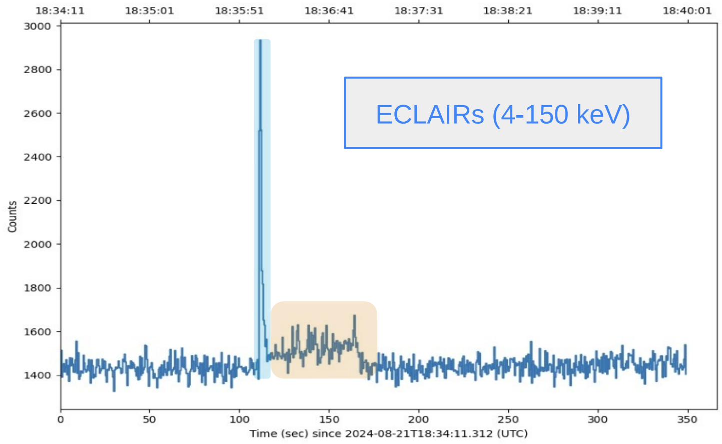


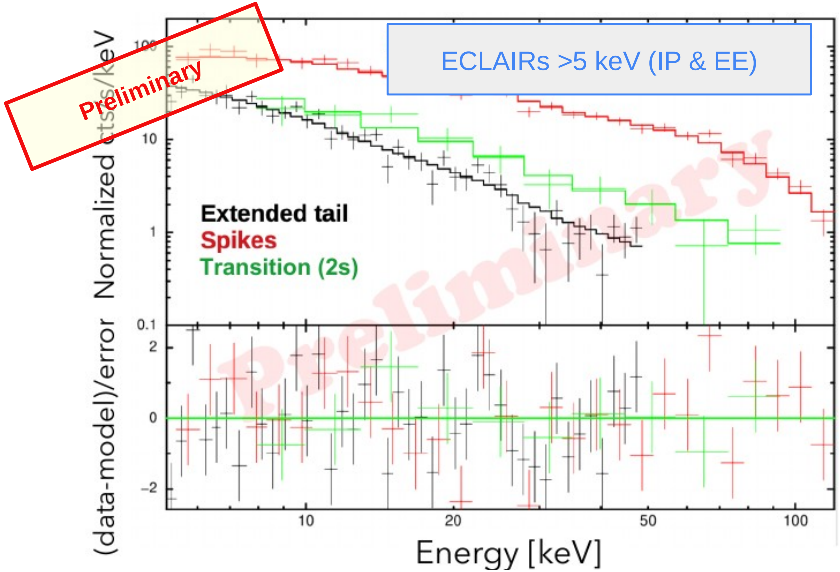
Short Gamma-Ray Bursts

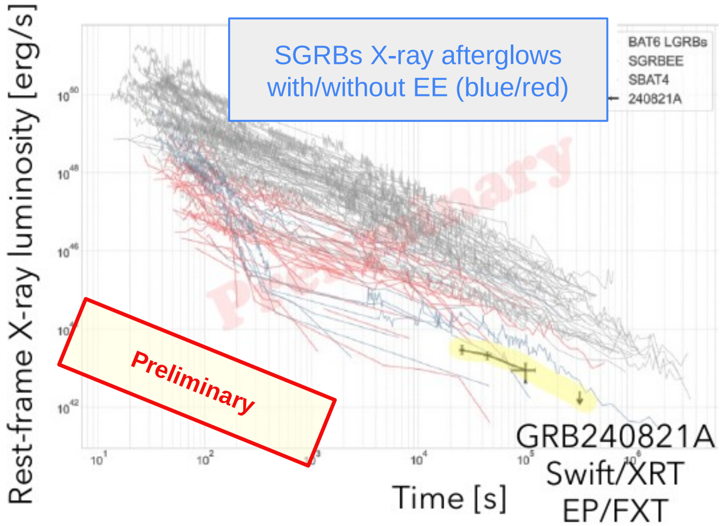
Goal: contribute to build a sample of fully characterized short GRBs, including the properties of the host galaxy

GRB 240821A (z = 0.238) Daigne, Zhang et al. (in prep)

- First ECLAIRs + GRM joint detection (T90 ~ 50 s)
- Initial pulse (IP) + temporally-extended emission (EE)
- EE plateau like, soft (<50 keV), non thermal, no sp. evolution
- Faint X-ray afterglow, but consistent with other SGRBs with EE
- Host galaxy (GTC, VLT, Keck) unusual for LGRB







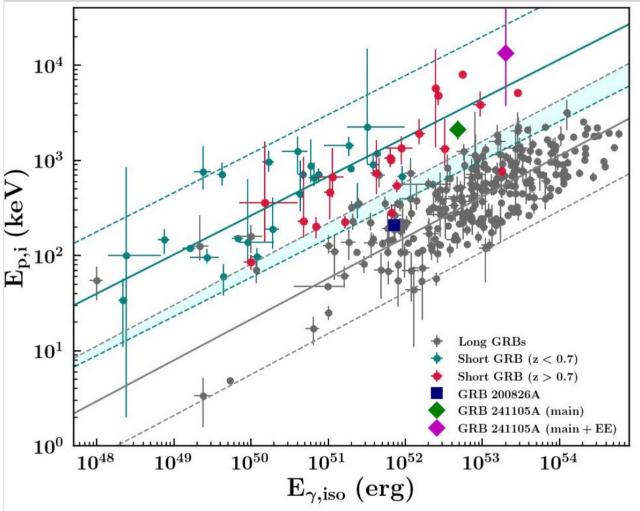
Short Gamma-Ray Bursts

GRB 241105A (z = 2.681): another SGRB+EE merger or a disguised LGRB?

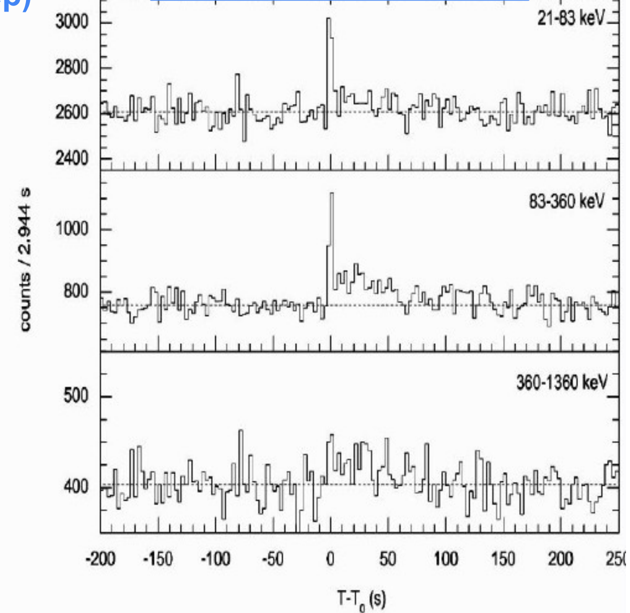
- Outside ECLAIRs FoV at trigger time
- Fermi/GBM, Konus-Wind and SVOM/GRM: EE less soft than in GRB240821A
- Would be the highest redshift for a SGRB
- JWST photometry → massive & star-forming host galaxy, at low-metallicity, similar to other collapsar hosts at this redshift

Dimple et al. (in prep)

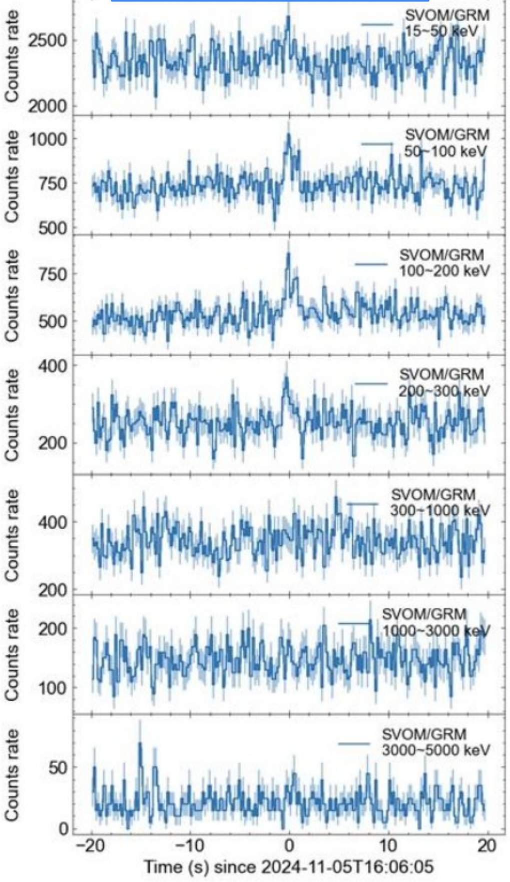
→ Collapsar origin favored



Konus-Wind (20-1400 keV)



GRM (15-5000 keV)

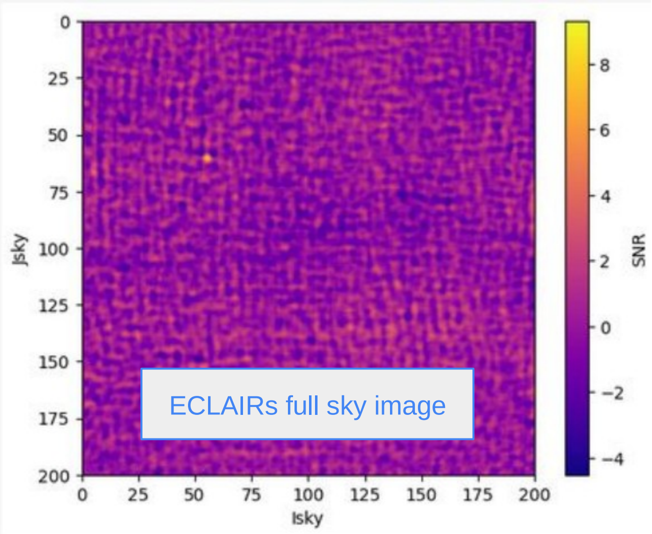


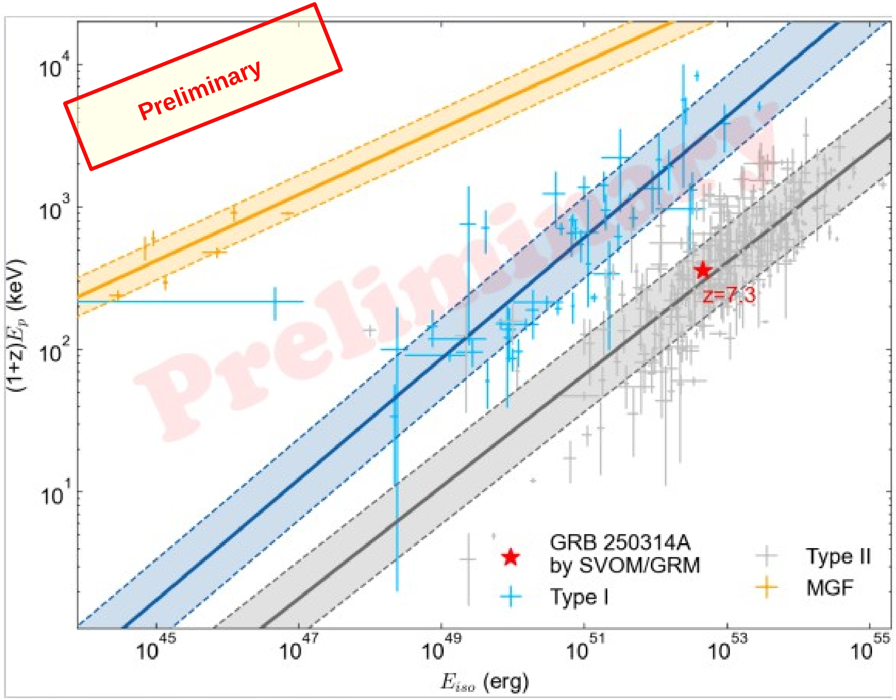
High-z Gamma-Ray Bursts

GRB 250314A at z ~ 7.3

Cordier, Wei et al. (in prep)

- Detected by ECLAIRs and GRM (T90 ~ 10s)
- GRM preliminary analysis: classical LGRB in Ep-Eiso diagram
- Fading X-ray afterglow confirmed by EP/FXT
- No detection by SVOM/VT despite automatic slew
- NIR afterglow discovered by the NOT (T0+12.3h)



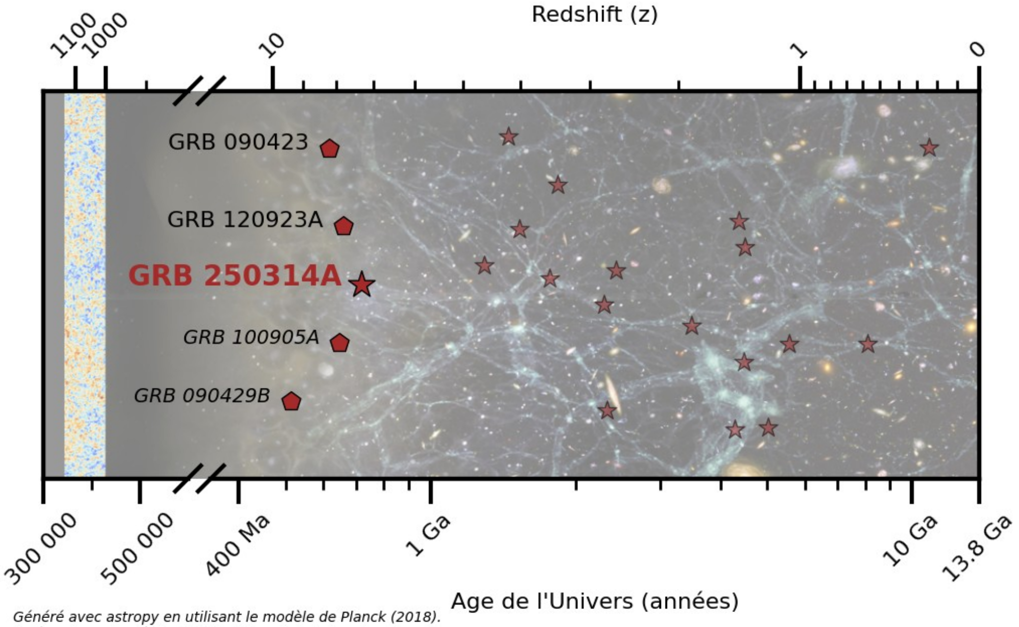


High-z Gamma-Ray Bursts

Cordier, Wei et al. (in prep)

GRB 250314A at z ~ 7.3

- VLT/X-shooter → photometric redshift
- 5th most distant burst, ~730 Myr after the Big Bang
- 12.5 years since the last very high-z burst



Généré avec astropy en utilisant le modèle de Planck (2018).
Arrière plan adapté de: ©ESA, ©Planck Collaboration.

VLT/X-shooter GCN circular

GCN Circular 39732

Subject GRB 250314A: VLT/X-shooter dropout, redshift z ~ 7.3
Date 2025-03-15T12:45:58Z (3 months ago)
Edited On 2025-03-15T20:14:19Z (3 months ago)
From Daniele B. Malesani at IMAPP / Radboud University <d.malesani@astro.ru.nl>
Edited By Vidushi Sharma at NASA GSFC/UMBC <vidushi.sharma@nasa.gov> on behalf of Daniele B. Malesani at IMAPP / Radboud University <d.malesani@astro.ru.nl>
Via Web form

D. B. Malesani (DAWN/NBI and Radboud), G. Pugliese (API-UvA), J. P. U. Fynbo (DAWN/NBI), B. Schneider (LAM), V. D'Elia (SSDC and INAF-OAR), A. de Ugarte Postigo (LAM), L. Izzo (INAF-OACn and DARK/NBI), P. G. Jonker (Radboud), A. J. Levan (Radboud and Warwick), J. T. Palmerio (CEA/Irfu), N. A. Rakotondrainibe (LAM), A. Saccardi (CEA/Irfu), N. R. Tanvir (U. Leicester), A. L. Thakur (INAF-IAPS), S. D. Vergani (CNRS, Obs. Paris/LUX), D. Xu (NAOC), Z.P. Zhu (NAOC) report on behalf of the Stargate collaboration:

We observed the near-infrared candidate counterpart (Malesani et al., GCN 39727) of the long SVOM/ECLAIRs GRB 250314A (Wang et al., GCN 39719) at the ESO VLT, using the HAWK-I near-infrared imager (on UT4, Kueyen) and the X-shooter spectrograph (on UT3, Melipal).

The object is well detected in the Y, J and H filters. HAWK-I observations started on 2025 Mar 15 at 05:23:28 UT (about 16.5 hr after the GRB). We measure preliminary AB magnitudes:

Y = 23.2 +/- 0.15
J = 22.4 +/- 0.1
H = 22.5 +/- 0.1

For the spectra, the observation mid time was 2025 Mar 15.26 UT (about 17.4 hr after the GRB). The data cover the wavelength range 3000-21,000 AA and consist of 4 exposures of 1200 s each.

In a preliminary reduction of the spectra, a faint continuum is confidently detected all across the NIR arm (down to 10,300 AA). Tentative signal is also seen in the very red end of the VIS arm, with a drop around 10,090 AA. While the S/N is too low to confidently identify individual metal absorption features, the break in the VIS is consistent with the onset of the Lyman forest (with possible contribution from damped Lyman-alpha absorption in the GRB host galaxy). The implied redshift is z ~ 7.3.

The HAWK-I photometry is consistent with a break, rather than with a generically red shape of the continuum, given the red Y-J vs blue J-H color, consistent with the Y filter being partly dropped out. Assuming a power law model (no dust extinction), a fit to the available photometry provides a redshift z = 7.21 +0.18 -0.38 (1 sigma c.l.), fully consistent with the spectroscopic value.

We acknowledge expert support from the ESO staff in Paranal, in particular Cedric Ledoux, Enrico Congiu, Francisco Nogueras-Lara, Pascale Hibon, Rodrigo Romero, and Susana Cerda.

Summary

SVOM “white paper”: Wei, Cordier et al., arXiv:1610.06892
SVOM special issue in RAA (in prep)

- **Nominal instrument performance and operations → scientific operations have started**

- **In one year, SVOM has detected >70 X-ray transients (mostly known galactic sources)**

- **In one year, SVOM has detected 131 GRBs (110 GRM, 46 ECLAIRs)**
- **SVOM is sensitive to all types of GRBs and started to explore the GRB diversity**
  - 105 LGRB, 18 SGRB(+EE), 8 XRF
  - Impact of the ECLAIRs low-energy threshold of 4 keV → better explore soft GRBs and high-z LGRBs
    - ECLAIRs + GRM: GRB prompt emission from 4 keV to 5 MeV
  - Impact of the optimized follow-up sequence
    - Several well-characterized events at the prompt-to-early afterglow transition in X-rays (MXT) and optical (VT)
    - Crucial role of Swift/XRT and EP/FXT for the X-ray afterglow observation
    - Already high rate of optical afterglow detection and redshift measurement
  - GRB public table (most scientific products) in prep at the French Science Center web site (www.fsc.svom.org)

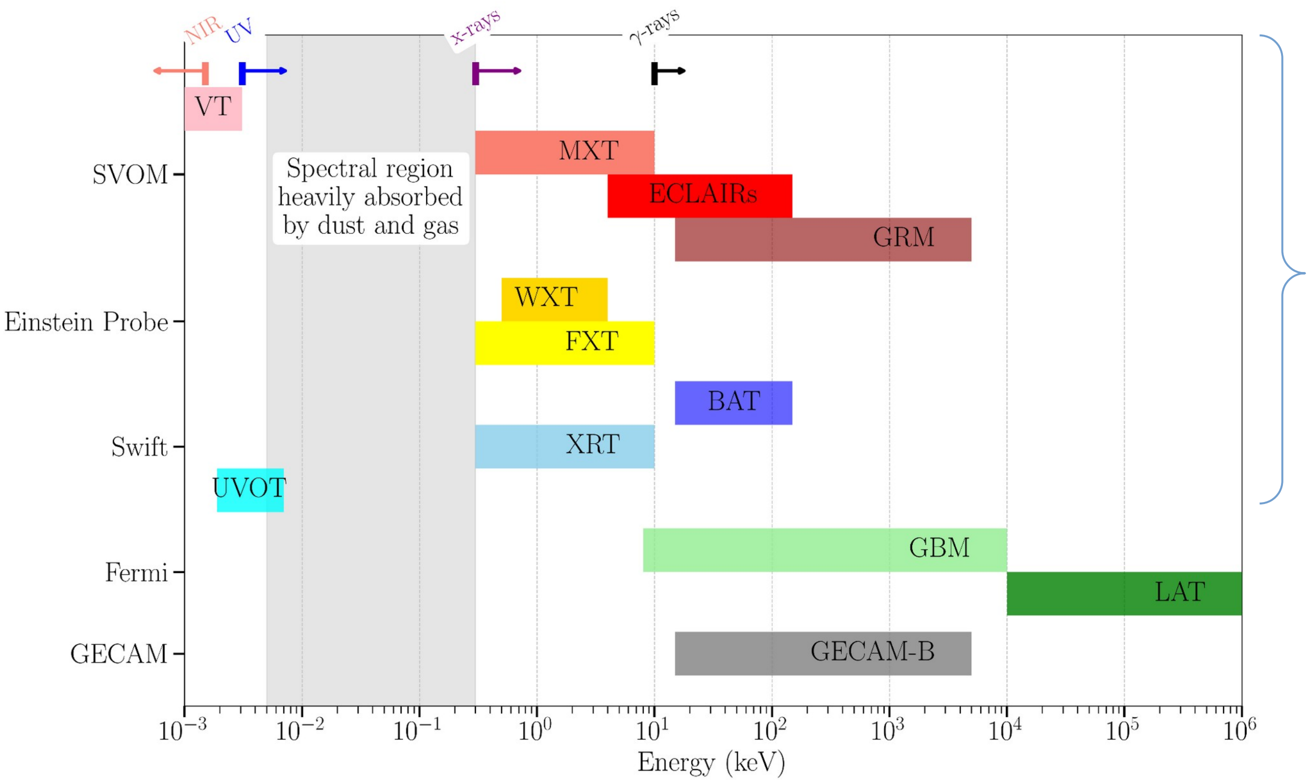
many single GRB papers
are under review

- **SVOM has already established excellent cooperation with many groups: Swift, Einstein Probe, Stargate, NOT/GTC etc, and more agreements are in preparation**

Questions?

Backup

SVOM: a unique spectral range to study high-energy transients

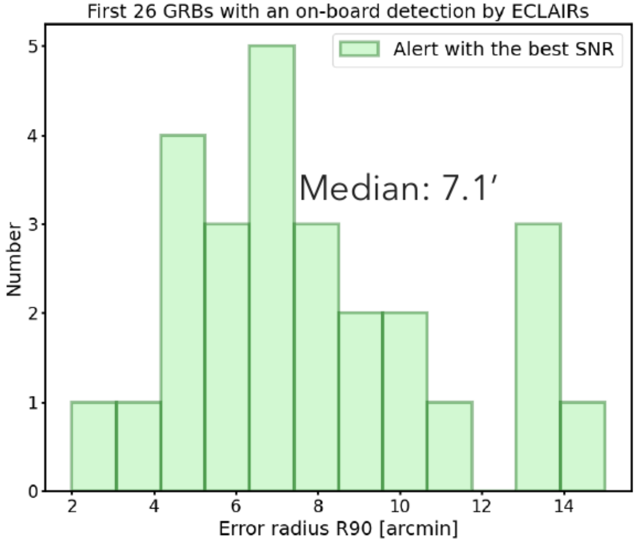


They localize <10 arcmin (except GRM)

+ onboard automated follow-up of new transients

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



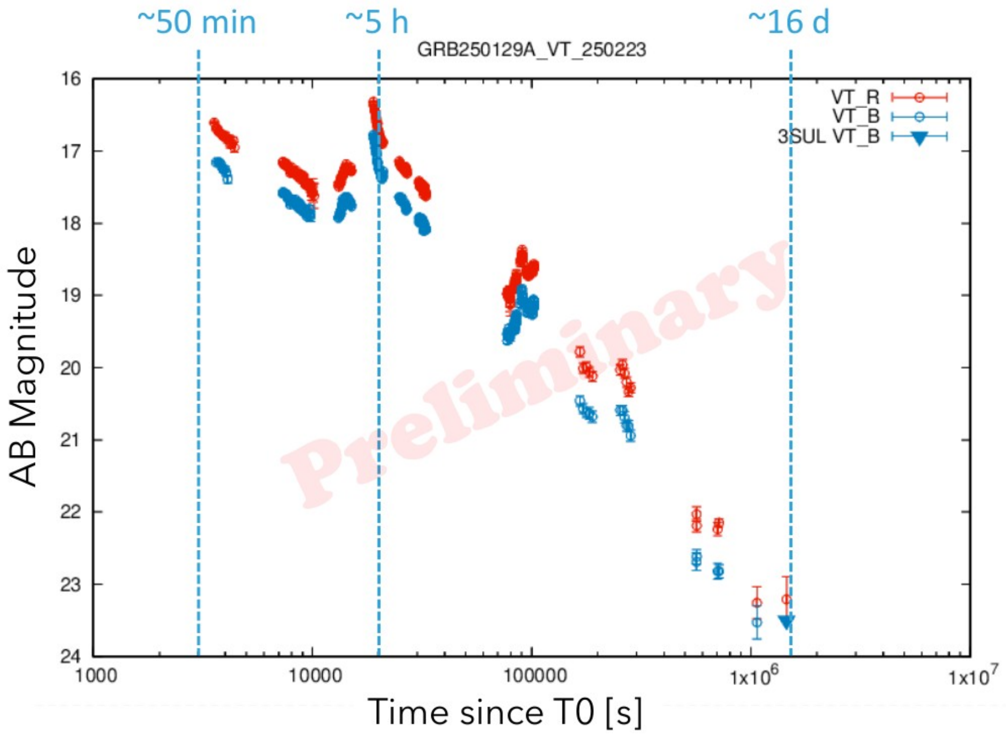
Statistical error on ECLAIRs localization
Systematics: 2′

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)

SVOM FOLLOW-UP OF SWIFT/BAT GRBS

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



LONG GRBS: EARLY AFTERGLOW

GRB250317B at z=3.44

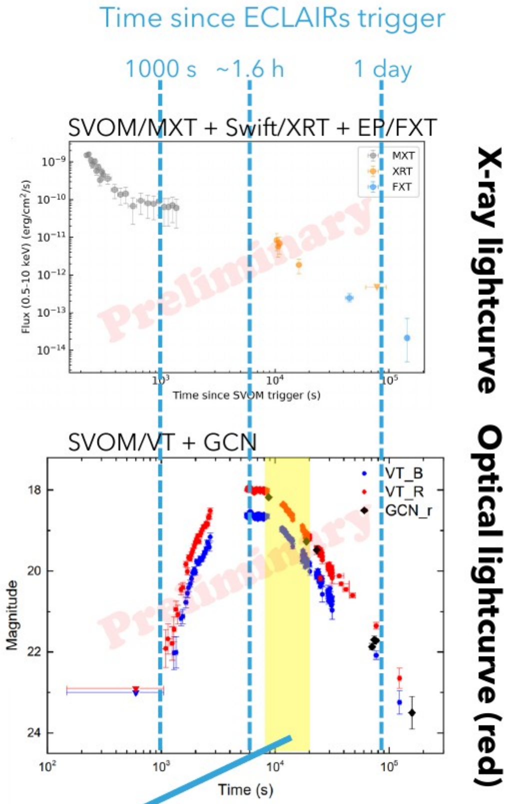
- **An event detected only in ECLAIRs mostly in the 5-8 and 8-20 keV bands**
- T90 ~ 15 s (4-120 keV)
- **Very weak in GRM**

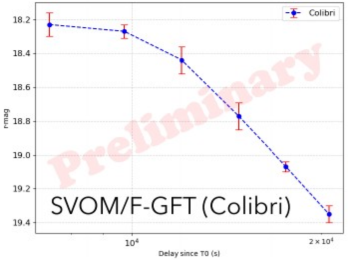
- **X-ray AG detected by SVOM/MXT**
  Follow-up with Swift/XRT and EP/FXT
- **Optical AG detected by SVOM/VT**
  Follow-up by many telescopes, including **SVOM/VT and SVOM/F-GFT (Colibri)**

  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?





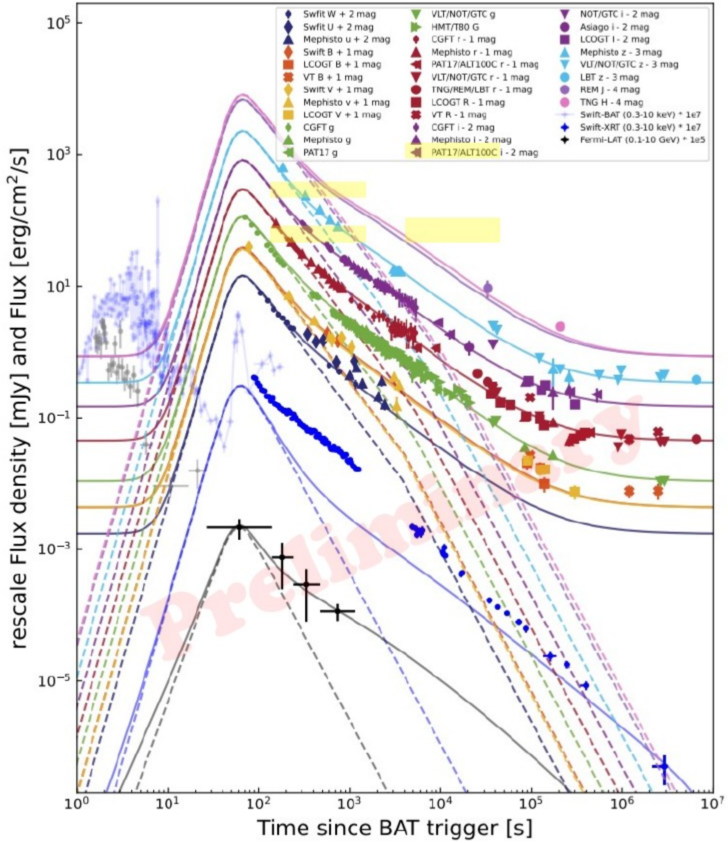
LCOGT (GCN#39757, GCN#39759)
OHP/T193 (GCN#39767, GCN#39777)
NOT (GCN#39770)
Mondy (GCN#39772, GCN#39790)

LONG GRBS: EARLY AFTERGLOW

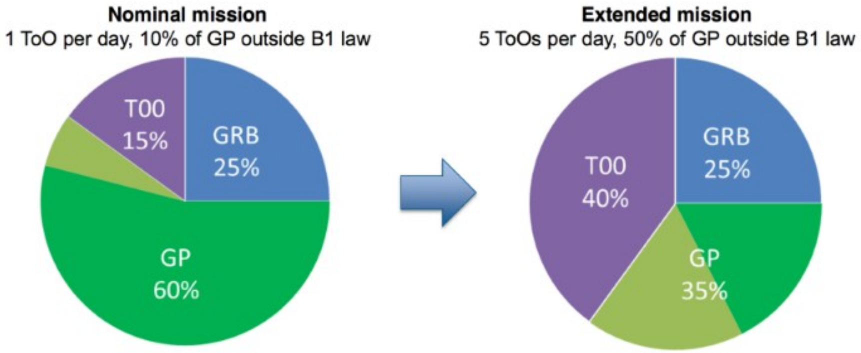
GRB240825A at z = 0.659

- **A Swift/BAT & Fermi/GBM+LAT long GRB (T90~4 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



Targets of Opportunity (ToOs)

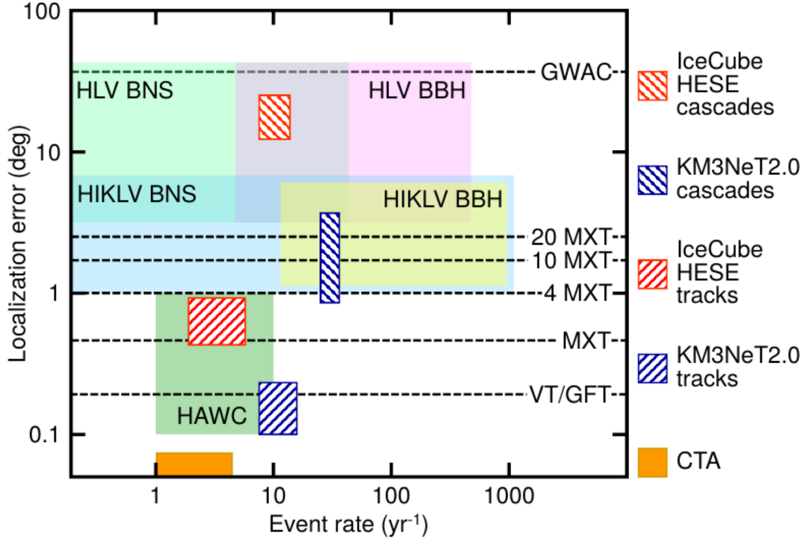


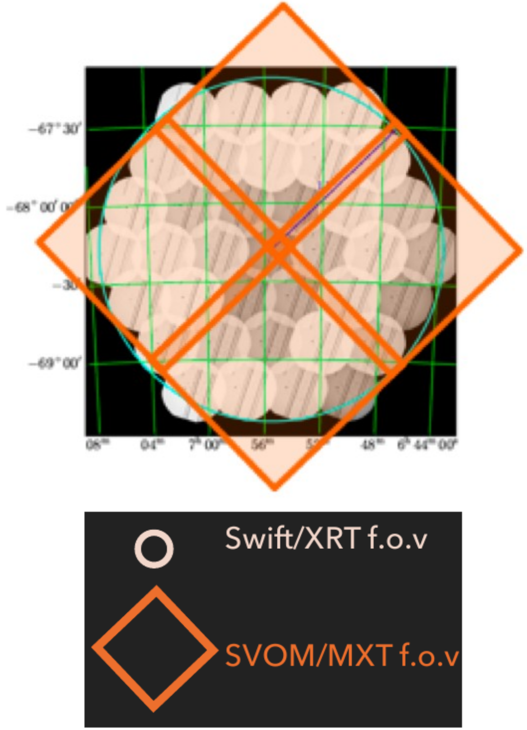
- ToO-NOM: nominal
- ToO-EX: fast (mainly through Beidou)
- ToO-MM: for large error boxes, with a tiling strategy

	ToO-NOM	ToO-EX	ToO-MM
Frequency	Nominal mission : 1/day Extended mission : 5/day	1/month => 1/day	1/week
Priority	Low	Low to Highest	Low to Very High
Upload Delays	< 48h (regular S-band)	< 12h (requested S-band) < 1h (Beidou)	< 12h (requested S-band) < 1h (Beidou)
Duration	Base : 1 orbit => 2.7ks Max : 14 orbits => 38ks SAA optimized	Max : 14 orbits => 38ks	Max : 14 orbits => 38ks SAA optimized
Tiling	No	No	Max tiles / orbit = 5 (close)
Data availability	X-band	X-band	VHF for MXT Position, Photon list, VT Attitude chart X-band
Statistics (6 Dec. 2024)	477	52	1

Multi-messenger astronomy with SVOM

- **Search for X-ray / visible counterparts to MM events with MXT and VT**
  - Gravitational Wave sources, kilonova / afterglow (depends on the viewing angle), neutrinos, VHE transients
  - Requires a tiling strategy





- **Search for NIR / visible counterparts to MM events with the GFTs**
  - Search: galaxy targeting within error box
  - Photometric follow up to characterize the counterpart (e.g. kilonova from BNS): requires accurate localization (<30')

A GRB sample with a complete description

- **A unique sample of 30-40 GRBs / year with**
  - Prompt emission over 3 decades (+ optical flux/limit: 16%)
  - X-ray and visible / NIR afterglow
  - Redshift

	Swift	Fermi	SVOM
Prompt	Poor	Excellent 8 keV -100 GeV	**Very Good** **4 keV - 5 MeV**
Afterglow	Excellent	> 100 MeV for LAT GRBs	**Excellent**
Redshift	~1/3	Low fraction	**~2/3**

- **Physical mechanisms at work in GRBs**
  - Nature of GRB progenitors and central engines
  - Acceleration, composition, dissipation & radiation processes of the relativistic ejecta
- **Diversity of GRBs: event continuum following the collapse of a massive star**
  - Low-luminosity GRBs / X-ray rich GRBs / X-ray Flashes and their afterglow
  - GRB/SN connection
- **Short GRBs and the merger model**
  - GW association / Short GRBs with extended soft emission
- **GRBs as a tool to study the distant Universe**