Evolution of the performance of the SVOM/ECLAIRs Camera

Laurent Bouchet
on behalf of the SVOM/ECLAIRs team

18th IACHEC meeting — 2026-04-19

Outline

- SVOM mission
- The ECLAIRs camera
- Performances
- Output scientific results

SVOM: Space-based multi-band astronomical Variable Objects Monitor

Launched : June 2024
Duration: 3 + 2 years

VT
"The visible telescope"
Ritchey Chretien Ø = 400 mm
FoV : 26' x 26'
Localization accuracy < 1 arcsec

GRM
"The Gamma-Ray burst Monitor"
X-rays and Gamma-rays detectors
Spectral range 15 keV - 5 MeV
Localization accuracy < 5°

ECLAIRs
"The trigger camera"
Wide-field X and Gamma rays telescope
FoV : 89° x 89°
Spectral range 4 -150 keV
Localization accuracy < 13 arcmin

MXT
"The Micro-pore X-ray Telescope"
FoV: 58'×58'
Spectral range 0.2 - 10 keV
Localization accuracy < 2 arcmin

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

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

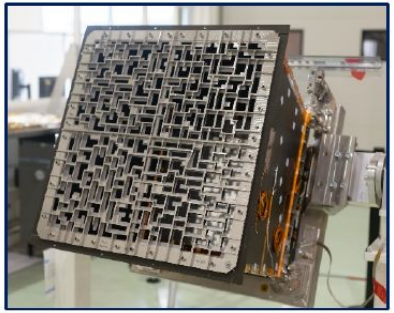
GFT-2
« Ground-based Follow-up Telescope »
Φ>1000mm

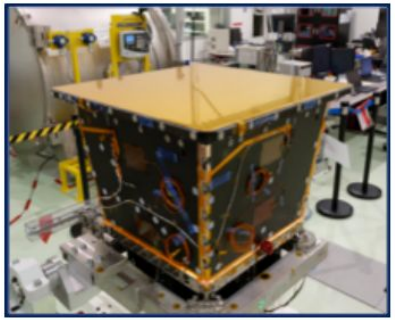
VHF Alert Network
... and more !

Tracking antennas

The  camera

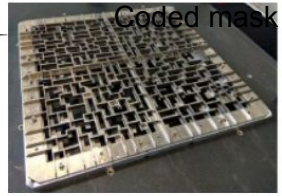
ECLAIRs in a nutshell

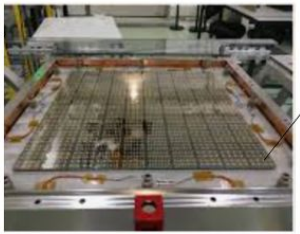


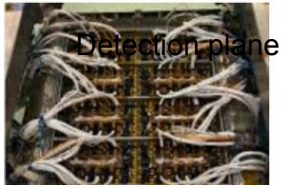


Data processing unit

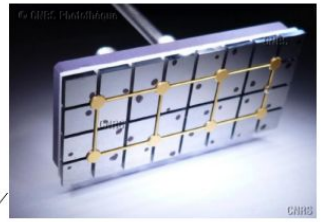
8 x Readout electronics



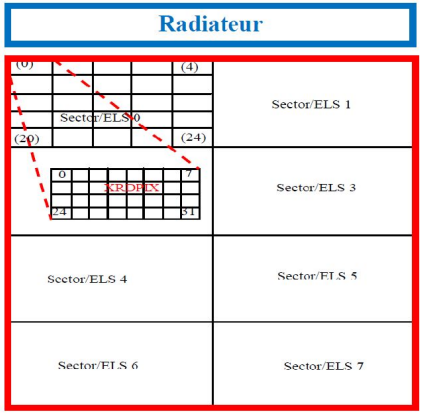




Interface cardboards under the detection plane



Elementary detection module



- 80x80 4x4 mm² and 1 mm-thick Schottky-type Pt/CdTe/In detectors from Acrorad Ltd (Japan)
  - operated at –300 V & nominal temperature range of [–25°C ; –18°C]
- Mask-to-plane distance = 46 cm & Mask dimension = 54 x 54 cm² & Ti-Ta (0.6 mm)-Ti sandwich
  - 40 % mask open fraction & quasi-random pattern
- Total FOV = 89 x 89 deg² (~2 sr) & Fully coded FOV ~ 22 x 22 deg² (~0.15 sr)

ECLAIRs in a nutshell

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

Performance measured on ground,validated in-flight!

- **4 keV energy threshold to increase sensitivity to X-Ray Flashes (soft GRBs) & high-z GRBs**
- **Photon counting mode**
  - All photons transmitted to the ground
  - Readout electronics able to flag events from particle showers, fluorescence and Compton scattering as multiple events
- **Automatic software to disable noisy pixels**
- **On-board autonomous detection [count-rate + image triggers] & localisation**
  - Time scales from 10 ms to 20 min
  - 4 energy bands, 9 detector zones
- **Expected rate ~ 50 – 70 GRBs/yr**

Godet et al., RAA, 2026

Outline for ECLAIRs

- Background evolution & SAA contours
- Evolution of the spectral performance
  - Energy threshold and energy scale
  - Spectral response
  - Cross-calibration
- Duty cycle
- Science results

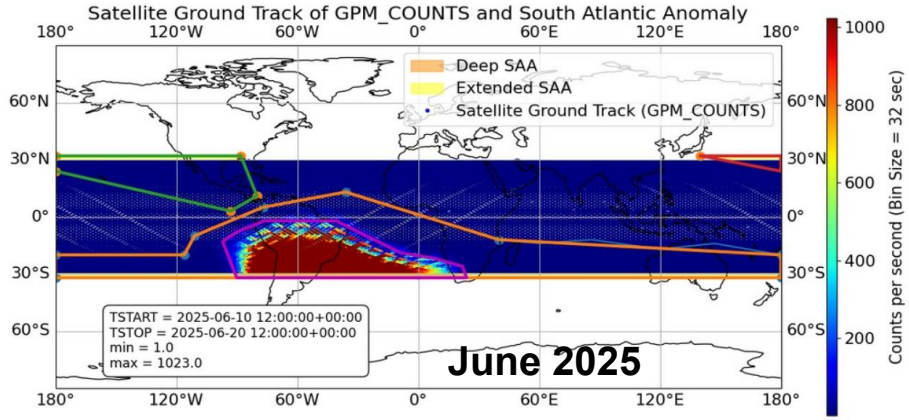
South Atlantic Anomaly (SAA)

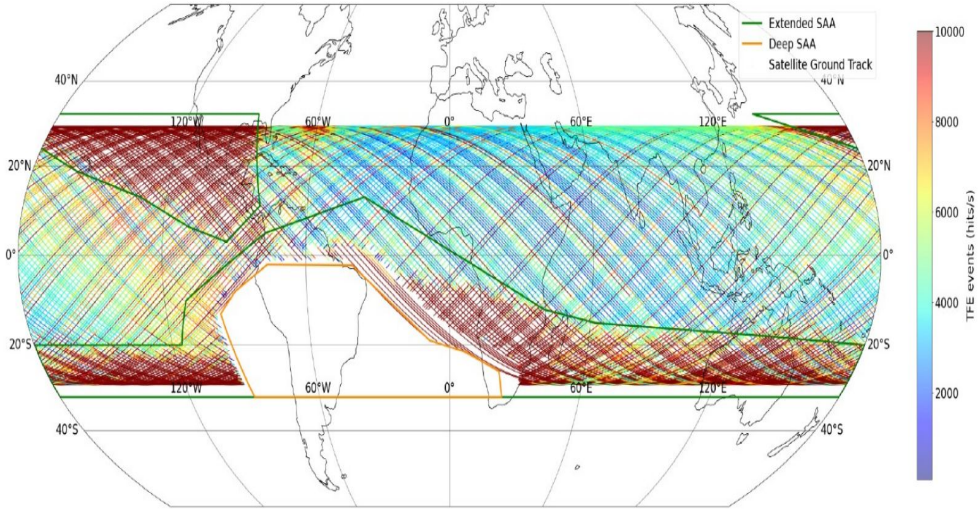
The SAA is a zone of high particle flux above the south Atlantic.

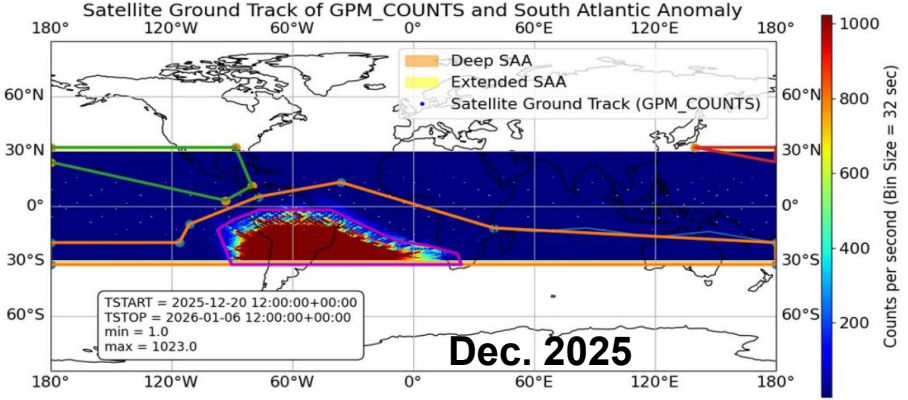
Inside the core SAA, the ECLAIRs high voltage is switched off.

In a region called “extended SAA”, the operation is slightly modified, with no management of noisy pixels.

→ No significant evolution on the SAA contours







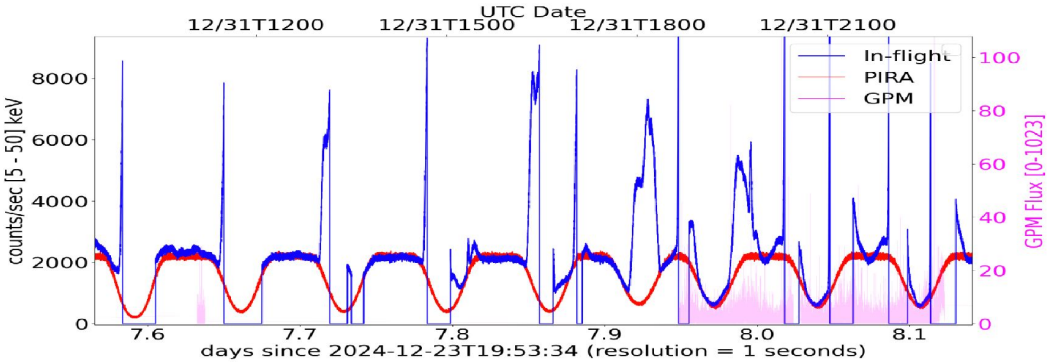
Godet et al., 2026a, RAA
Claret et al., 2026, RADECS

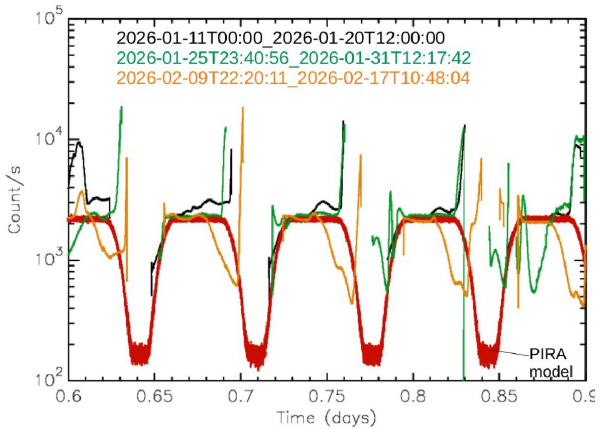
Background

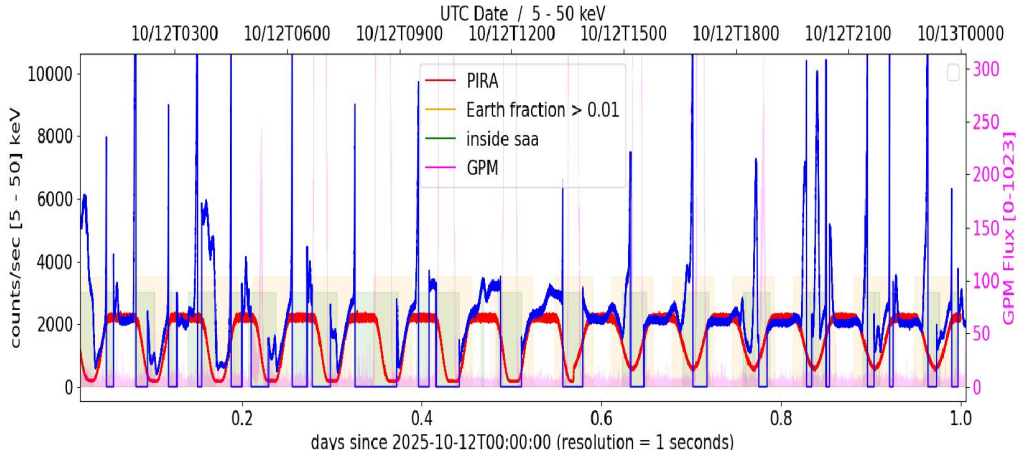
Due to the high solar activity, the count rates are strongly affected by particles trapped in the magnetosphere.

During calm portions of the orbit, the background is close to predictions of Monte Carlo simulations.

No noticeable evolution seen in the detector efficiency.

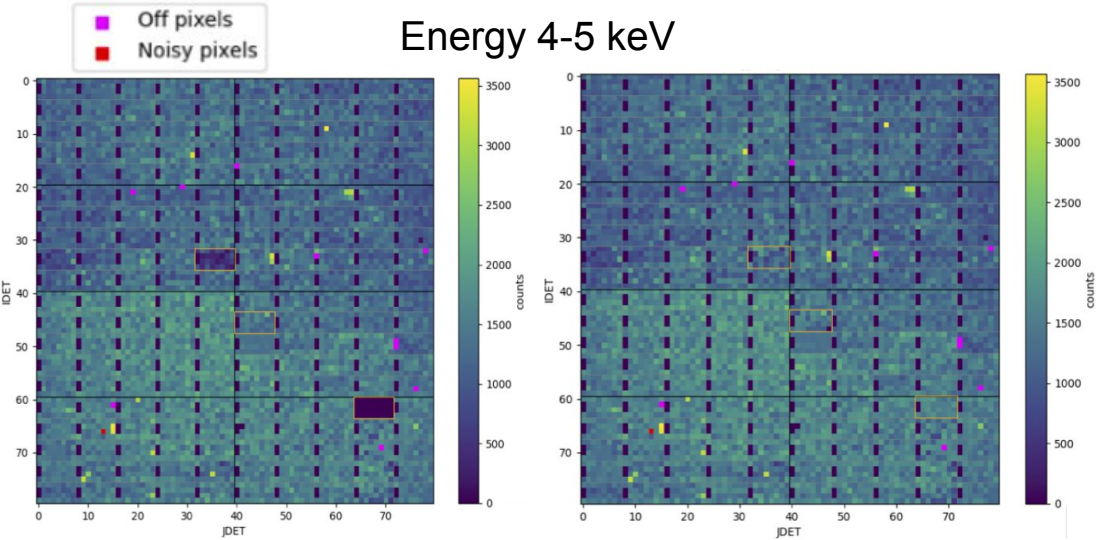


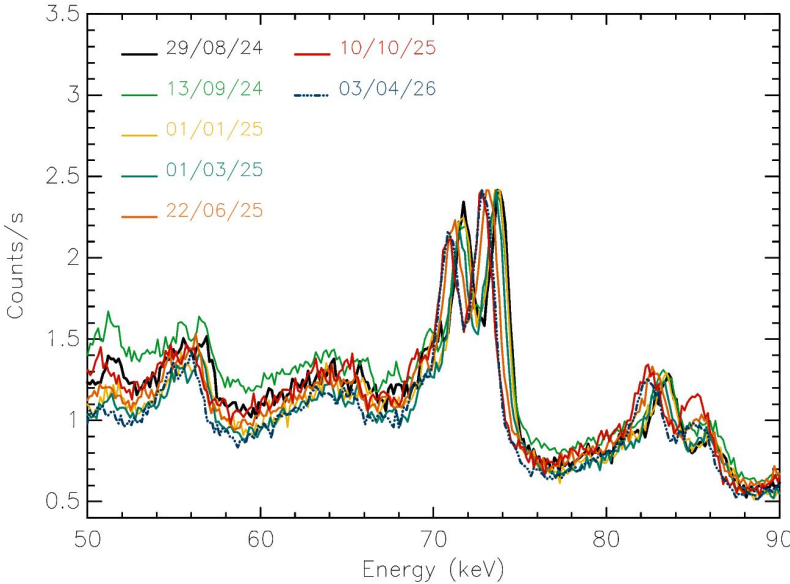




See Godet et al., 2026a, RAA

Energy scale





5 modules with bad energy scale since launch masked out onboard for the deconvolution (2.5 % of effective area)

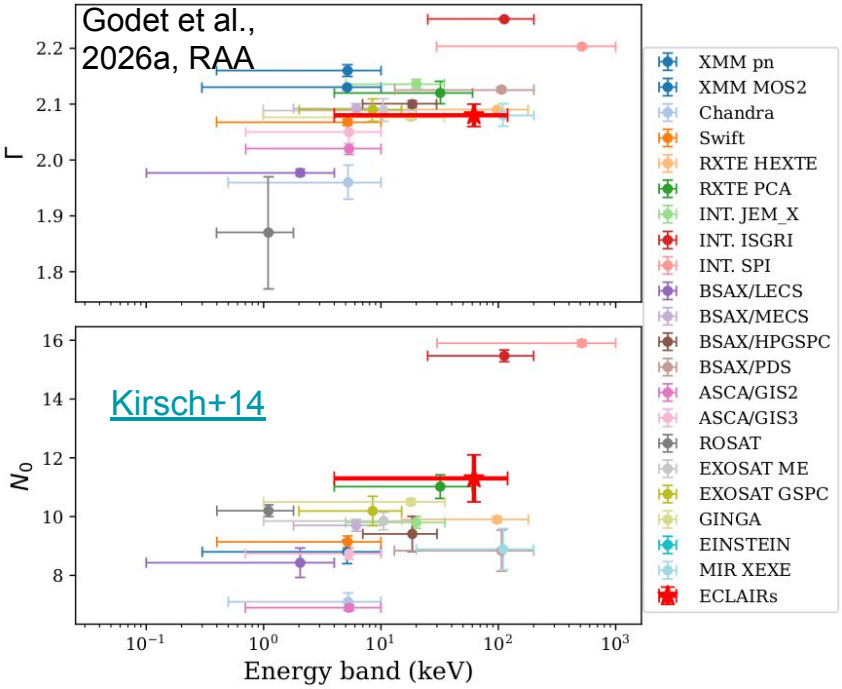
Correction of the gain/offset of these modules

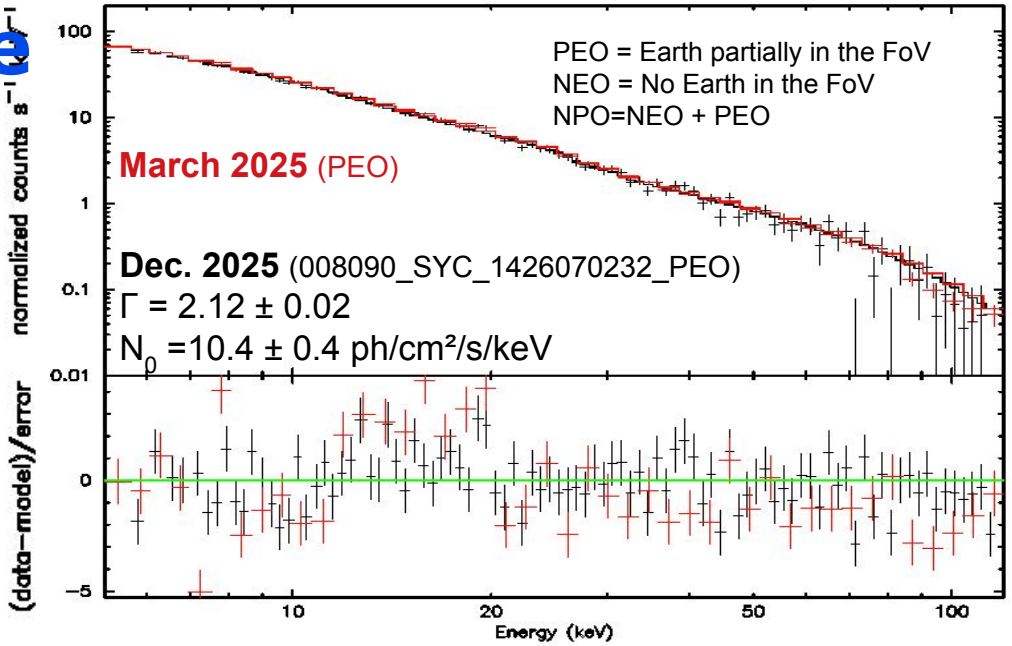
⇒All the modules now used for the deconvolution

Slow variation of the detection plane energy scale from August 2024 to October 2025 as shown by the down shift of the Pb fluorescence lines (~0.7 keV). Shift smaller at lower energies

Need to update the gain/offset table – work in progress

Spectral response





Parameter	NEO	PEO	NPO
Γ	2.09 ± 0.02	2.06 ± 0.03	2.07 ± 0.02
N_0 (ph cm^{-2}s^{-1}keV^{-1})	11.6 ± 0.6	10.8 ± 1.0	11.3 ± 0.7
Flux (4–120 keV) ($\times 10^{-8}$ ergs/s/cm^2)	4.8 ± 0.2	4.8 ± 0.2	4.82 ± 0.09

From data collected before April 2025
Godet et al., 2026a&b, RAA

→ Overall good consistency of the Crab spectra over time

→ No strong change in the ECLAIRs spectral response

→ Good agreement of spectral parameters with other HE missions.

Cross-calibration

ECLAIRs – MXT

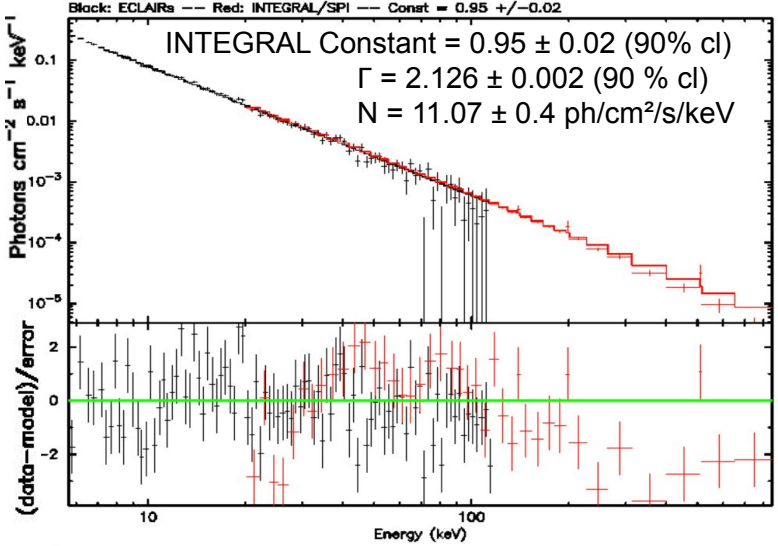
- Using the Crab nebula, agreement on the spectral index within 5 % and on the 4 – 10 keV flux within 8 %
- **Compliant with science requirements**

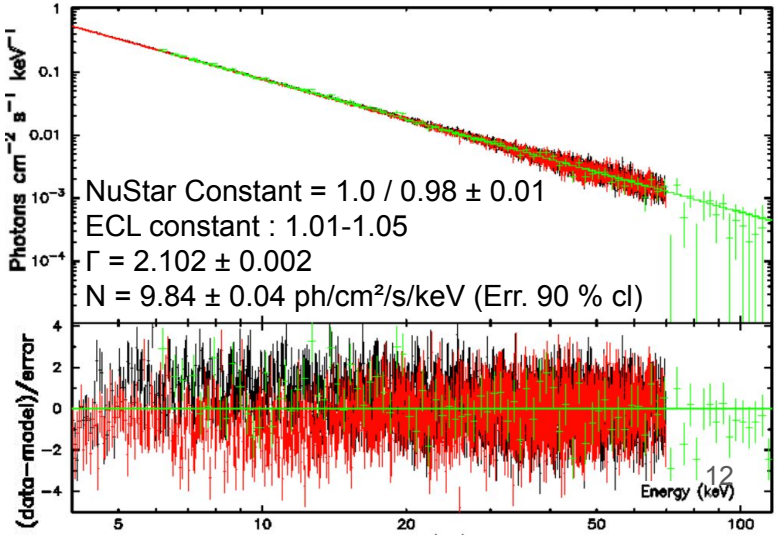
ECLAIRs – GRM – Still on-going

- Not possible to use the Crab nebula for GRM (Variation of the bkg during the acquisition)
- Instead use of the Crab pulsar
- On ECLAIRs side, still investigating how to extract the pulsed spectrum of the Crab
- **Joint fits on GRBs show a good consistency**

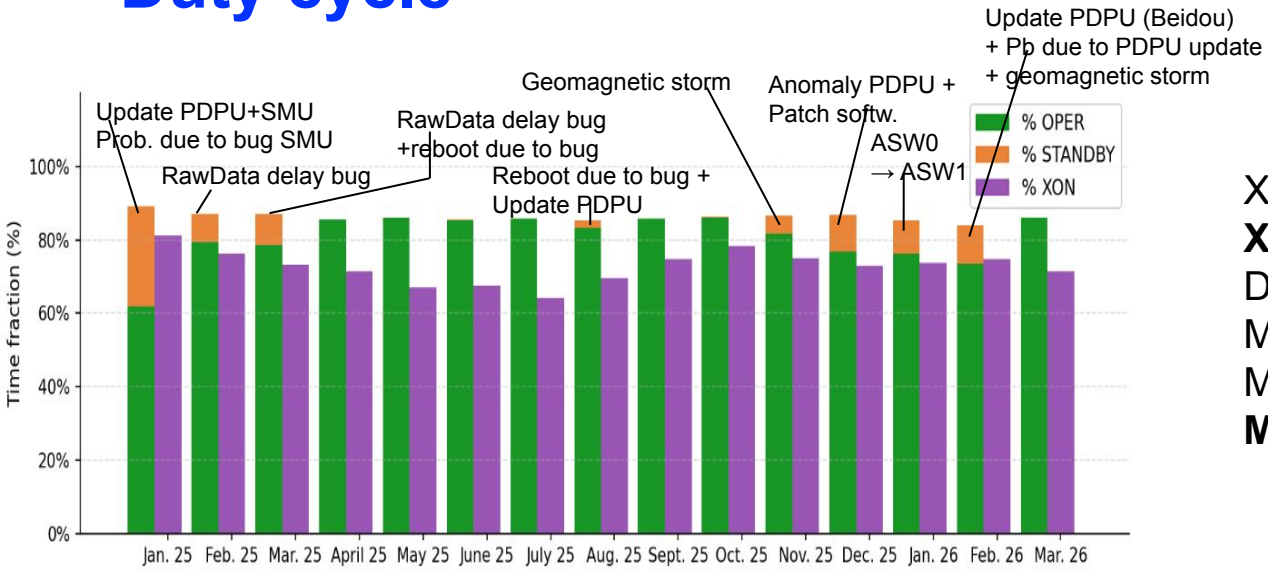
Good agreement with NuSTAR/FMP & INTEGRAL/SPI!

Good agreement when fitting Fermi/GBM GRB spectra

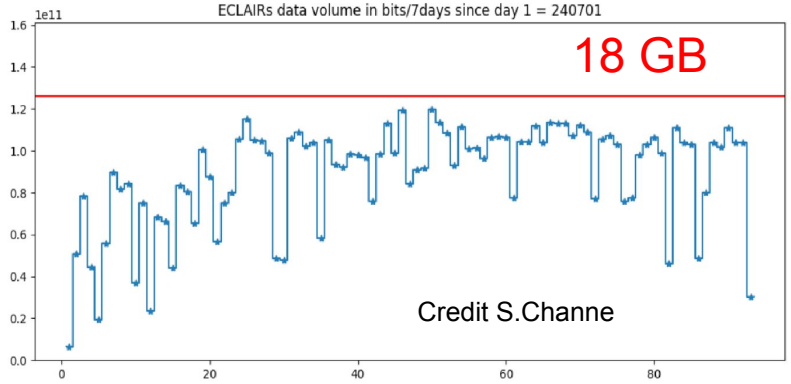




Duty cycle

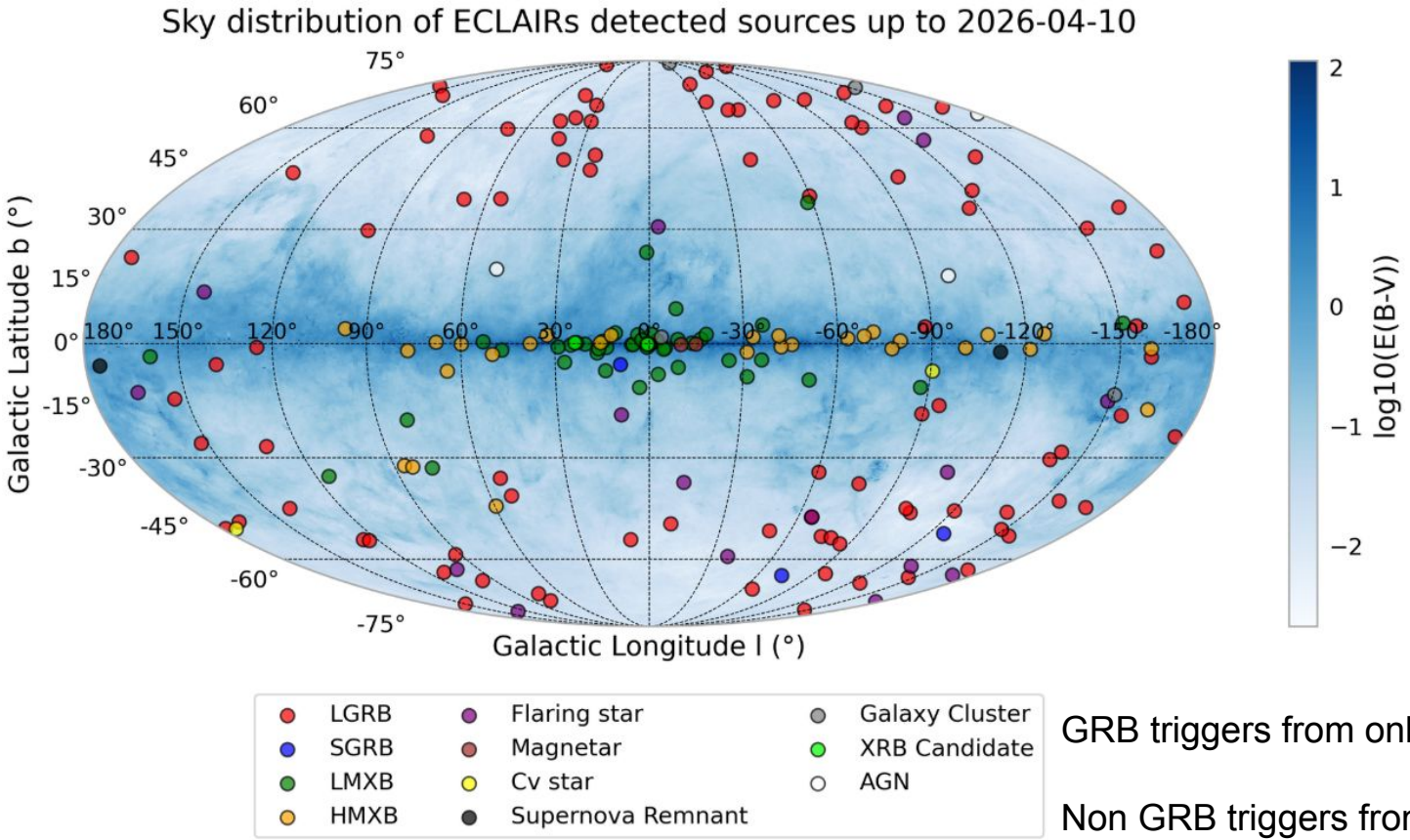


XON = data acquisition ON
XON% depends on solar activity
Duty Cycle = XON% x OPER%
Mean XON = 72.8 %
Mean OPER = 80.8 %
Mean Duty Cycle = 58.8 %



Data volume stays within onboard ECLAIRs data allocation

- X band (Full telemetry) 6 passes per day



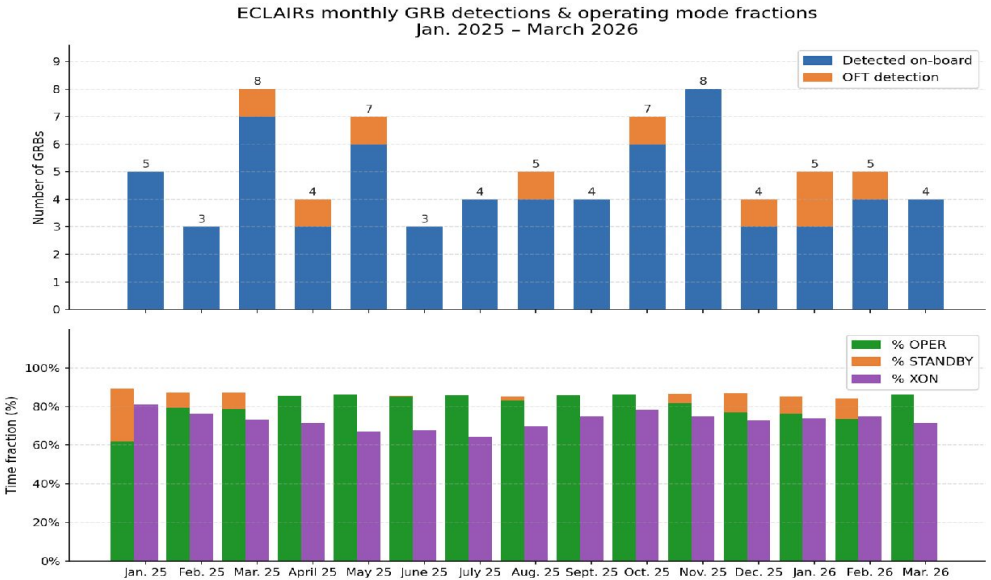
GRB triggers from onboard + OFTG

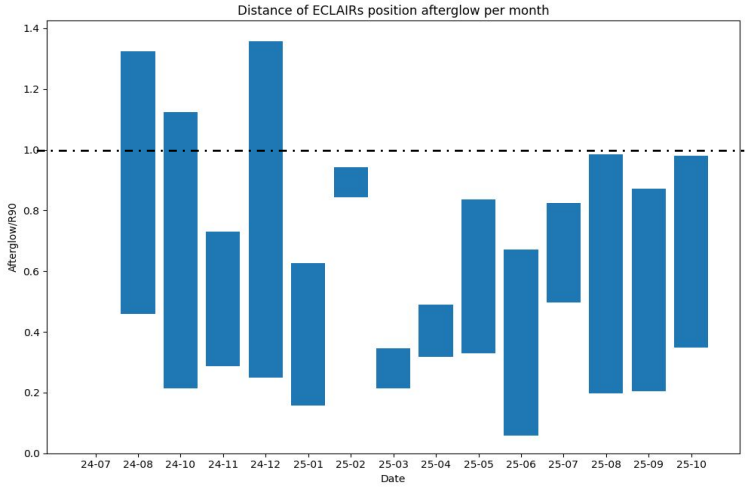
Non GRB triggers from onboard + OFTG + QLA

Credit: M. Brunet

GRB Trigger

- From Jan. 2025 to March 2026, 67 GRBs detected onboard + 9 on ground by the offline trigger - OFTG)
- Detection rate per year is as expected (50-70)





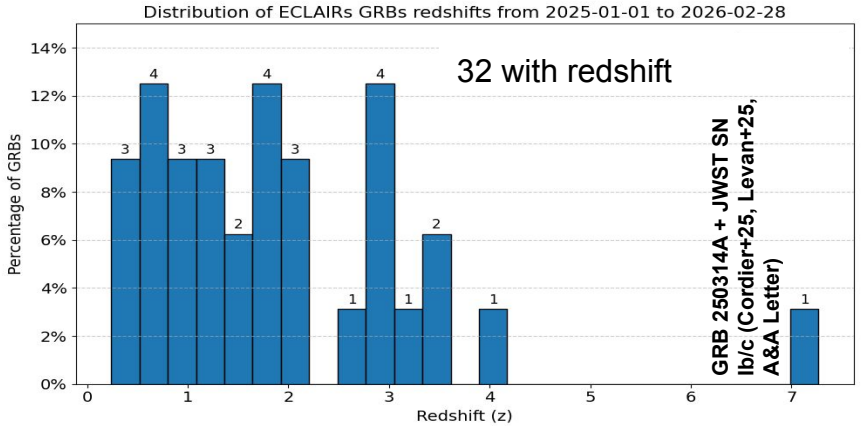
- ECLAIRs localization accuracy is good.
- Adding 2' systematics to Err90

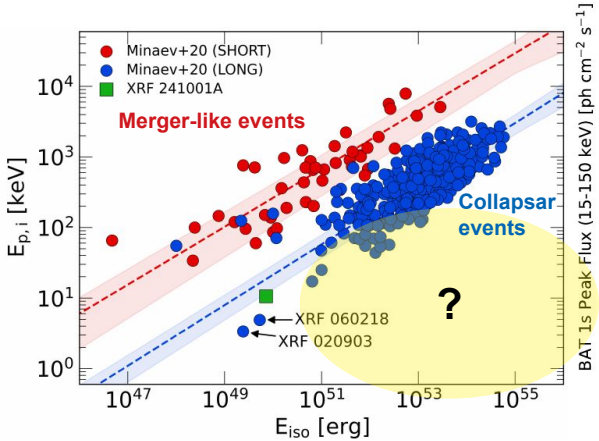
- Systematic check of GRB detections from other HE missions with OFTG

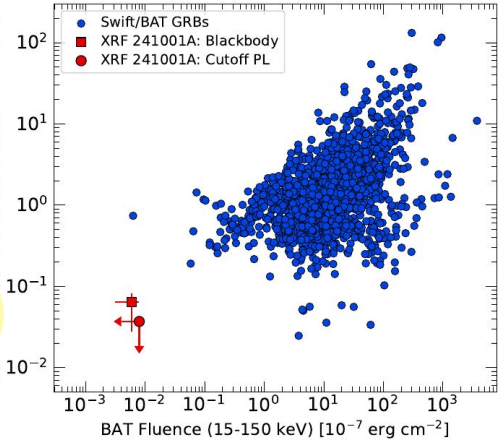
Godet et al., 2026a, RAA
Lachaud et al. 2026, RAA

GRBs

- 82 GRBs
  → 39% with redshift
- Detection of all types of GRBs (e.g. high-z GRBs, XRFs, 3 short GRBs, ultra long GRBs)
- Systematic check of GRB detections from other HE missions with OFTG
- 10 detected onboard in common with EP/WXT + 3 with OFTG







- ECLAIRs (+ EP) unveils new population of soft GRBs not seen by other GRB missions
- Investigation of low-E breaks/additional features in GRB prompt emission spectra

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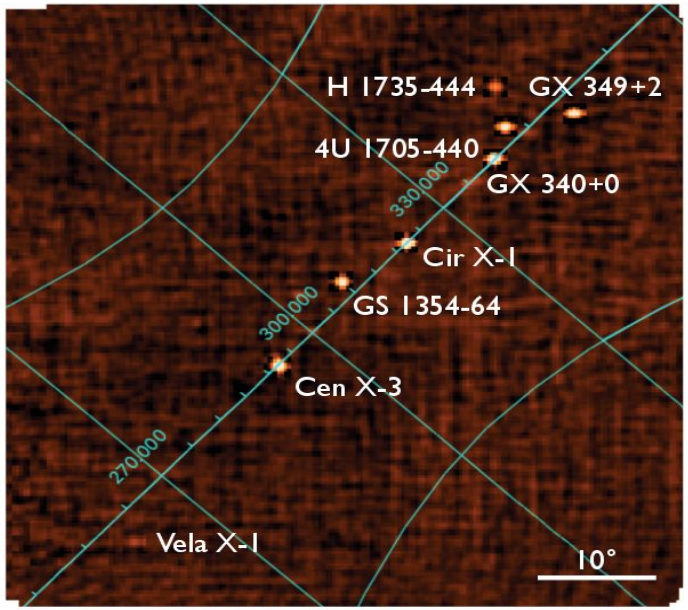
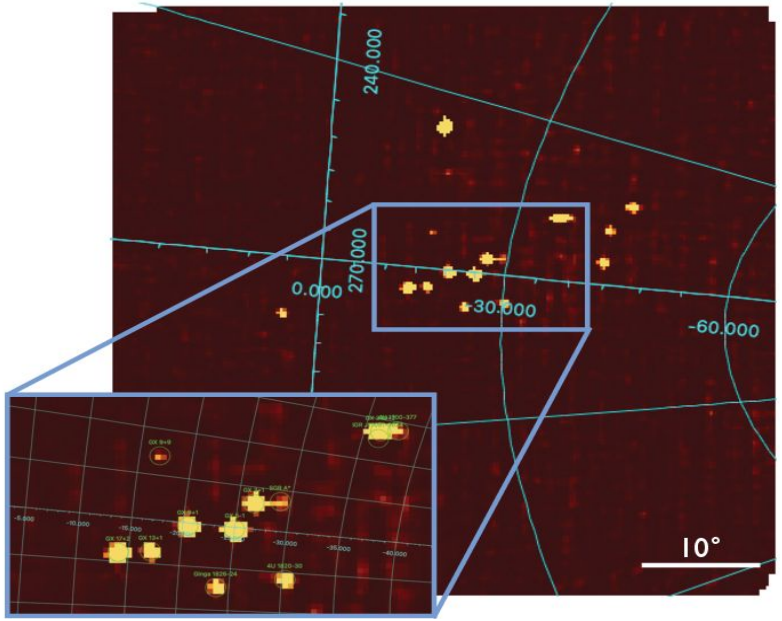
Non-GRB Science: High-Energy Sources Working Group

ECLAIRs 4-10 keV view of the Galactic plane



ECLAIRs 4-10 keV view of the Galactic center



- **453 triggers** (298 onboard, 150 OFT) since the launch
- **27 ATels** on Type I X-ray bursts, HMXB/LMXB outbursts, AGN outbursts
- **2 GCNs** on flaring stars

Non-GRB Science

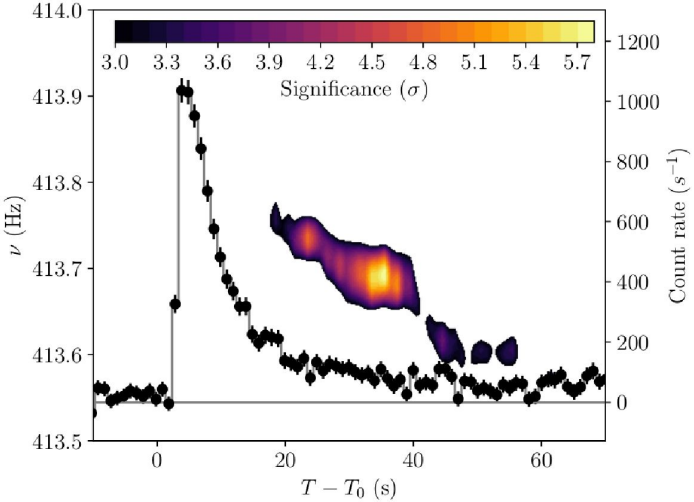
ECLAIRs very efficient to detect other types of HE transient/variable sources over different timescales from onboard and on-ground (OFTG, QLA) detections

- In particular, Type-I X-ray bursts with the OFTG (> 100 events),

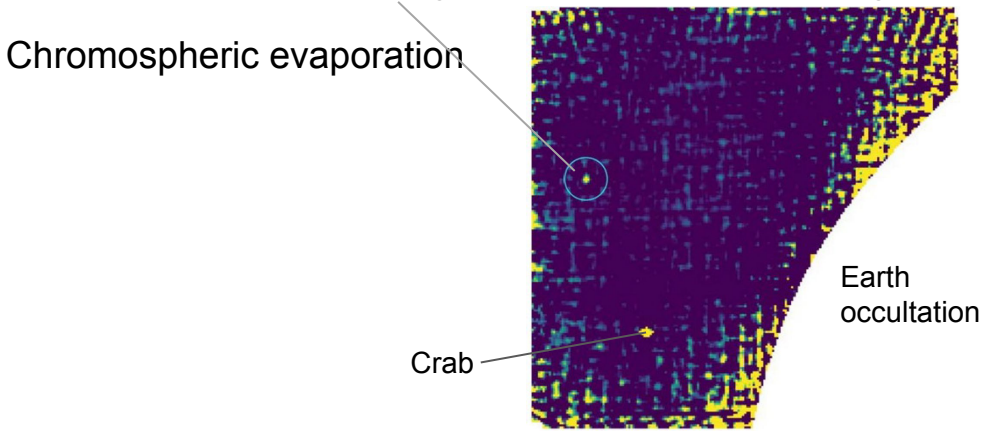
- But also stellar flares, XRB outbursts, AGN, Solar flares reflected onto the Moon, X-ray Earth auroras, TGF candidates, …

NS-LMXB 4U 0614+091 - LeStum+26, ApJ

Type I burst



RS CVn–Type Star HD 22468 - Wang+26, ApJ



Summary

- **ECLAIRs works nominally & allow us to perform cutting-edge science!**
  - All detector modules are working well, along with their electronics.
  - UGTS is fully functional. On-board trigger software performs very well.
  - New features to come in the new onboard trigger software as well as on-ground software
    ⇒ Further increase capabilities to explore study transients of different kinds over different timescales!
  - Good maturity of data analysis tools
    ⇒ Start building first source catalogs and performing population studies / GRB classification

- **The performances are as expected :**
  - Background level when avoiding SAA does not show any significant changes
  - Low change of the energy scale – To be corrected in forthcoming weeks
  - No strong variation of the spectral response – good agreement with other HE missions
  - GRB detection rate within the science requirements – good localization performance

→To organize cross-cal. obs., please contact ogodet@irap.omp.eu & laurent.bouchet@irap.omp.eu
→If you want to access SVOM data, please contact us

Publications

End of March 2026, **726** GCN have been published by the SVOM collaboration on the NASA website

Gamma-ray burst science **39** papers (4 published an 35 in preparation).

Observatory science **13** papers (4 published and 9 in preparation)

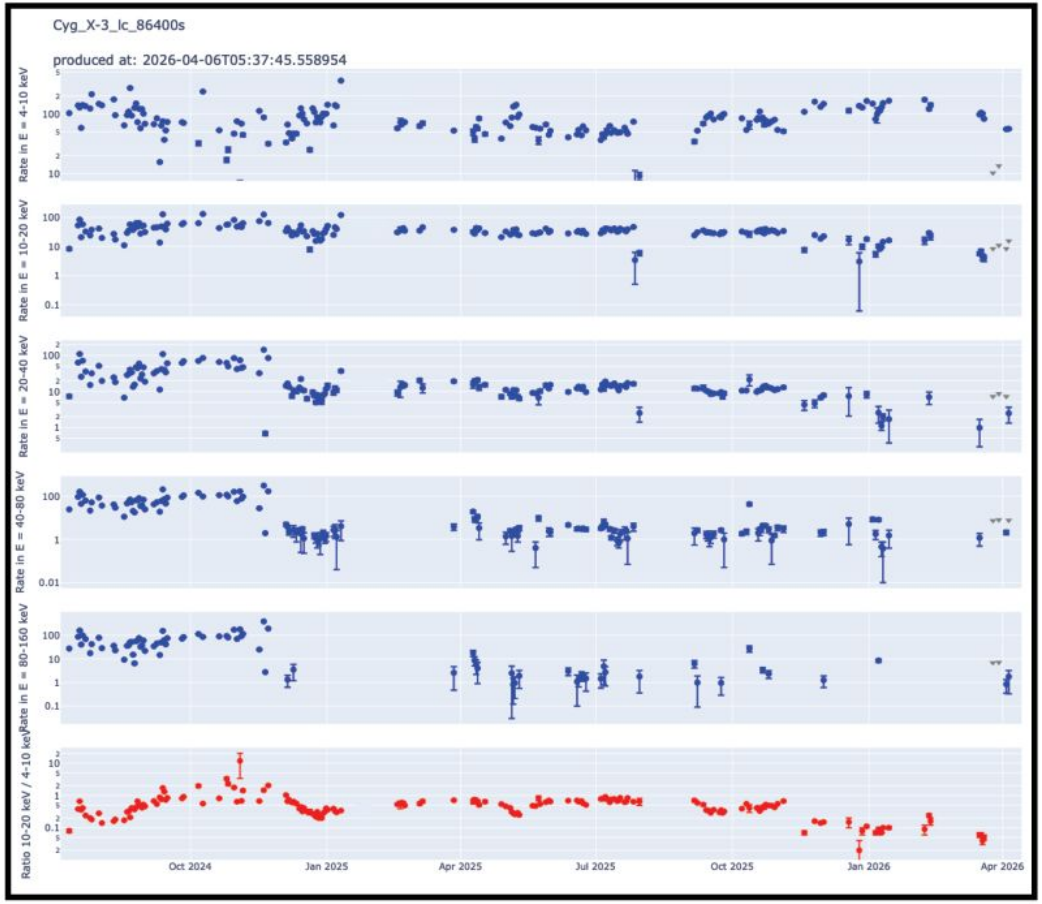
A **special issue** of the Chinese scientific journal *Research in Astronomy and Astrophysics* is planned to present the SVOM mission, its instruments,its ground segment and the first results (**36** papers divided into nine sections, 31 already accepted).

→ Submission on Astro-ph April 27, 2026

BACK-UP SLIDES

Serendipitous High-Energy Sources Working Group (SHES-WG)

Long-term lightcurves provided by ECPI/QLA



SVOM/ECLAIRs detection of Cyg X-3 in a likely ultrasoft state

ATel #17585; *P.-O. Petrucci (IPAG, France), F. Cangemi (APC, F), A. Coleiro (APC, F), S. Guillot (IRAP, F), L. Tao (IHEP, China), L. Zhang (IHEP, C)*
*on **8 Jan 2026; 08:58 UT***
Credential Certification: Floriane Cangemi (cangemi@apc.in2p3.fr)

Subjects: X-ray, Binary

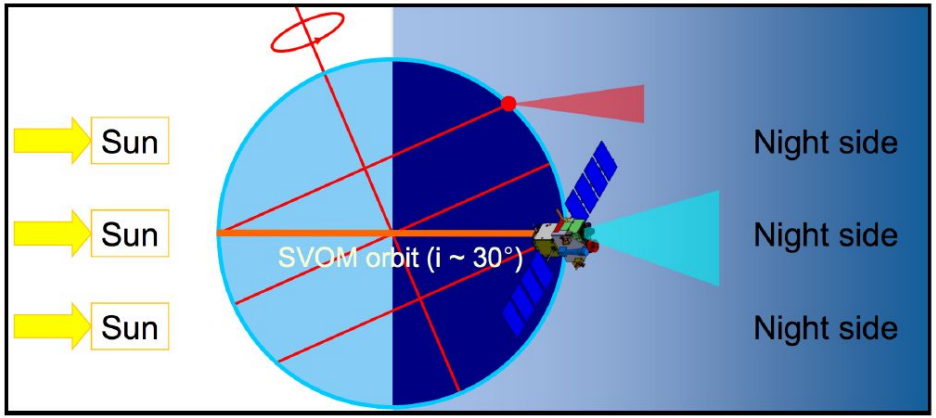
Referred to by ATel #: 17605, 17661

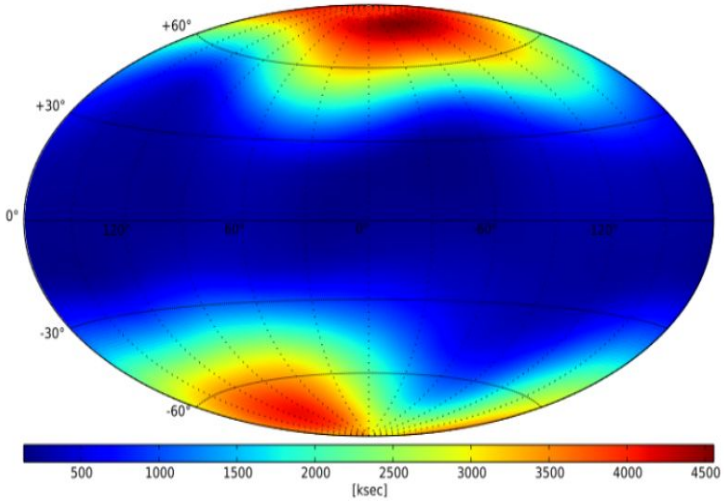
Post

We report an increase in the X-ray flux of the microquasar Cyg X-3, detected by the ECLAIRs coded-mask instrument onboard the SVOM mission. The source was detected by the Xband quicklook analysis of observations acquired on January 5th, 2026 after 398 s of exposure with a SNR of 47 in the 4-10 keV energy range.

The ECLAIRs long-term lightcurve showed a spectral softening of the source which started in Nov./Dec. 2025. The 4-40 keV spectrum obtained on January 5th, 2026 is well described by a diskbb model (chi2/dof = 11.80/13), with an inner disk temperature of kT = 1.42 +/- 0.07 keV (90% confidence range) and a 4-0 keV flux of (6.3 +/- 0.3)e-9 erg/cm^2/s (90% confidence range). The spectral analysis of the November 4th, 2025 observation shows that the spectrum is well described (chi2/dof = 11.11/9) by an absorbed cutoff power-law model, with a photon index of Gamma = -0.06 +/- 0.74, an energy cutoff of Ecut = 8 (+4) (-2) keV and a hydrogen column density fixed at NH = 8.7e22 cm^2 (Cangemi et al. 2021), yielding a 4-40 keV flux of (5.7 +/- 0.6)e-9 erg/cm^2/s. An iron emission line is also detected in the spectrum, with a centroid energy of 6.4 (+0.3) (-0.8) keV and a line width of 0.4 (+0.8) (-0.3) keV. This clearly indicates that the source underwent a spectral state transition starting from this date and persisting up to the present time.

Pointing strategy





- Low Earth Orbit (625 km, 96 min), 30° inclination
- **Nearly anti-solar pointing to facilitate follow-up observations from ground**

  → Earth in the FoV: 65% duty cycle for ECLAIRs (50% for MXT and VT)

  → Redshift measurement for ~2/3 of detected GRBs
- **ECLAIRs FoV: avoidance of Galactic plane and Sco-X1 (B1-Law)**

- ECLAIRs annual exposure time
  - ~4000 ks on the Galactic poles
  - ~500 ks on the Galactic plane

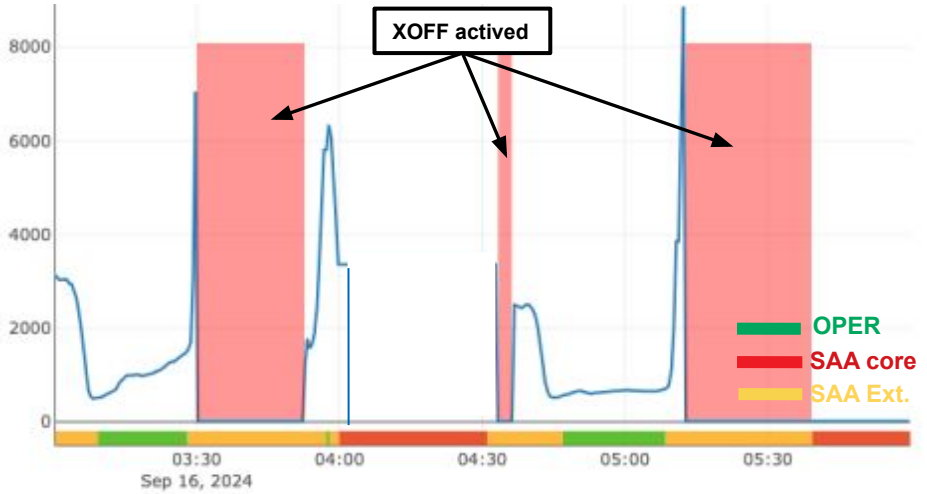
Data Rate / XOFF

The ECLAIRs data rate was initially higher than expected due to the high particle background related to the high solar activity.

A mechanism, called *Xoff*, was activated to reduce the data recorded on-board and to preserve the onboard trigger software from receiving too high counts.

- ➢ This mechanism stops photon data acquisition when the data rate exceeds a preset level.
- ➢ Xoff's mechanism only activated in the extended SAA.

The present data rate is ≈ 15 Gb/day well within the allocation



Daily ECLAIRs data rate (incl. Xband + VHF)

South Atlantic Anomaly

The SAA is a zone of high particle flux above the South Atlantic.

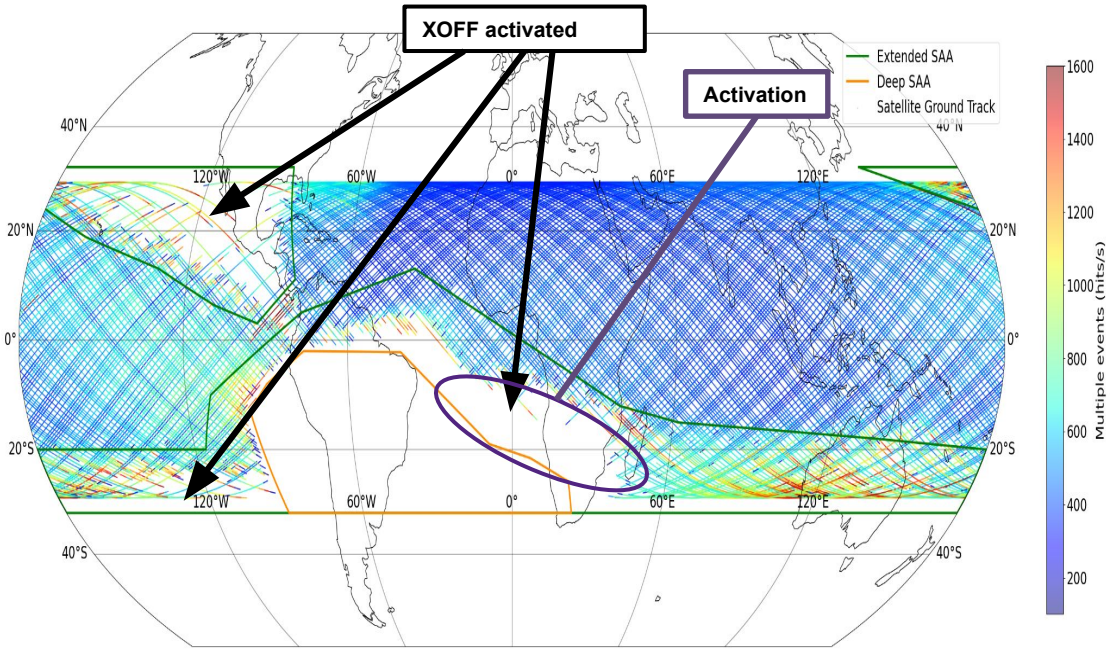
Inside the core SAA, detectors are depolarized.

Outside the core SAA, regions of high particle background that induce high count rates (in particular when the Sun is active)

In these regions called “extended SAA” the operation is slightly modified, with no management of noisy pixels.

SAA management via time-tagged TCs works fine.

SVOM proton particle monitor (GPM) can be used to determine the core contour of the SAA.



Applied core & extended SAA contours since 2024-12-03. Count tracks shown as coloured lines.

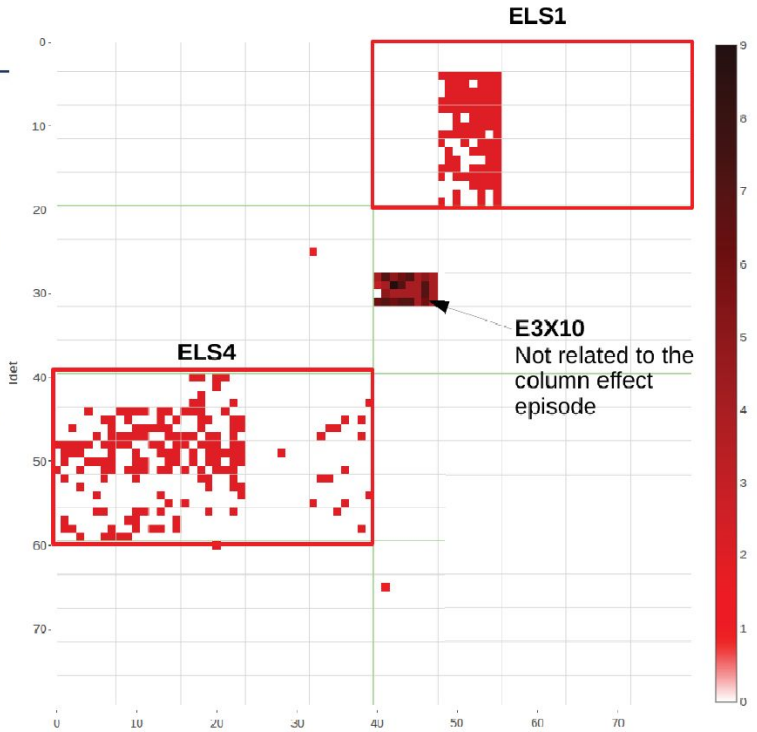
Noisy pixels

Few episodes when a module or several columns of modules became noisy

- Important number of disabled pixels
- Lead to series of false alerts because disabled pi not flagged for the deconvolution
- Find ways to mitigate bad effects on triggers

These instabilities observed during the on-ground testing

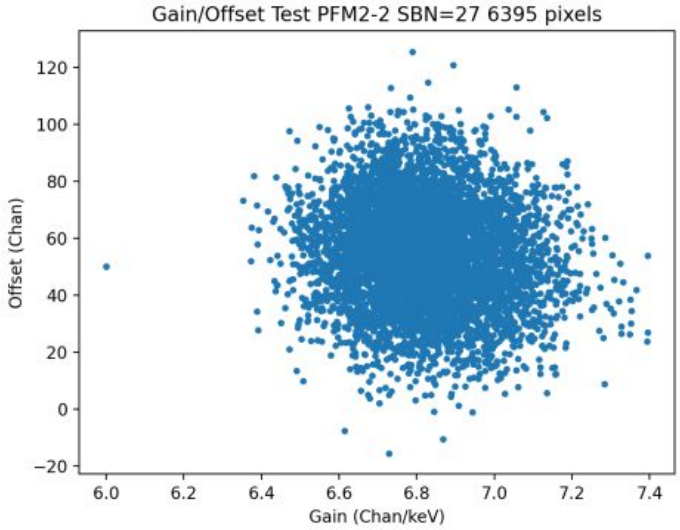
Occurrence of these events not related to solar activities, nor to an ageing of the detector/electronics



Episode on 2025-06-26

© cnes

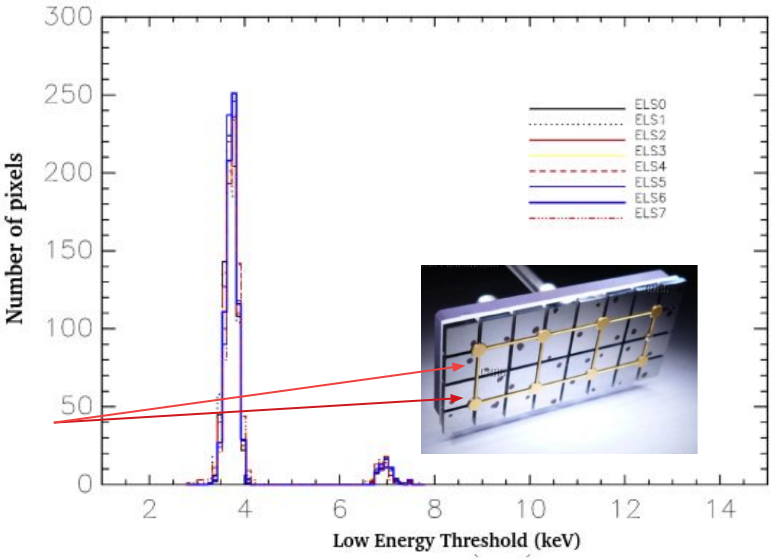
Before launch: Energy scale and low-energy threshold (SBN)



Calibration of the Channel -Energy relation to reconstruct the energy scale

=> Very good homogeneity of the gain/offset coefficients

detectors no 8 & 16



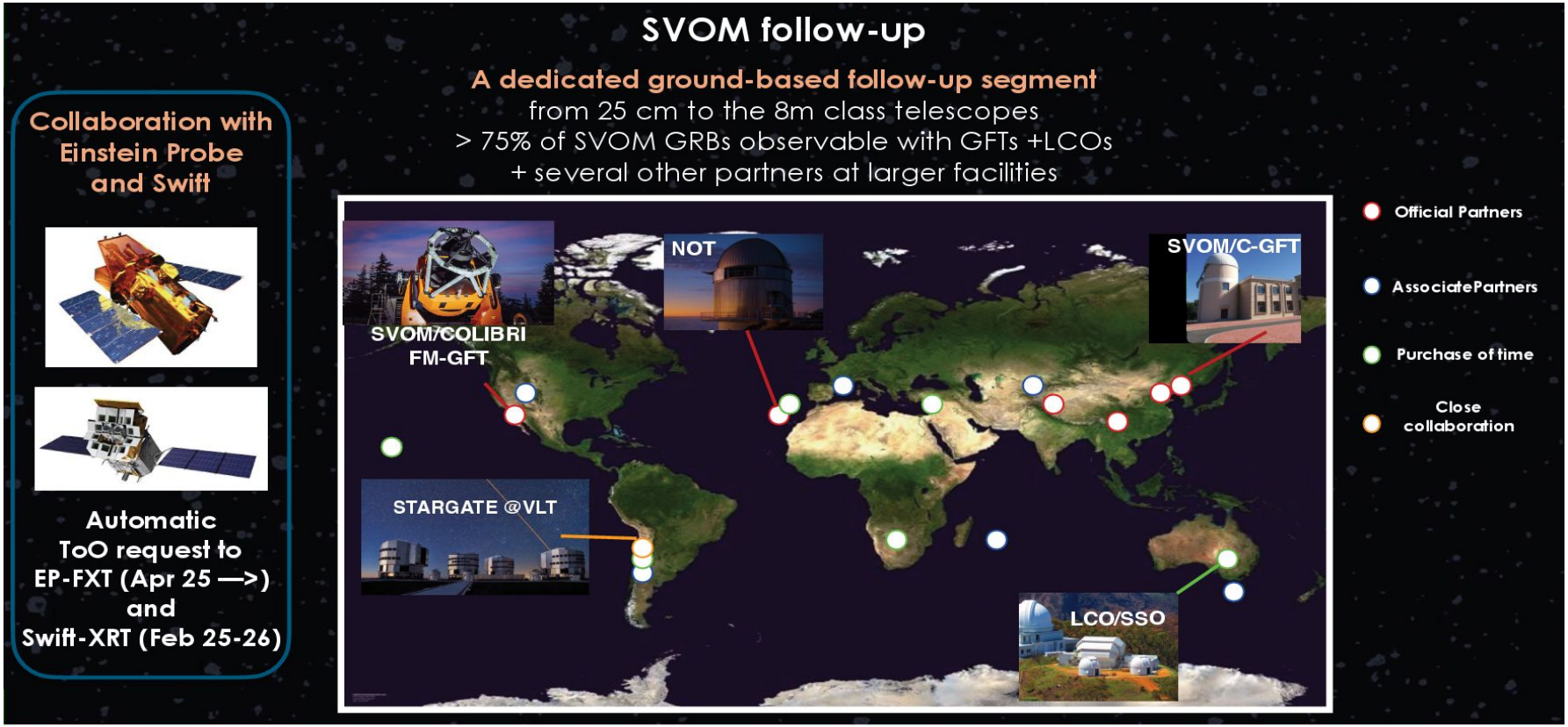
Calibration of the SBN – Ethr(keV) relationship with SBN, a number setting the low-E threshold

⇒ Building of the SBN table so that Ethr = 3.8 keV except for pixels 8 & 16 with Ethr = 7 keV to mitigate cross-talk effects (6 % of the 6400 pixels)

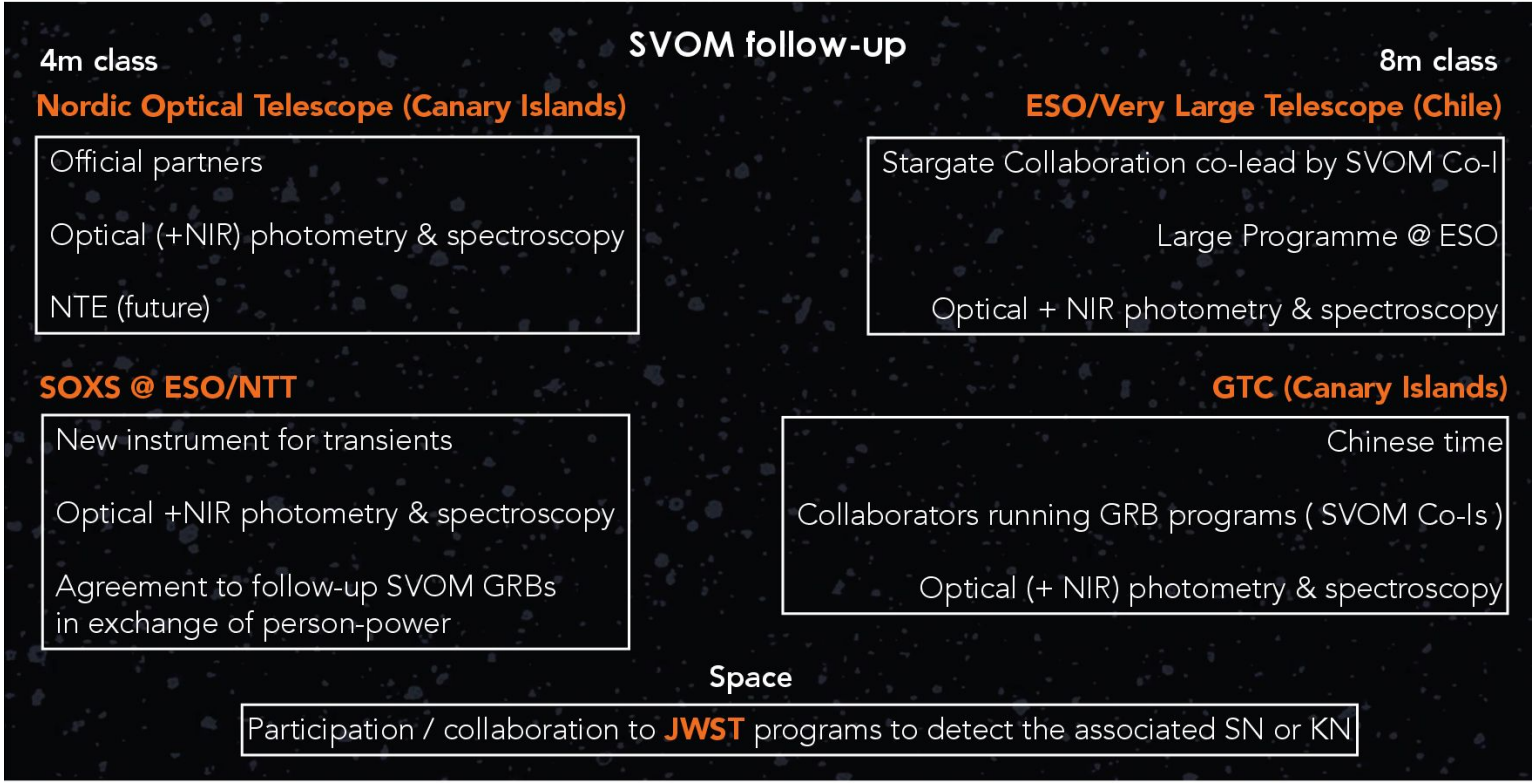
⇒ Very good homogeneity of the SBN values

⇒ Very precise setting of the low-energy threshold!

⇒ Only 7 dead pixels (SBN=63) over 6400 detectors



+ Nordic Optical Telescope (Canary Islands) - **ESO/Very Large Telescope (Chile) - SOXS @ ESO/NTT - GTC (Canary Islands) - ….**


SVOM follow-up
4m class
Nordic Optical Telescope (Canary Islands)
Official partners
Optical (+NIR) photometry & spectroscopy
NTE (future)
8m class
ESO/Very Large Telescope (Chile)
Stargate Collaboration co-lead by SVOM Co-I
Large Programme @ ESO
Optical + NIR photometry & spectroscopy
SOXS @ ESO/NTT
New instrument for transients
Optical +NIR photometry & spectroscopy
Agreement to follow-up SVOM GRBs
in exchange of person-power
GTC (Canary Islands)
Chinese time
Collaborators running GRB programs (SVOM Co-Is)
Optical (+ NIR) photometry & spectroscopy
Space
Participation / collaboration to JWST programs to detect the associated SN or KN