# **Time-domain Astronomy** with SVOM



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on behalf of the SVOM consortium

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#### The "Space-based multi-band astronomical Variable Objects Monitor" (SVOM) has been launched on June 22, 2024 at 7:00 UT from the Xichang base (China)



- Launch announced successful
- Everything working nominal
- Currently in commissioning phase



# The SVOM consortium

### China (PI J.Wei)

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

### Mexico



- UNAM (Colibrì)

### 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

### UK



- University of Leicester (MXT)

#### Germany

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





# The SVOM mission in a nutshell





# The Core program



Frigger and locate GRBs, alerts distributed in nearly real-time

Rapid alert dissemination and optimal attitude law for ground-based followup to favor redshift measurement for a large fraction of GRBs

Synergy among 7 instruments in space and on ground for a complete monitoring of GRBs and high-energy transients over 7 decades in energy and from the trigger up to the late afterglow

# **Orbit, pointing strategy and alerts dissemination**

- Low Earth orbit (625 km, 96 min), 30° inclination
- Nearly anti-solar pointing
- Avoidance of the galactic plane and bright sources as Sco X-1
- Alerts transmitted to a network of 40 antennas. Goal: 65% of alerts within 30s
  - ➡Favorable conditions for early follow-up from other facilities, especially large ground-based telescopes for redshift measurement (2/3 of cases)
  - ➡Earth in the fov: 65% duty cycle for ECLAIRs, 50% for MXT and VT





**ECLAIRs 1 yr exposure map:** 

- $\cdot\,$  4 Ms on the galactic poles
- 500 ks on the galactic plane



MXT and VT pointings (1yr scenario, including 65 GRBs and 1 ToO/day)



# The GRB prompt emission

#### **ECLAIRs:**

#### • 4-120 keV

- Fov ~ 2 sr
- Loc. < 12'
- 42-80 GRBs/yr, including 3-4 GRBs/yr at z>5

# GWAC:

- 2x5400 deg<sup>2</sup> (half of ECLAIRs fov)
- 500-800 nm
- m<sub>lim</sub> ~ 16-17 (10s exposure)
- ECLAIRs+GRM measure the prompt spectrum over 3 decades in energy
- GWAC will add a constraint on the **associated prompt optical emission** in a good fraction of cases (16%).

#### GRM (3 GRDs):



- 15 keV 5 MeV
- Fov ~ 5.6 sr
- Loc. ~5-10 deg (3 GRDs)
- ~90 GRBs/yr
  - ECLAIRs sensitive to all classes of long GRBs
  - Sensitivity to short GRBs improved
     by combining ECLAIRs+GRM

# Simulation of the multi-component spectrum of GRB 100724B



<sup>(</sup>Bernardini et al., 2017)



(Wang et al., 2013)

# The SVOM GRB sample

A unique sample of **30-40 GRB/yr** with:

- prompt emission over 3 decades (+ optical flux/limit: 16%)
- X-ray and V/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 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

#### GRBs as cosmological probes of the early Universe

# **Exploring the Transient sky with SVOM**



#### **FoOs Program:**

- Search for X-ray and optical counterparts of external triggers
- Joint searches for counterparts of MM triggers, and validation of candidates at other wavelengths

#### General Program:

Multi-wavelength observations of transient or flaring sources:

- X-ray and optical monitoring of ULXs
- Discovery of **TDEs** by direct trigger with ECLAIRs or serendipitously in X-ray galaxy surveys
- Broad energy band monitoring of CVs and XRBs + outburst detectable with ECLAIRs and GRM
- Discovery and spectral characterization of magnetar giant flares and short bursts

# **Multi-messenger astronomy with SVOM**



Ducoin et al., 2020, 2023

#### Ideal scenario: detection of the sGRB

- ➡ ECLAIRs/GRM: large fov, independent trigger or offline search
- Likely scenario: external alert received
  ➡ MXT/VT: slew after the alert ToO-MM
  - ➡ Galaxy tiling strategy if the error box is larger than 1 deg<sup>2</sup>



### **SVOM as an open observatory**

The general program (GP): Observation proposals being awarded by a TAC (<u>a SVOM co-I</u> <u>needs to be part of your proposal</u>) for astrophysical targets, mostly compliant with the

ToO

ToO-NOM

ToO-EX

Latency Frequency

1-5/day

1/month

<48hrs

<12hrs

**Duration** 

1 orbit or more

7-14 orbits

~14 orbits

satellite attitude law (form 10% to 50% of time can be spent on low galactic latitude sources). It can include ToOs. GO program not implemented for the first year.

#### Target of Opportunity (ToO) program:

- ToO-NOM nominal ToO which covers the basic needs for efficient transient follow-up alerts (GRB revisit, known source flaring, new transient).
- **ToO-EX** exceptional ToO which covers the needs for a fast ToO-NOM in case of an exceptional astrophysical event we want to observe rapidly.
- **ToO-MM** ToO-EX dedicated to EM counterpart search in response to a multimessenger alert (unknown position, tiling of large portion of the sky).



### SVOM GRB sample (updated to October 16th)

- 42 validated GRB triggers (34 GRM, 4 ECLAIRs, 4 ECLAIRs+GRM)
  - 34 LGRBs, 3 SGRBs, 2 SGRBs+EE, 3 XRFs/XRRs
  - 5 GRBs with redshift (3 GRM, 1 ECL, 1 ECL+GRM)
  - 15 GRB afterglow detections
- 31/42 also seen by other space missions/instruments:
  - 22 by Fermi/GBM and 2 by Fermi/LAT
  - 3 by GECAM
  - 3 by EP/WXT
  - 5 by Swift/BAT



### ECLAIRs GRBs with afterglows (updated to October 16th)



Credits D.Turpin

### **GRM GRBs with afterglows (updated to October 16th)**



# **GRB 241018A:** the first complete automatic sequence of observations from space!

### GCN Circular 37812

Subject	GRB 241018A: Detection of a bright long GRB by SVOM
Date	2024-10-18T12:52:26Z (4 days ago)
From	Jean-Luc Atteia at IRAP <jean-luc.atteia@irap.omp.eu></jean-luc.atteia@irap.omp.eu>
Via	Web form

During the commissioning phase, the SVOM/ECLAIRs telescope triggered and located a bright long burst GRB 241018A (sb24101802) at 2024–10–18T11:54:34 UT (T0).

# **GRB 241018A: the first complete automatic sequence of observations from space!**

#### GCN Circular 37812

Subject GRB 241018A: Detection of a bright long GRB by SVOM

#### GCN Circular 37831

SubjectGRB 241018A: SVOM/GRM observationDate2024-10-20T16:26:45Z (2 days ago)

From zhengchao astro@foxmail.com

During the commissioning phase, the SVOM/GRM was triggered in-flight by GRB 241018A (SVOM trigger reference: sb24101802) at 2024–10–18T11:54:37.500 UT (T0), which also triggered SVOM/ECLAIRs (Atteia et al., GCN <u>37812</u>).

**GRB 241018A: the first complete automatic sequence of observations from space!** GRB 241018A seen by GRM



**GRB 241018A: the first complete automatic sequence of observations from space!** GRB 241018A seen by GRM

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SubjectGRB 241018A: SVOM/GRM observationDate2024-10-20T16:26:45Z (2 days ago)Fromzhengchao astro@foxmail.com

### GCN Circular 37814

Subject	GRB 241018A: X-ray afterglow candidate observed by MXT
Date	2024-10-18T16:00:16Z (4 days ago)
From	Damien Turpin at CEA-Saclay <dturpin-astro@hotmail.com></dturpin-astro@hotmail.com>
Via	Web form

MXT started to observe the field of GRB 241018A (Atteia et al., GCN 37812) at 11:58:18 UT in an

A source is detected at RA= 67.9693 Dec = 42.997 with a 90% c.l. error of 41.7 arcsec before VT bias correction to which we recommend adding 1.5 arcminutes of systematic uncertainty in quadrature. The light curve looks flat on 1900 s and the spectrum is hard with photon index = 0.85 +/- 0.1, at low absorption (NH < 1e20 cm-2). Further results will be given once the full telemetry is received and analyzed.



**GRB 241018A: the first complete automatic sequence of observations from space!** GRB 241018A seen by GRM

### GCN Circular 37812

Subject GRB 241018A: Detection of a bright long GRB by SVOM

### GCN Circular 37831

SubjectGRB 241018A: SVOM/GRM observationDate2024-10-20T16:26:45Z (2 days ago)Fromzhengchao\_astro@foxmail.com

### GCN Circular 37814

SubjectGRB 241018A: X-ray afterglow candidate observed by MXTDate2024-10-18T16:00:16Z (4 days ago)

### GCN Circular 37819

SubjectGRB 241018A: SVOM/VT follow-up and optical candidateDate2024-10-18T19:43:45Z (4 days ago)FromLiping Xin at NAOC, SVOM <xlp@nao.cas.cn>ViaWeb form



VT started to observe the field of GRB 241018A triggered by SVOM/Eclairs(Atteia et al., GCN <u>37812</u>) in an automatic way after the slew of the satellite. The VT conducted observations simultaneously in two channels: VT\_B (400nm-650nm) and VT\_R (650nm-1000nm).

With the VHF data started at 2024–10–18T12:00:28 UT, in which the cataloged source brighter than 21 mag is completed relative to the PS1 catalog. An uncatalogued source was found within the errorbox of Eclairs and has an angular distance of 1.8509 arcmin from the position of MXT (Maggi et al., 37814).

GRB 241018A: the first complete automatic sequence of GRB 241018A seen by GRM observations from space!

### GCN Circular 37812

GRB 241018A: Detection of a bright long GRB by SVOM Subject

### GCN Circular 37831

Subject GRB 241018A: SVOM/GRM observation 2024-10-20T16:26:45Z (2 days ago) Date zhengchao astro@foxmail.com From

### GCN Circular 37814

Subject GRB 241018A: X-ray afterglow candidate observed by MXT 2024-10-18T16:00:16Z (4 days ago) Date

### **GCN Circular 37819**

Subject GRB 241018A: SVOM/VT follow-up and optical candidate 2024-10-18T19:43:45Z (4 days ago) Date From

- Liping Xin at NAOC, SVOM <xlp@nao.cas.cn>
- Web form Via

+ Konus-Wind, Swift/XRT, optical ground based telescopes



- Other non-GRB triggers (mostly galactic X-ray binaries):
  - Outburst from HMXB XTE J1946+274 (Atel 16719) + MAXI
  - 2 bursts from SGR 1E 1841-045 (GCN 37297) + Swift, Fermi, GECAM
  - Spectral transition of Aql X-1 (Atel 16843)



Credits D.Turpin

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Thanks to the EP and Swift teams and ground-based facilities for the follow-up!!

#### **SVOM GRB** sample:

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- 34 LGRBs, 3 SGRBs, 2 SGRBs+EE, 3 XRFs/XRRs
- 5 GRBs with redshift (3 GRM, 1 ECL, 1 ECL+GRM)
- 15 GRB afterglow detections

#### +1 LGRB with the full sequence (ECLGRM+MXT+VT)

