SVOM
first scientific results

Bertrand Cordier & Wei Jianyan
On behalf the SVOM collaboration

2025 March 26, Celebrating 20 years of Swift Discoveries, Florence

The SVOM consortium

China (PI J.Wei)

- SECM Shanghai
- NSSC Beijing
- NAOC Beijing
- IHEP Beijing
- GuanXi University

Mexico

- UNAM (Colibrì)

UK

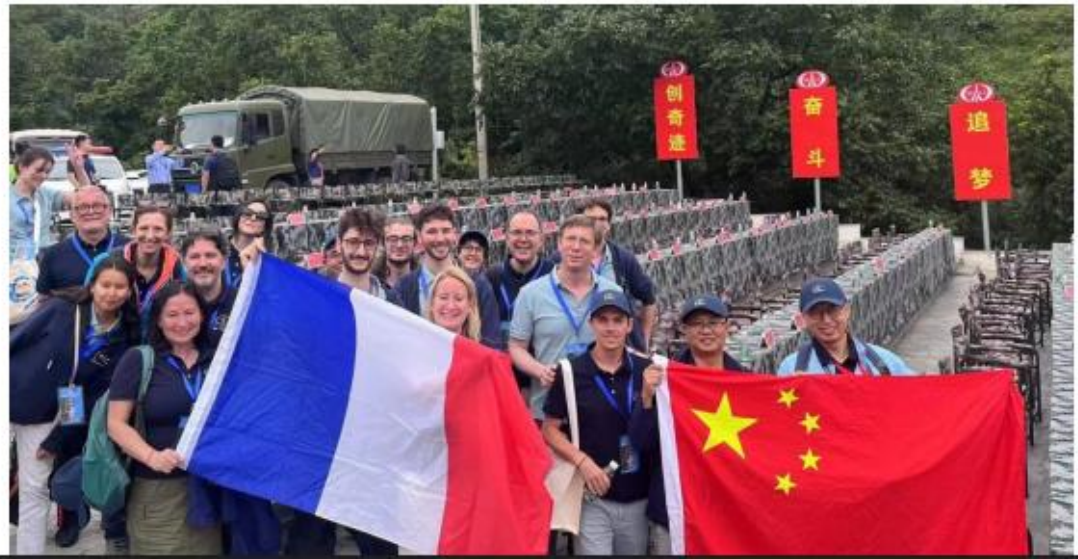
- University of Leicester (MXT)

Germany

- MPE Garching (MXT)
- IAAT Tübingen (MXT)

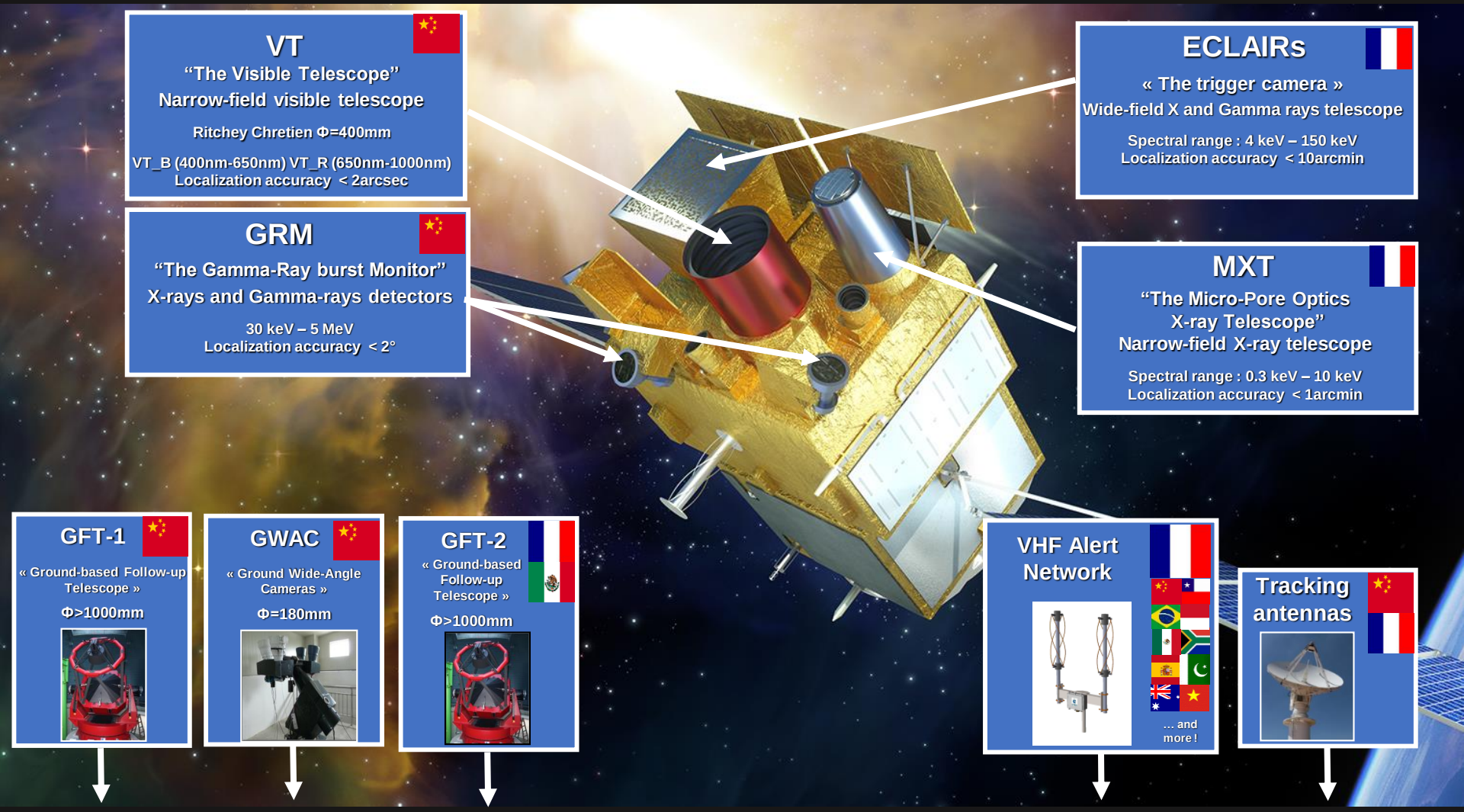
France (PI B.Cordier)

- CNES Toulouse
- APC Paris
- CEA Saclay
- CPPM Marseille
- GEPI Meudon
- IAP Paris
- ICJLab Orsay
- IRAP Toulouse
- LAM Marseille
- LUPM Montpellier
- ObAS Strasbourg




2024 June 22
SVOM
Launch

The SVOM System



VT
"The Visible Telescope"
Narrow-field visible telescope
Ritchey Chretien Φ=400mm
VT_B (400nm-650nm) VT_R (650nm-1000nm)
Localization accuracy < 2arcsec

GRM
"The Gamma-Ray burst Monitor"
X-rays and Gamma-rays detectors
30 keV – 5 MeV
Localization accuracy < 2°

ECLAIRs
« The trigger camera »
Wide-field X and Gamma rays telescope
Spectral range : 4 keV – 150 keV
Localization accuracy < 10arcmin

MXT
"The Micro-Pore Optics X-ray Telescope"
Narrow-field X-ray telescope
Spectral range : 0.3 keV – 10 keV
Localization accuracy < 1arcmin

GFT-1
« Ground-based Follow-up Telescope »
Φ>1000mm

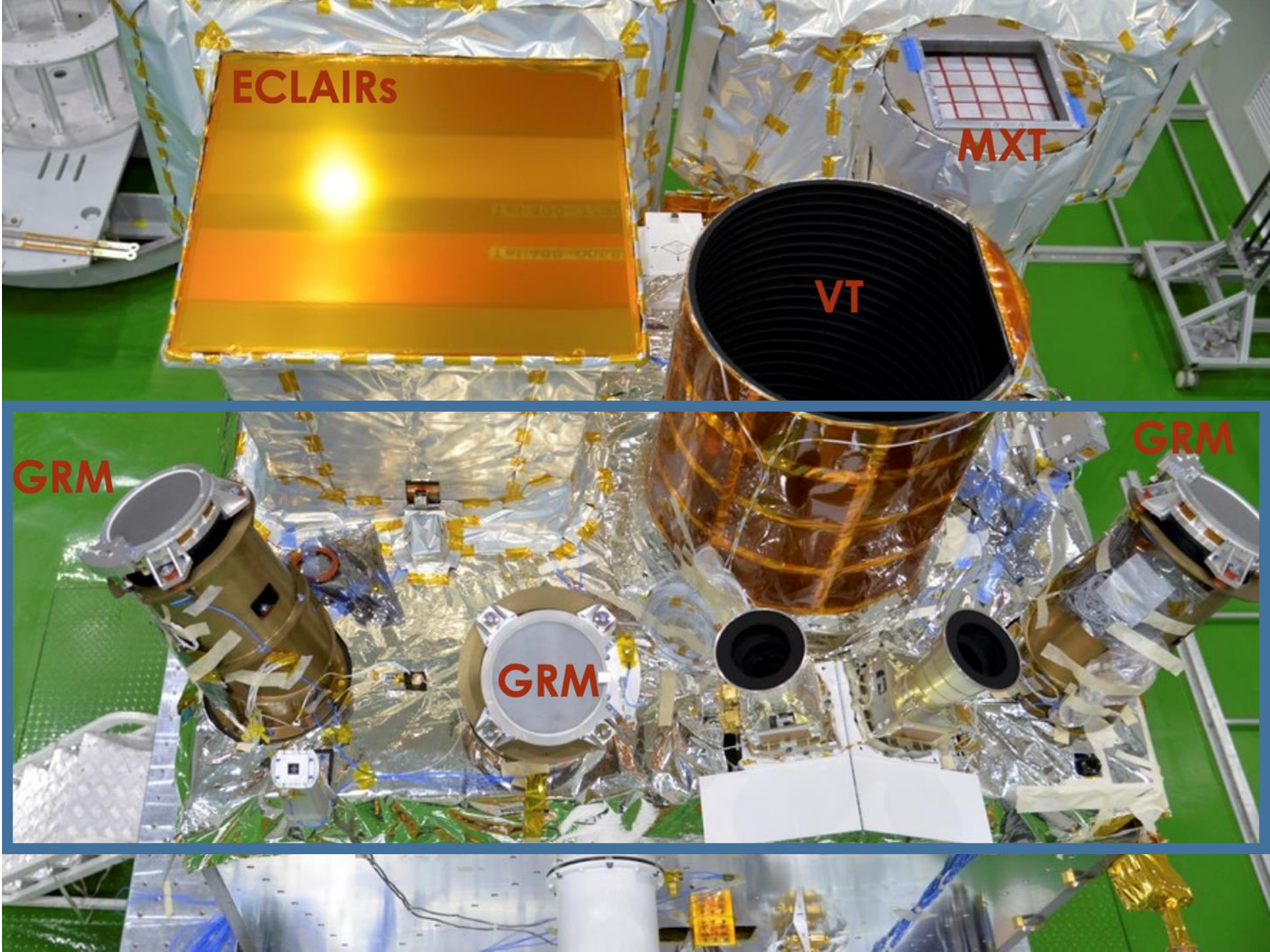
GWAC
« Ground Wide-Angle Cameras »
Φ=180mm

GFT-2
« Ground-based Follow-up Telescope »
Φ>1000mm

VHF Alert Network
... and more !

Tracking antennas

Low Earth Orbit :650km, 30°
Raw antisolar attitude law
End of the validation phase – January 2025


ECLAIRs
MXT
VT
GRM
GRM
GRM

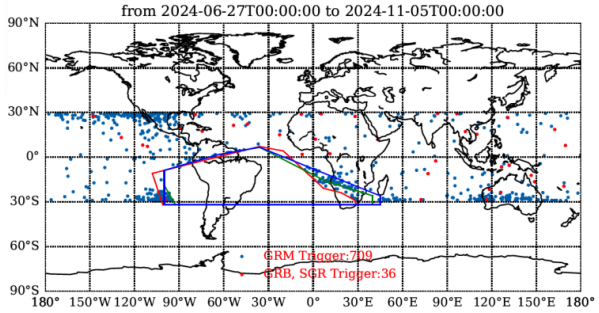
Calibration and test show that GRM meets all requirements

Parameters	requirements	Test results	Compliance
Energy Range (GRD)	15-5000 keV	**GRD1: 4.1~7686 keV** **GRD2: 3.7~7398 keV** **GRD3: 3.3~7249 keV**	yes
Field of View* (GRD)	± 60° (one GRD)	**Design Guarantee**	yes
Geometric Area* (GRD)	200 cm^2 (one GRD)	**Design Guarantee**	yes
Dead Time	< 8 μs	**4.167 μs**	yes
Time Accuracy	< 20 μs	**~8 μs**	yes
Energy Resolution (GRD)	≤ 19% @ 60 keV	**GRD1:15.7%@60 keV** **GRD2:16.4%@60 keV** **GRD3:16.8%@60 keV**	yes
GRB Detection Rate	> 90/year	**~124/year**	yes
Localization error	< 5° (Fluence > 1e-6·erg·cm^{-2} @1-1000 keV, 1s)	**The localization statistical error for some bright GRBs meets the requirements**	Under validation
Weight	≤ 36 kg	**34.6 kg**	yes
Power Consumption	≤ 35 W	**25.5 W**	yes
Lifetime	5 years (3 years)	**5 years（analysis）**	yes
Reliability	0.97 (after 3 years)	**0.9828（analysis）**	yes

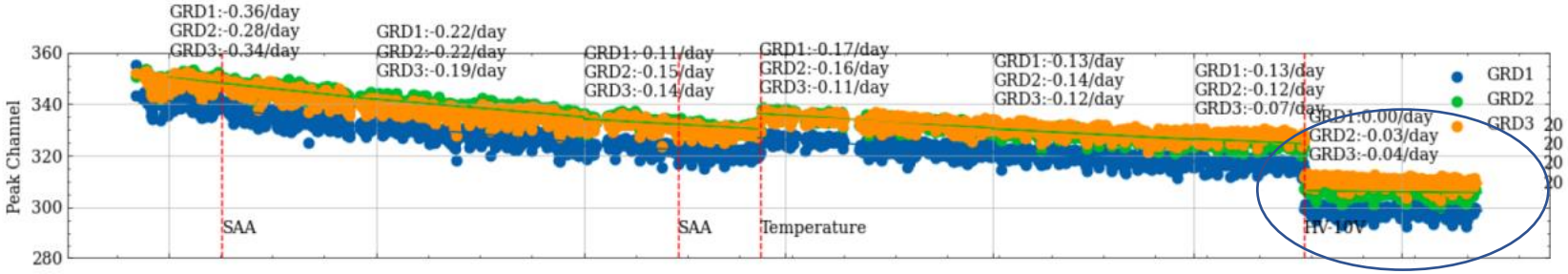
*The geometric field of view and area of GRD are determined by the design of the detector.

Summary of GRM status at the end of the validation phase

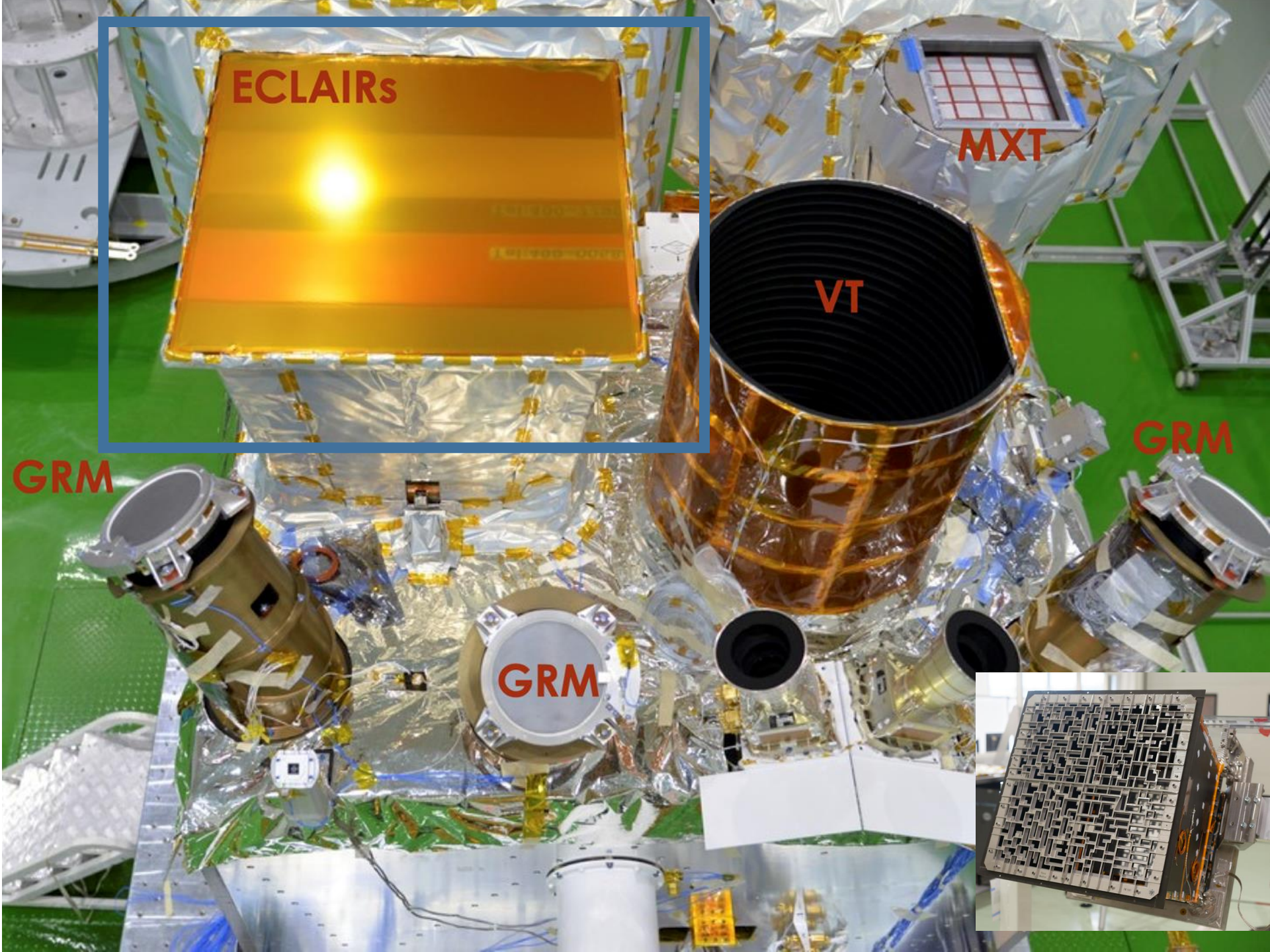
- **GRM is fully operational and works in a continuous manner since end of June.**
- **The in flight trigger operates nominally** but is disturbed in areas near the SAA and those with high geomagnetic latitude.



- **We observed a reduction in the gain of the photomultipliers**, probably due to damage to the last dynode by heavy electron bombardment.
  - By reducing the high voltage of the PM, the drop in gain was significantly reduced. This problem is under control.



- **The location** calculated with the 3 GRDs on the ground is of the order of 5° for fluences ＞1E-06 erg cm-2 @ 1-1000 keV, 1s, but still under validation.

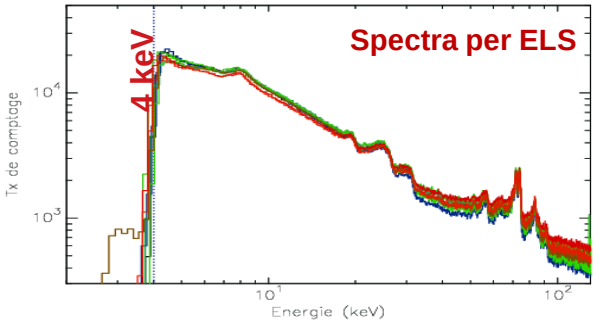

ECLAIRs
MXT
VT
GRM
GRM
GRM

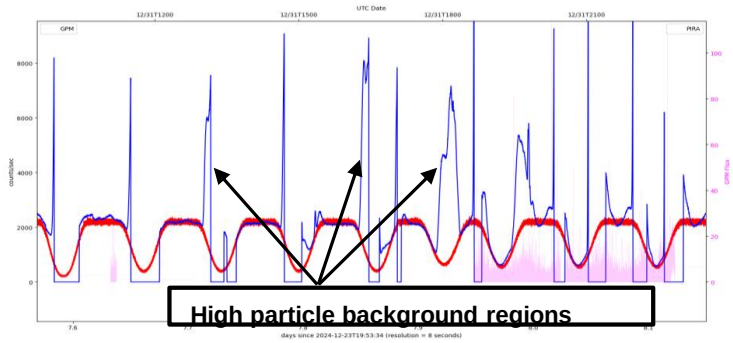
Calibration and test show that ECLAIRs meets all requirements

Parameter	Requirement	Compliance
Energy range	4 – 150 keV	C, by measurement
Detecting area	~950 cm²	C, by design
Detectors	6400 CdTe detectors	C, by design
Total effective area in 10-70 keV	≥ 340 cm²	C, by measurement
Photopeak effective area @ 6 keV	≥ 200 cm²	C, by measurement
Field of view	2.05 sr total	C, by design
Sensitivity to 1 second long GRB	2.5 10^{-8} erg cm^{-2} s^{-1} in [5–50] keV	Under validation
Source Localization Error	11.5' for sources with SNR=8	C, by measurement
Energy resolution at 60 keV	< 1.6 keV	C, by measurement
Time resolution	20 µs	C, by design
Dead time	< 10% for 10^5 c/s	Under validation
Single/multiple interaction tagging		C, by design and measurement
Data acquisition	mode Photon mode	C, by design and measurement
Data rate	≤ 18 Gb/day	C, by measurement
Energy calibration accuracy	≤0.3 keV below 80 keV	C, by measurement

Summary of ECLAIRs status at the end of the validation phase

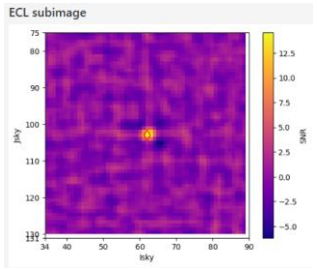
- **ECLAIRs is fully operational and works in a continuous manner since December 3rd .**
  - The low energy threshold at 4 keV is achieved for ≈ 91% of the pixels.



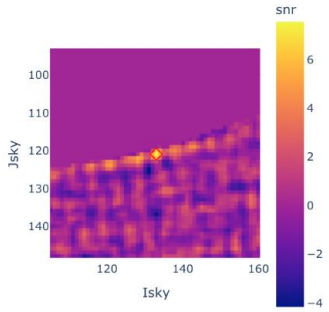


- **We understand how to operate the instrument, even with the current high solar activity:**
  - The current configuration is effective to mitigate triggers due to particles, X-ray sources and camera non-uniformities -> **GRB detection rate ~ 50-60 GRB/year**

GRB 250219A

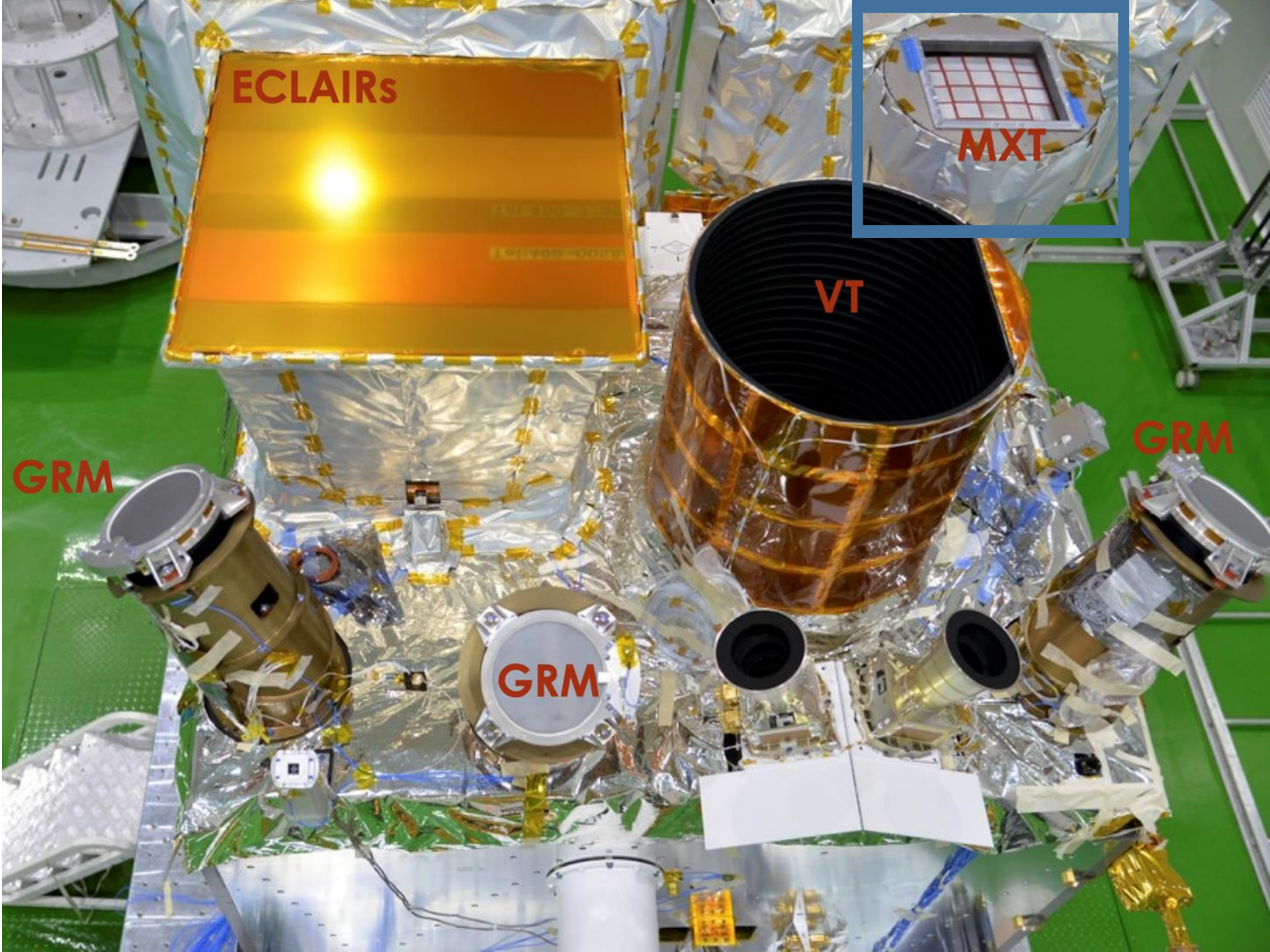


A false alert



- At **the trigger threshold** the 90% C.L. radius is **is 11.5 arcmin** and **~3 arcmin for a bright source** (including systematics error of 2 arcmin added in quadrature).

To now how the trigger works see S. Schanne poster in this conference.

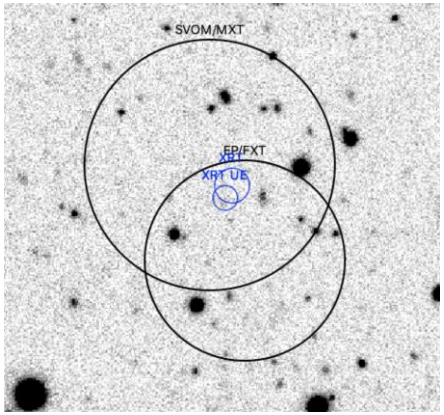

ECLAIRs
MXT
VT
GRM
GRM
GRM

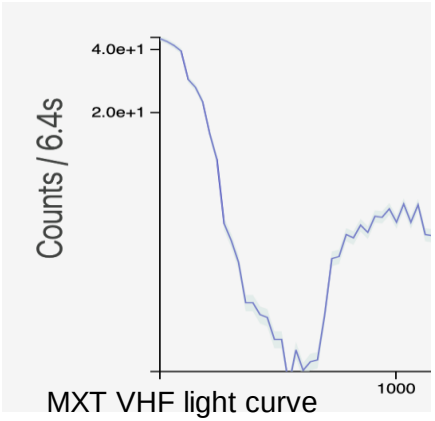
Calibration and test show that MXT meets all requirements

	Requirements	Test results	Compliance
Energy Range	0.2 - 10 keV	Measured on ground and in flight	Yes
Field of view	≥ 58′X58′	Measured on ground and in flight	Yes
PSF (Angular resolution)	11′ @1.5keV	Measured on ground and in flight	Yes
Time resolution	100 ms	Validated	Yes
Energy resolution	80 eV (FWHM) at 1.5 keV	Measured on ground and in flight	Yes
Source loc. accuracy	120′′ (In MXT ref Frame)	Measured in flight. In line with simulations	Yes
Sensitivity (5σ)	• in 10 s 2x10-10 erg cm-2 s-1 ≈ 10 mCrab (TBC) • ~ 4x10-12 erg cm-2 s-1 ≈ 150 microCrab in 10 ks (TBC)	Measured in flight (effective area and background)	Yes

Summary of MXT status at the end of the validation phase

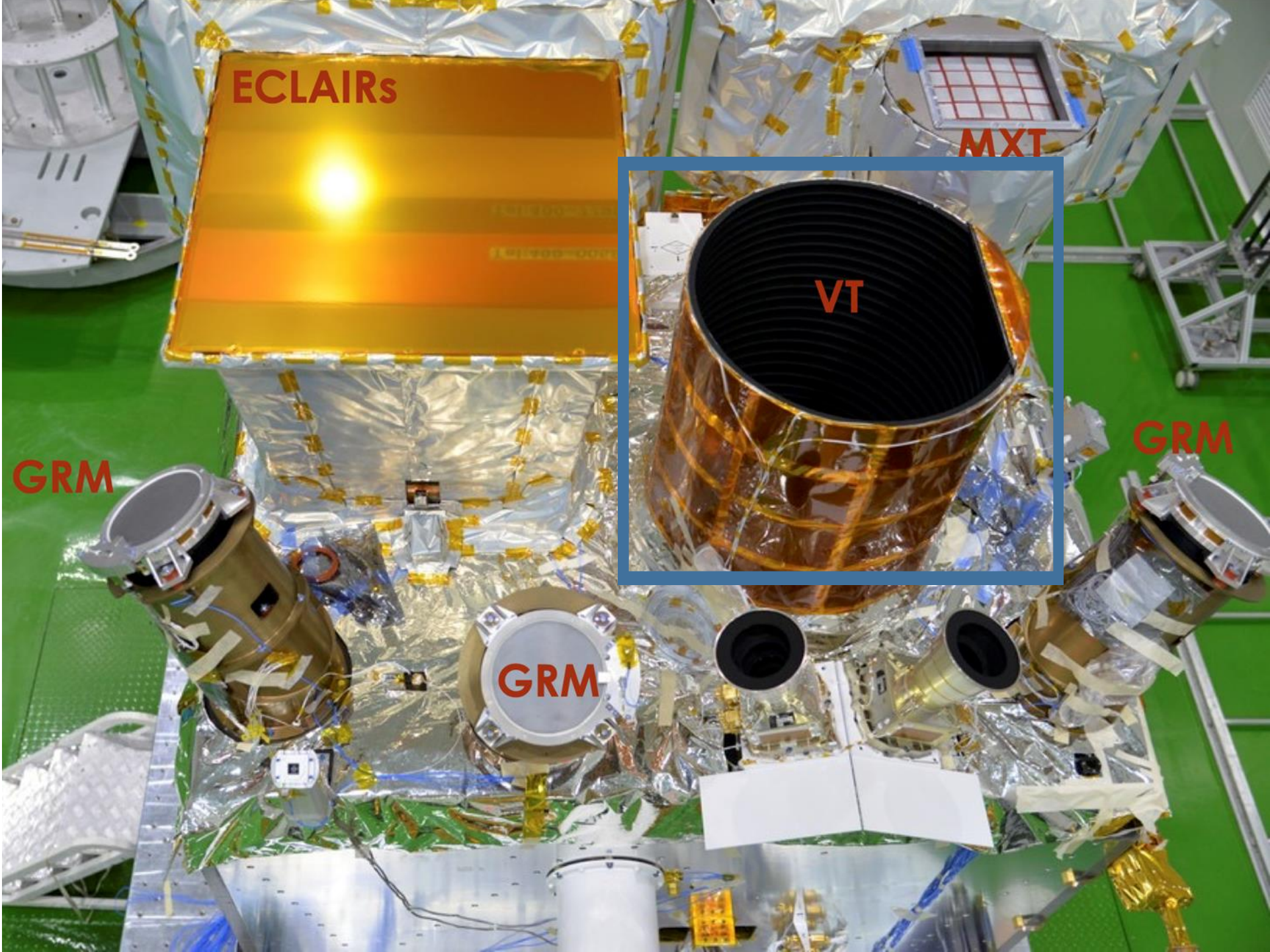
- **MXT is fully operational :**
  - The PSF measured in flight is in perfect agrement with the value measured on ground.
  - The Calibration on the Crab confirmed the estimated efficiency ~ 39 cm2 at 1.5 keV.
  - Background in line with expectation -> MXT sensitivity as expected.
  - Localization works nominally.





GRB 241217A

- **Earth Stray light issue :**
  - A large amount of stray light is seen when the satellite approaches the Earth occultation. The entry point for this stray light is not yet understood.
  - The impact is a significant reduction in the instrument's operability.
  - We are in the process of implementing on-board adjustments to anticipate problematic periods and fine-tune the telescope's operability (now ~35%).


ECLAIRs
MXT
VT
GRM
GRM
GRM

Calibration and test show that VT meets all requirements

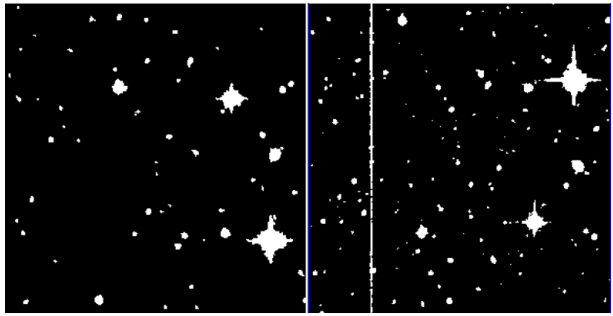
The Blue channel from 450 to 650nm and the Red channel from 650 to 1000 nm.

	Requirements	Test results	Compliance
Read out noise	6e-	Blue：4.9e-@100khz Red：5.7e-@100khz	YES
Encircled Energy	Blue：80%@1.5 arcsec Red：70%@1.0 arcsec	Blue：80%@1.41 arcsec Red：70%@0.91 arcsec	YES
Detection limit (3sigma @ 300s)	V22.5	Blue：V22.78 Red；V22.72	YES
photometry accuracy	<2%	Blue：1.3% Red：0.5%	YES
straylight level	1/3 background at full moon	1/10 background	YES
VT- STR Bias matrix	60 arcsec	15 arcsec	YES

Summary of VT status at the end of the validation phase

- **VT is fully operational and works nominally:**

We met a pollution issue at the beginning of the mission but the pollution is well under control since end of August by heating the sealed windows in front of the detectors from -25°C to 5°C (red) and 10°C (blue).

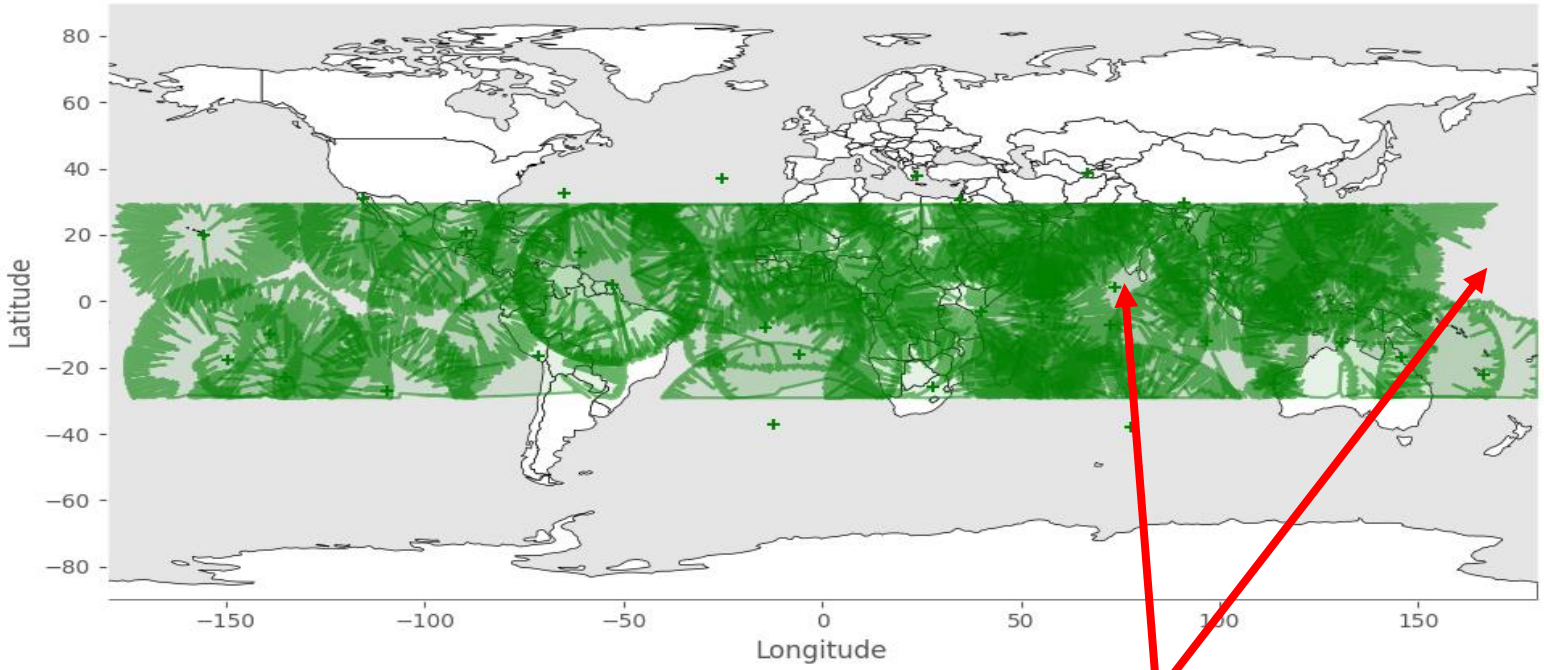


1 bit image for GRB 250108A

- **The Hot pixels** are under control, an internal calibartion is performed evry month.
- Deep detections could be down to **~ 24 mag** with image stacking.
- The onboard data processing software performs well.

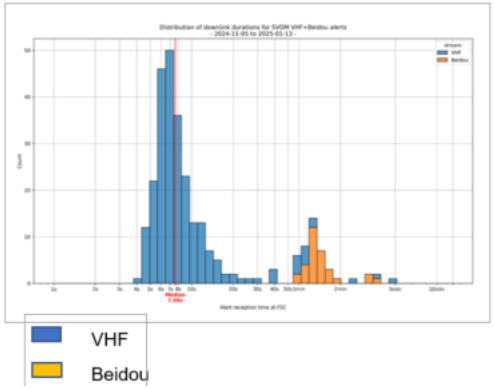
The VHF alert netwok

47 stations were deployed under the satellite track



When alert packets are not received by the VHF network (coverage gap) they are recovered via Beidou.

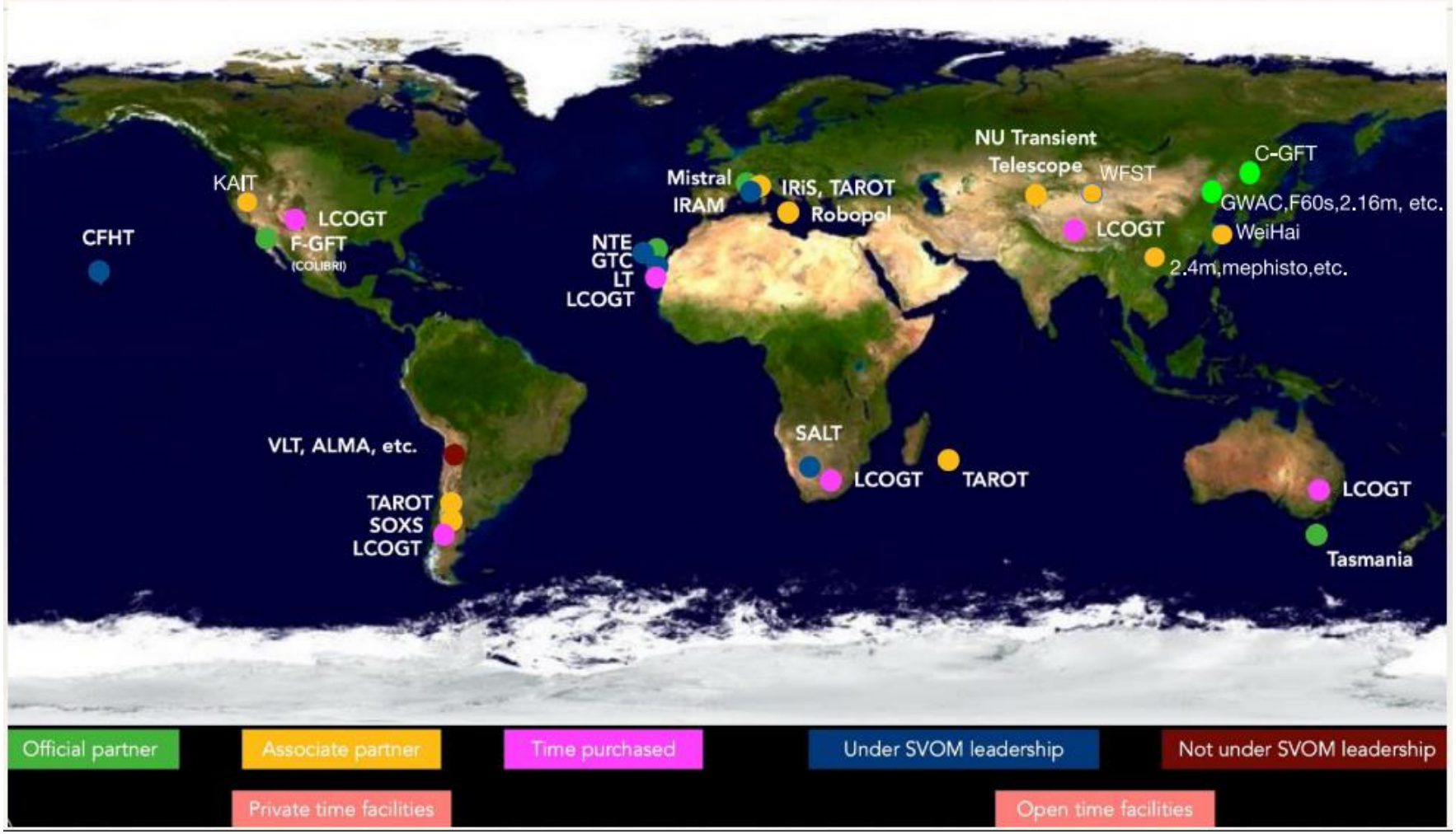
The median time between on-board transmission and reception at the FSC is **7.59s**.



VHF network performance median delay : 7.24s.

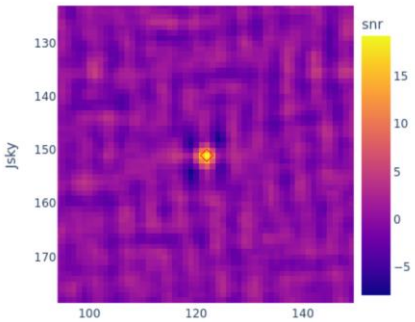
Beidou performance, median delay : 80,89s.

The SVOM follow-up network

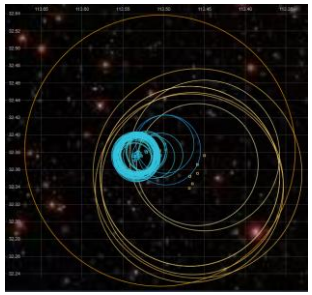


The SVOM System : a textbook case : **GRB 250205A**

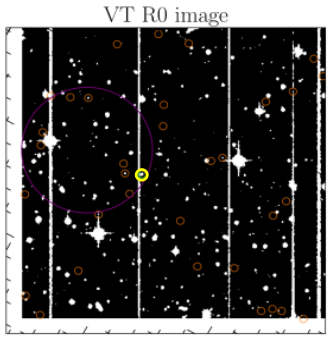
ECLAIRS
4,5 arcmin)



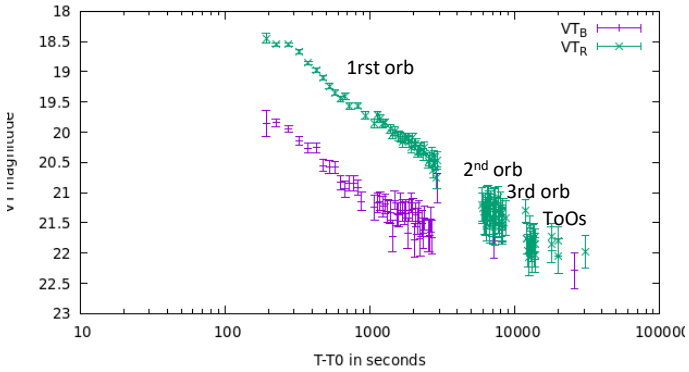
MXT
80 arc sec



VT
1 arcsec



VT Follow-up



T0

20s

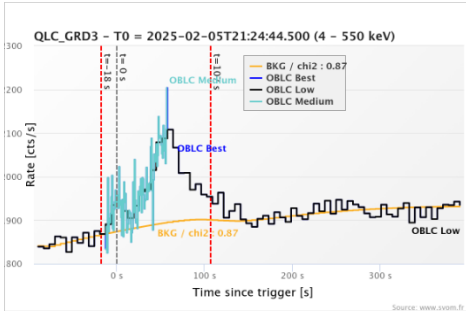
132s

450s (VT)
593 (MXT)

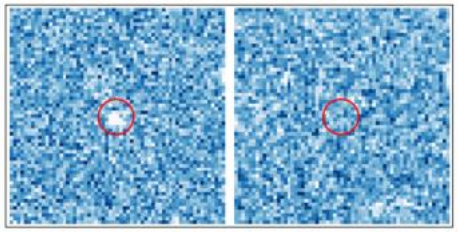
23000s (F-GFT)

Time

GRM



Pan-STARRS DR2



Colibri (F-GFT) 6,4 hours
r = 22.89 +/- 0.11

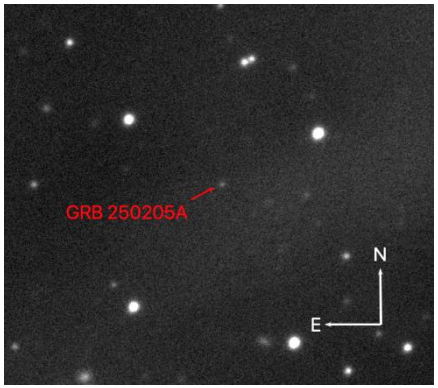
A textbook case : **GRB 250205A mobilization of the GRB community**

The redshift measurement made with OSIRIS+ on the GTC

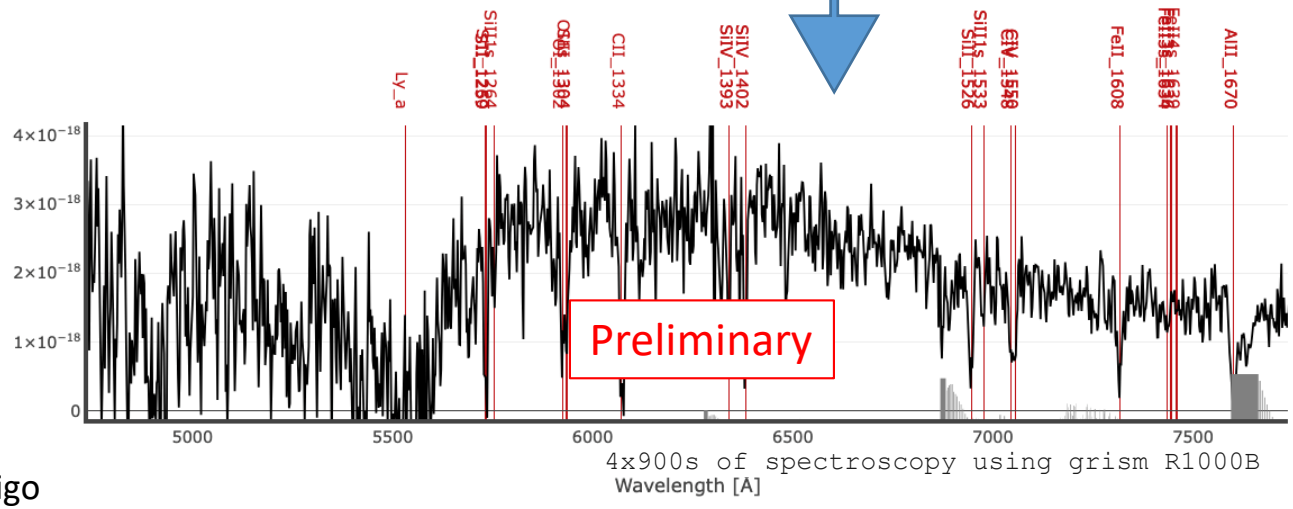
time

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

Z=3.55



30 s acquisition in r-band



4x900s of spectroscopy using grism R1000B

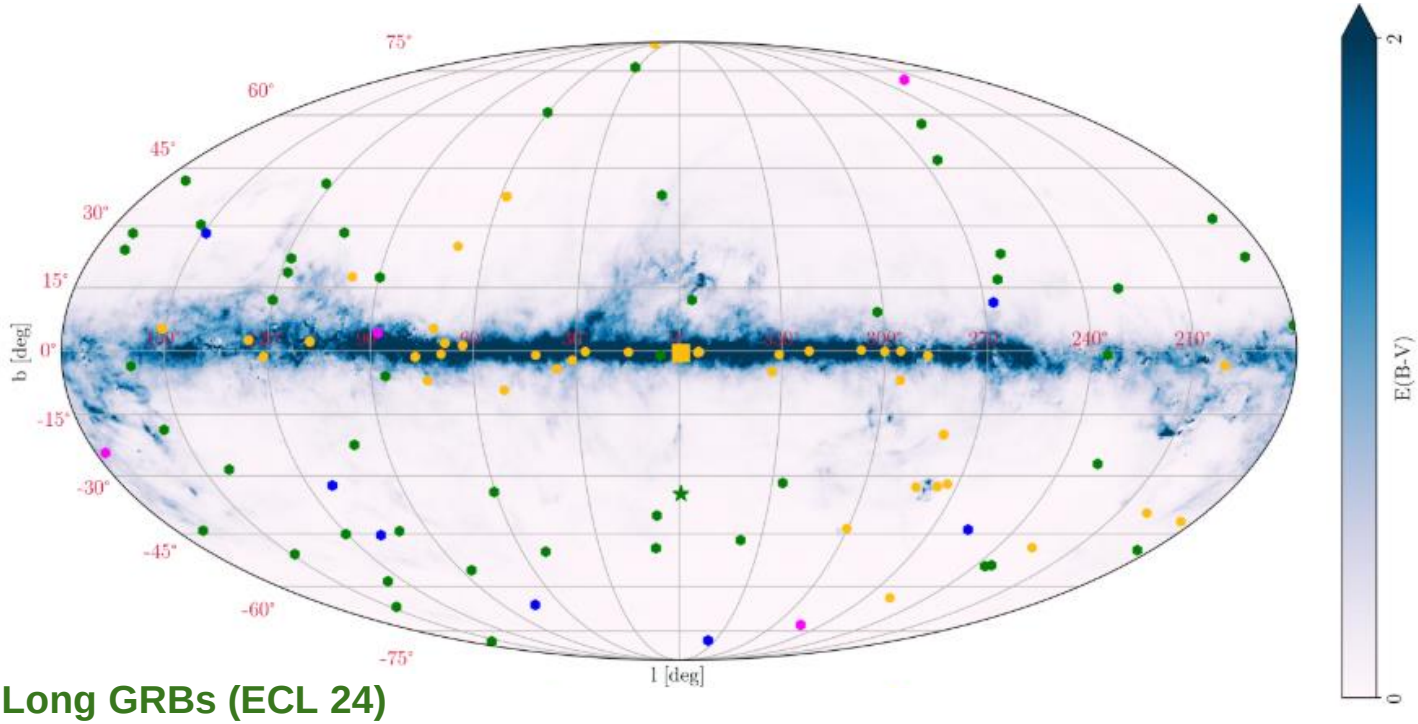
From Antonio de Ugarte Postigo

Summary of transient sources detection (at 2025 March 21)

- Number of triggers received at French Science Center
  - ECLAIRs 382
  - GRM 1055
- Among these triggers, number related to astro. sources
  - ECLAIRs 125
  - GRM 94
- Among theses astronomical sources, number of GRB
  - ECLAIRs **30**
  - GRM **87**

199 astrophysical alerts (updated March 21, 2025)

- **99 Gamma-Ray Bursts** (87 GRM, 30 ECLAIRs of which 18 ECLAIRs+GRM)
- **100 Catalogued sources** (7 GRM, 95 ECLAIRs of which 2 ECLAIRs+GRM)

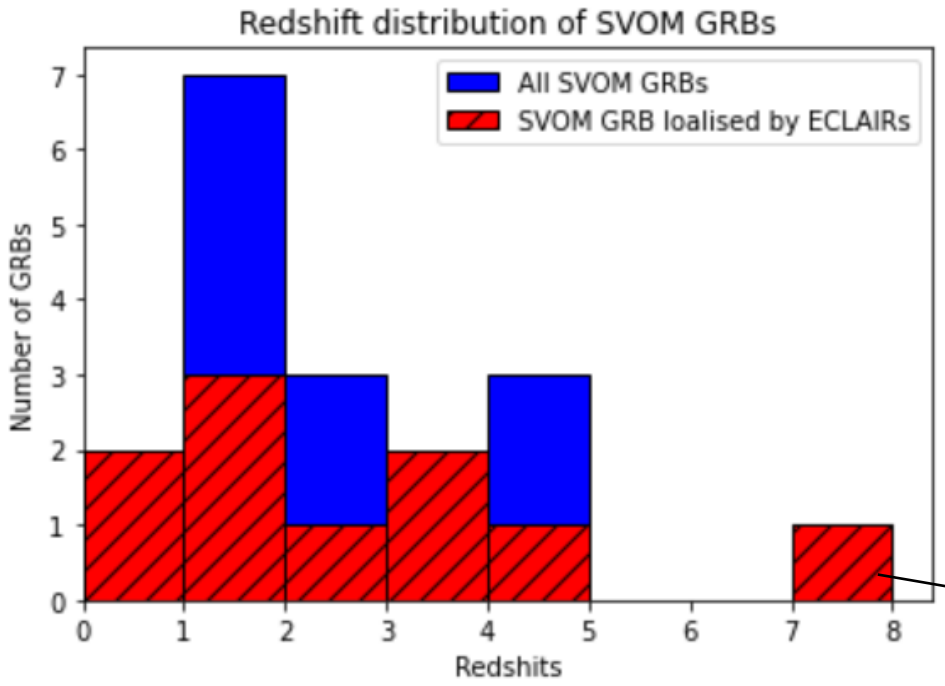


- 80 Long GRBs (ECL 24)
- 15 Short GRBs (ECL1)
- 4 X-ray Rich GRBs (ECL 4)
- 100 alerts related to catalogued X-ray sources (essentially in the galactic plane)

- **18 bursts with measured redshift (ECL 10)**

See talk of F. daigne

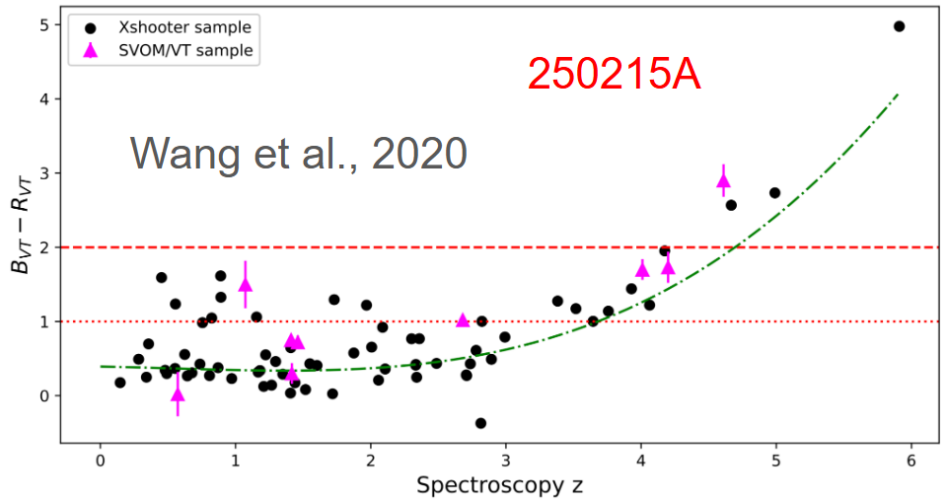
Log of redshift for SVOM triggered GRBs



18 GRBs with redshif

Update to 2025.03.21

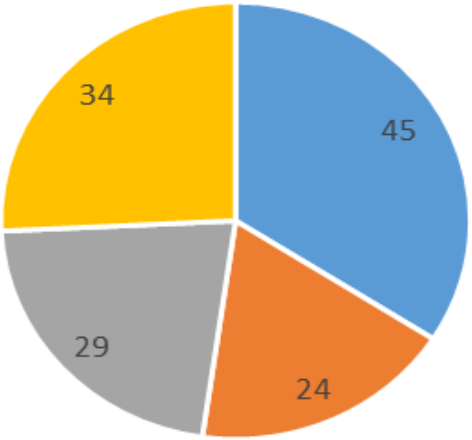
GRB 250314A



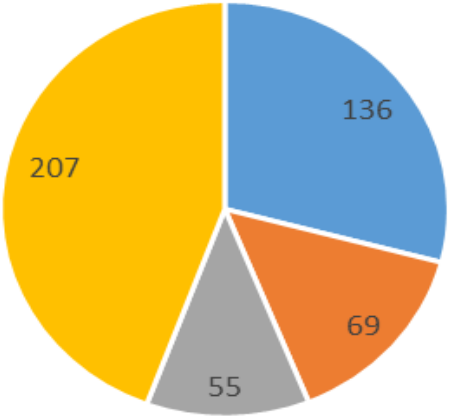
VT could provide early diagnostic of GRB distance

Summary of ToO observatories during Validation phase

Number Of ToO 132



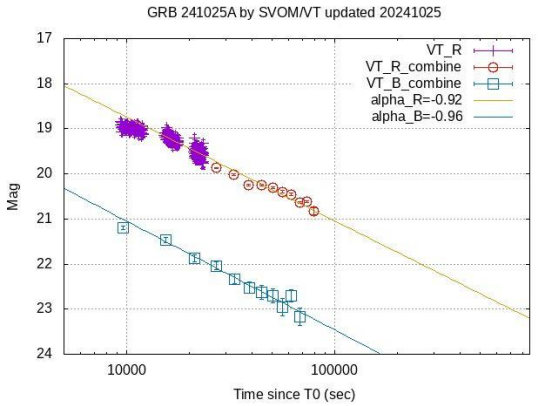
Number of orbits 467



ToO GRB SVOM ToO GRB Ext ToO Astro ToO Calib

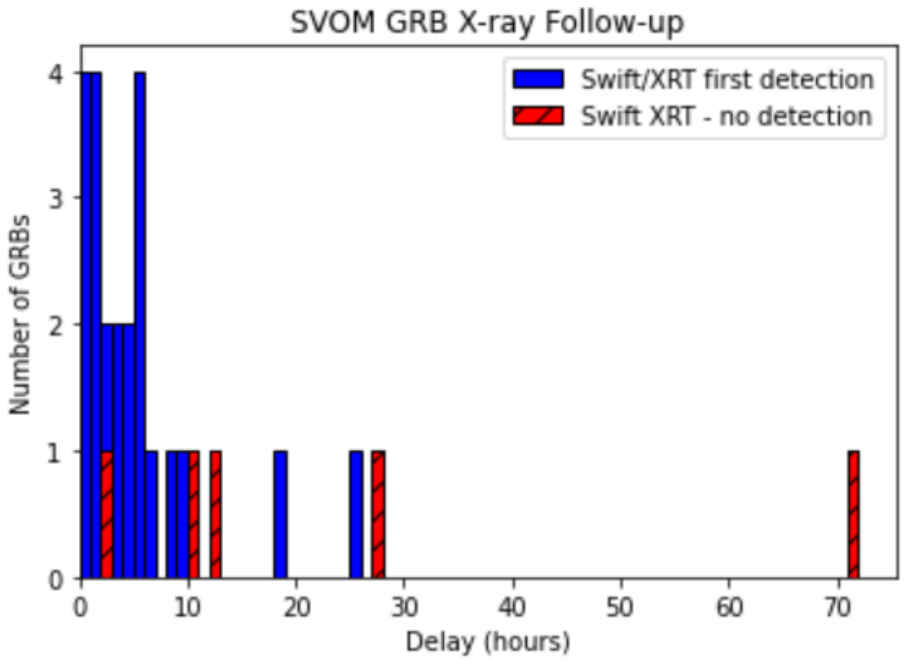
About half of the ToOs (number and duration) were devoted to the follow-up of GRBs with the VT.
-> 2/3 to SVOM GRBs and 1/3 to EXT GRBs

GRB ext : Swift 54%, EP 37%, Fermi 8%



Swift helps SVOM !

Of the **30** GRBs located by ECLAIRs, Swift performed a ToO observation **28** times and detected the X-ray counterpart in **23** cases.
The non-detections can be partly explained by the late start of observation.



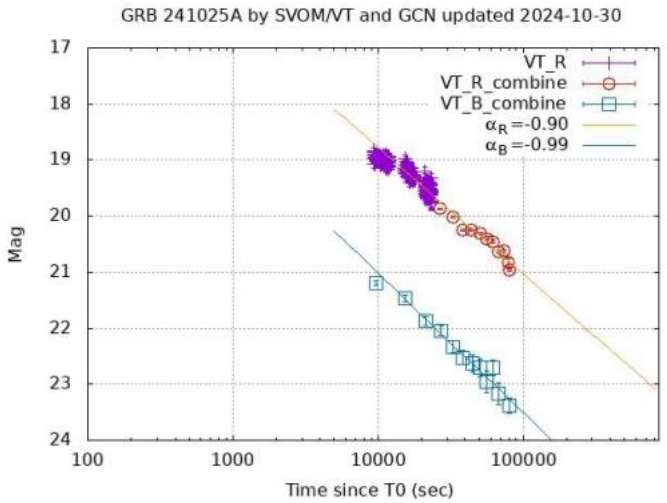
Since mid-February, we have set up an automatic ToO request as soon as the ECLAIRs notice is sent. **Many thanks to Jamie, Phil, James and Brad !**

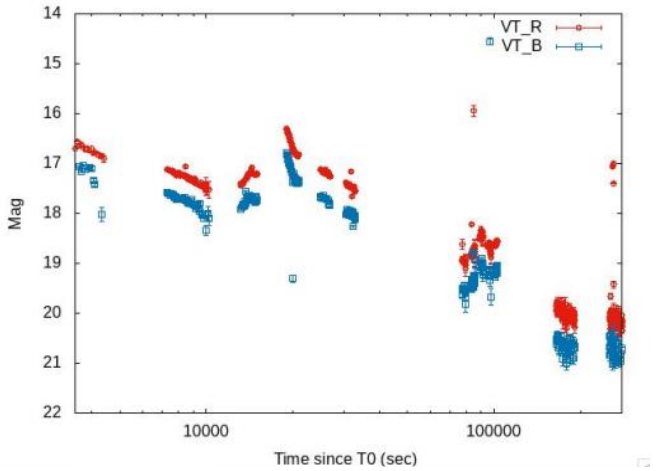
This should significantly increase the probability of detection, reduce the time taken to detect the X-ray counterpart and compensate for cases where MXT cannot work (Earth occultation, Straylight).

SVOM helps Swift!

List of Swift bursts monitored by Svom

GRB	Trigger time in UTC	T-T0 for follow-up	Orbits	Detecteed?
240809A	2024-08-09T08:30:29	22.629h	3	YES
240905E	2024-09-05T18:26:03	19.527h	1+2=3	NO
241025A	2024-10-25T01:36:50	1.918h	3+10+2+1+3=19	YES
241213A	2024-12-13T02:19:00	10.636h	4+4=8	YES
250101A	2025-01-01T13:22:50	16.832h	3+1=4	YES
250103B	2025-01-03T15:44:17	1.461h	4+2+3+3=12	YES
250129A	2025-01-29T04:45:09	0.926h	6+6+5+6+5+2+2+1+1=34	YES





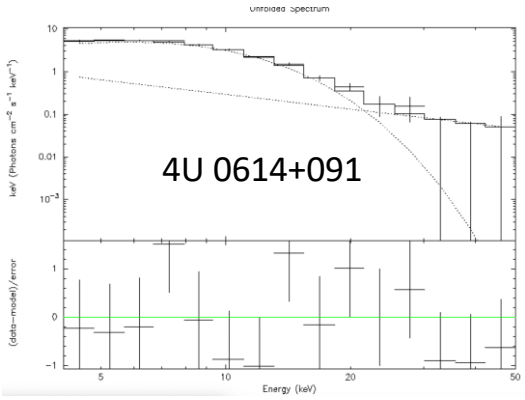
We are currently implementing an automatic SVOM ToO request as soon as the Swift notice is received. Goal mid April 2025.

OBSERVATORY SCIENCE

The **100** alert messages from catalogued sources are partly explained by calibration and trigger adjustment activities.

Nevertheless, SVOM has detected several flares from galactic nuclei, X-ray binaries and stars. In the case of exceptional events, telegrams have been published.

See Le Stum poster



Spectrum of the burst fited with an unabsorbed black body model

21 Astronomers's Telegram written.

- SVOM/ECLAIRs detection of a thermonuclear burst from 4U 0614+091
- SVOM detection of an X-ray flare from V* CC Eri
- X-ray outburst of the TeV blazar 1ES 1959+650 observed by SVOM
- Likely spectral transition of Aql X-1 seen by SVOM/ECLAIRs
- SVOM/C-GFT optical observations of the X-ray outburst from XTE J1946+274
- SVOM/ECLAIRs likely detection of a new XTE J1946+274 outburst confirming the MAXI trigger
- ……

Data policy

SVOM is not an observatory, and we have constraints vis-à-vis our agencies (CNSA and CNES), but we are very open to any collaboration with the community.

Notices are public and have been sent automatically to NASA's GCN server since February 20.

Most of the scientific products created with data from an GRB will be made public shortly, and will be grouped together in a table accessible on the French Science Center website (www.fsc.svom.org), target June 2025.

CONCLUSION

The validation phase has been scientifically completed at the end the year. All SVOM instruments (ECLAIRs, GRM, MXT, VT) are in operation.

Scientific operation have officially begun. So far, everything is nominal and working well, both on the satellite, the instruments and the associated ground segment.

From 2024 July 3 to 2025 March 21,

- the mission has already detected **99 GRBs**
- **617** GCN circulars referring to SVOM have been published (detection by SVOM and follow-up by other missions/instruments)
- **21** Astronomer's telegram referring to SVOM

Several scientific publications are in progress (GRB 240821A, GRB 240825A, GRB 241001A, GRB 241029A, GRB 241030A, GRB 241105A, GRB 250103A, GRB 250205A, GRB 250219A)

With Swift, SVOM and EP working together, all this is very promising for a rich scientific return.

Several SVOM posters at this conference

- The ECLAIRs on board trigger by S. Schanne et al.
- The ECLAIRs off-line trigger by M. Brunet et al.
- ECLAIRs and GRM joint data analysis by T. Maiolino et al.
- ECLAIRs and GRM joint calibration by M.G. Bernardini et al.
- The Colibri telescope (F-GFT) by N.A. Rakotondrainibe
- SVOM Observatory Science by S. Le Stum

Thank you for your attention and happy birthday to Swift

Back-up slides

The F-GFT status (aka COLIBRI)

Brand new 1.3 m telescope installed in Mexico:

Wide field of view: 26 arcmin
Visible domain: B to SDSS z bands.
Infrared domain: up-to H band.

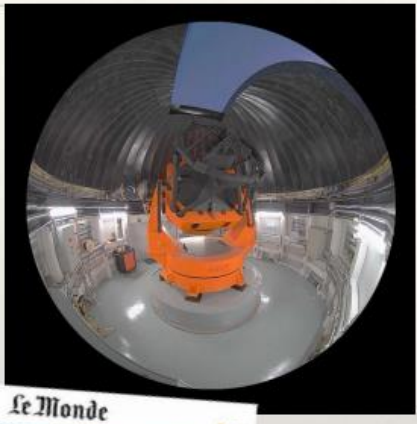
Performances in line with the requirements:

Measured image quality: sub-arc seconds PSF.
Very good pointing speed and damping performances: starting of the observation in much less than 20 sec after alert reception.

Still in Commissioning phase:

- DDRAGO starts its scientific exploitation in February 2025.
- CAGIRE installation schedules for June 2025.

But already 13 GCNs since September 2024.




Le Monde

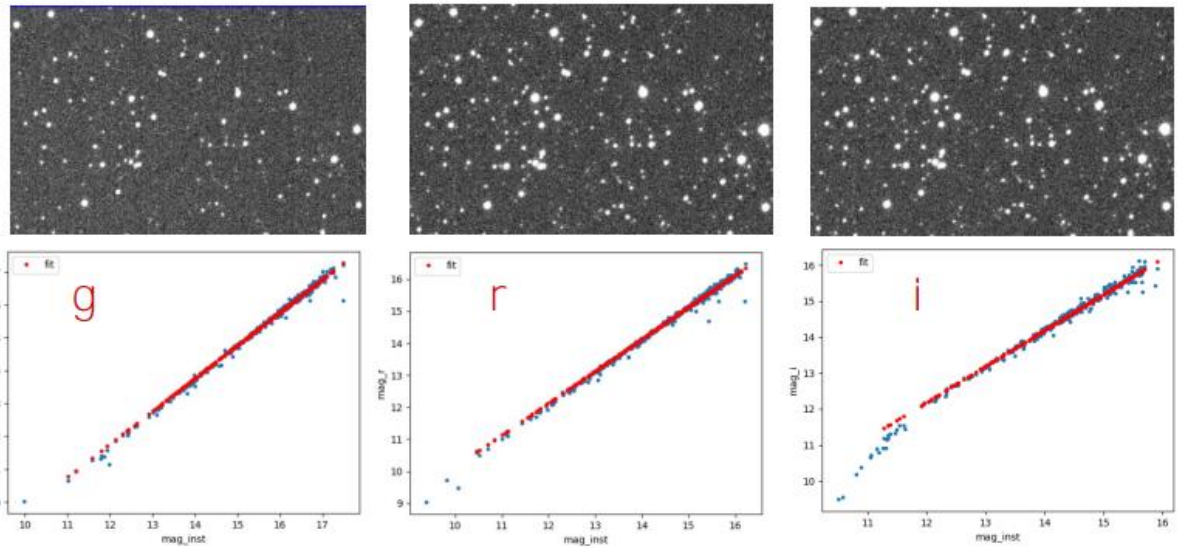
Colibri, un nouveau télescope hyperréactif, livre ses premières images au Mexique

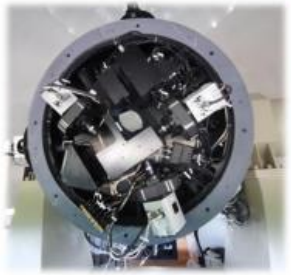
The C-GFT status

C-GFT has two instruments:

- 3-channel Imager: simultaneous observation in g,r,i FOV = 21' X 21' ✓
- Prime Focus camera : multiple filter in g,r,i FOV=1.28degx1.28 deg ✓

☐ C-GFT has capability of taking g,r, and i band image.



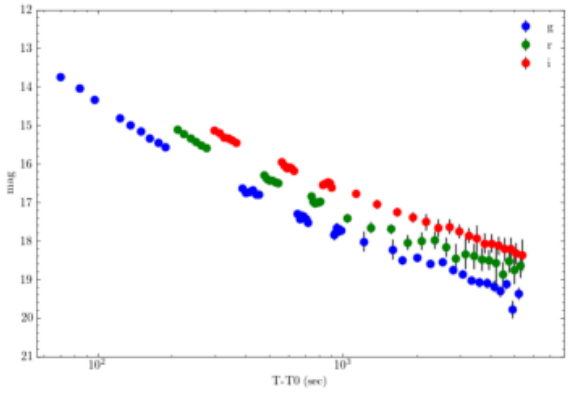


The C-GFT status

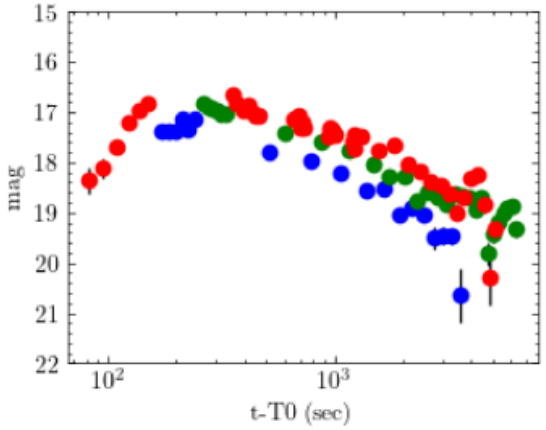
- Response to trigger (results to GCN): total 15 events= [SVOM : 8 events + other (Swift+EP): 7 events] : 6 of 15 events are real-time response, C-GFT started to observe < 1 min after receiving trigger. ✓
- Limiting magnitude, mag_r=19 (100sec, 5sigma) ✓
- Capability of localization accuracy of 0.5 arcsecond ✓

- 3 Examples of early afterglow observation:

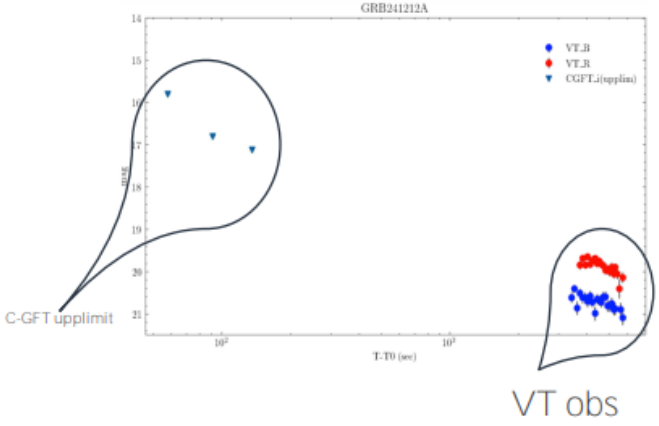
GRB 240825A T0+65s



GRB 250101A T0+77s



GRB 241212A T0+77s



The GWAC status 1/2

Installed in the Xinglong Observatory, China:

- Cameras : 40
- Diameter : 180mm
- Focal Length : 220mm
- Wavelength : 500—800nm
- Total FoV : ~5000 Sq.deg
- Limiting Mag : 16.0V（3 ， 10sec）

The GWAC status 2/2

- Operation of GWAC is very stable every night.
  - ✓ Temporal resolution is 3 seconds.
  - ✓ Data flow from camera to the data servers performance well.
  - ✓ Real time data process is running for SVOM alerts.
  - ✓ Calibrated images could be produced in real time.
  - ✓ Results involved in candidates are being validated at IS level.
- Next step is to generate the SPs in real time, which is expected to be fixed in the next four months.