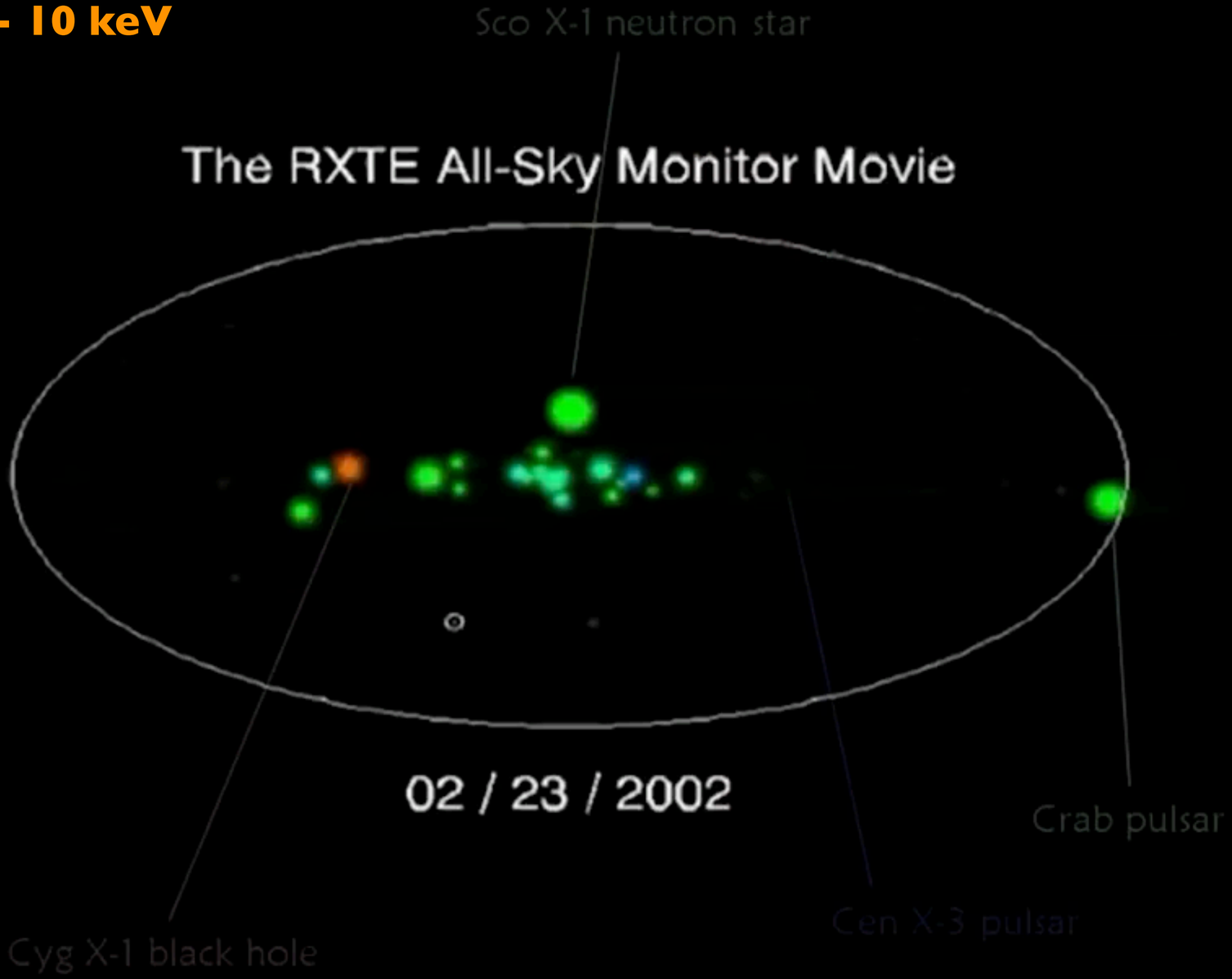
Exploring the transient sky with SVOM

Alexis Coleiro
APC - Université Paris Cité

March 30, 2026 | LPNHE

2 - 10 keV



RXTE / DA Smith et al.

- **Galactic / extragalactic transients**
- **Different timescales and energies**
- **Related to compact objects (black holes or neutron stars)**
- **Requires:**
  - wide field-of-view instruments
  - dedicated observing strategies
  - multi-wavelength/multi-messenger follow-up

The SVOM consortium

CNSA & CNES-led mission

- **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

https://fsc.svom.org/home/collaboration/collaborators

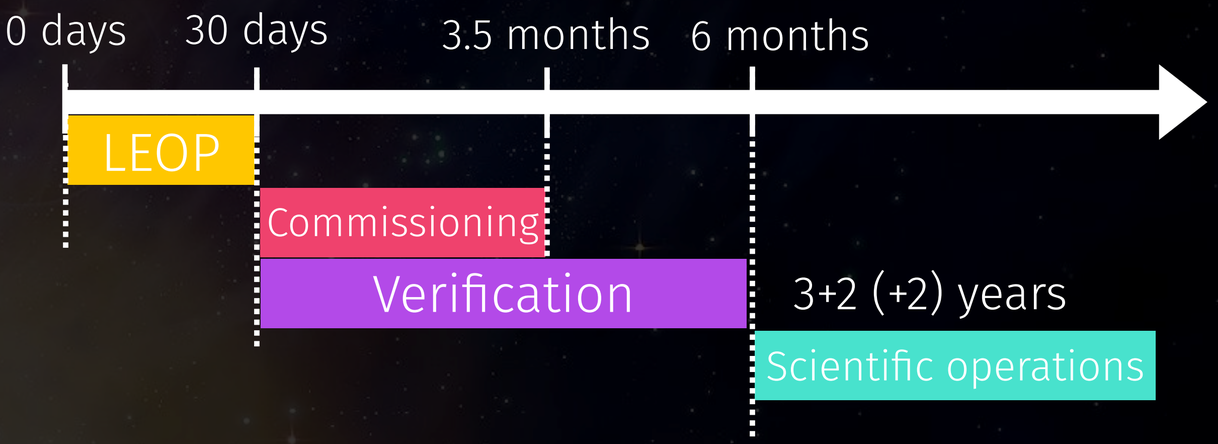
- **France (PI B. Cordier)**
  - CNES Toulouse
  - APC Paris
  - CEA Saclay
  - CPPM Marseille
  - LUX Meudon
  - IAP Paris
  - IRAP Toulouse
  - IJCLab Orsay
  - LAM Marseille
  - LUPM Montpellier
  - OAS Strasbourg
- **UK** University of Leicester
- **Germany**
  - MPE Garching
  - IAAT Tübingen

SVOM launch

China/France collaboration

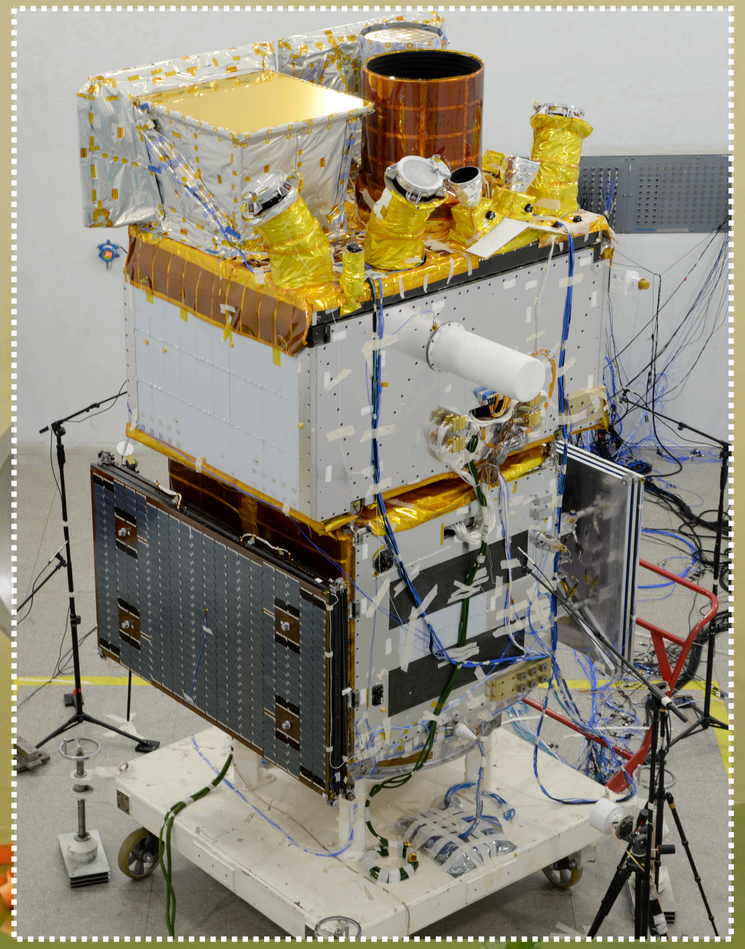
Launched on *June 22, 2024*

from the Xichang Space Center



The SVOM mission

Satellite: 930 kg
Payload: 450 kg



The SVOM mission

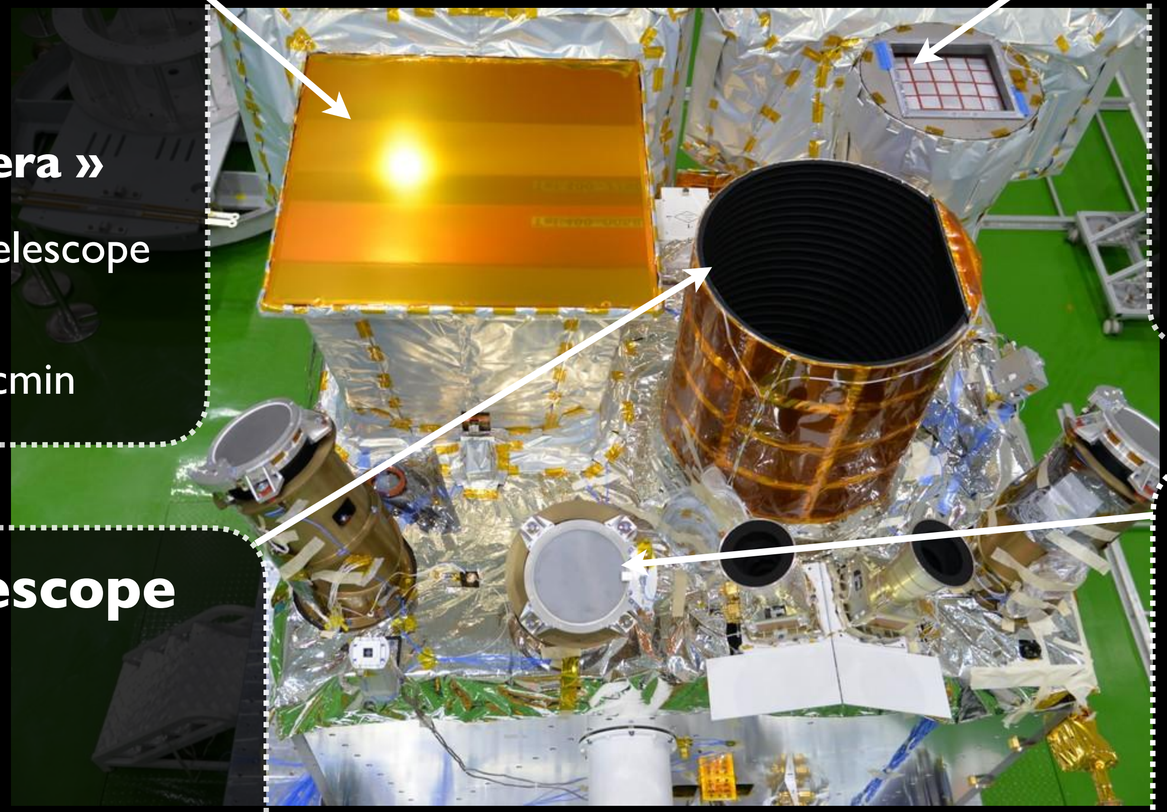
ECLAIRs

« The trigger camera »

Wide-field X and γ rays telescope

4 - 150 keV

Loc. accuracy: < 12 arcmin



MXT

Microchannel X-ray telescope

Narrow-field X-ray telescope

0.3 - 10 keV

Loc. accuracy: < 1 arcmin

The Visible Telescope

Blue and red channels

Loc. accuracy: < 1 arcsec

GRM

Gamma-ray Burst Monitor

Scintillator modules to extend spectral coverage of ECLAIRs

15 keV - 5 MeV

The SVOM mission

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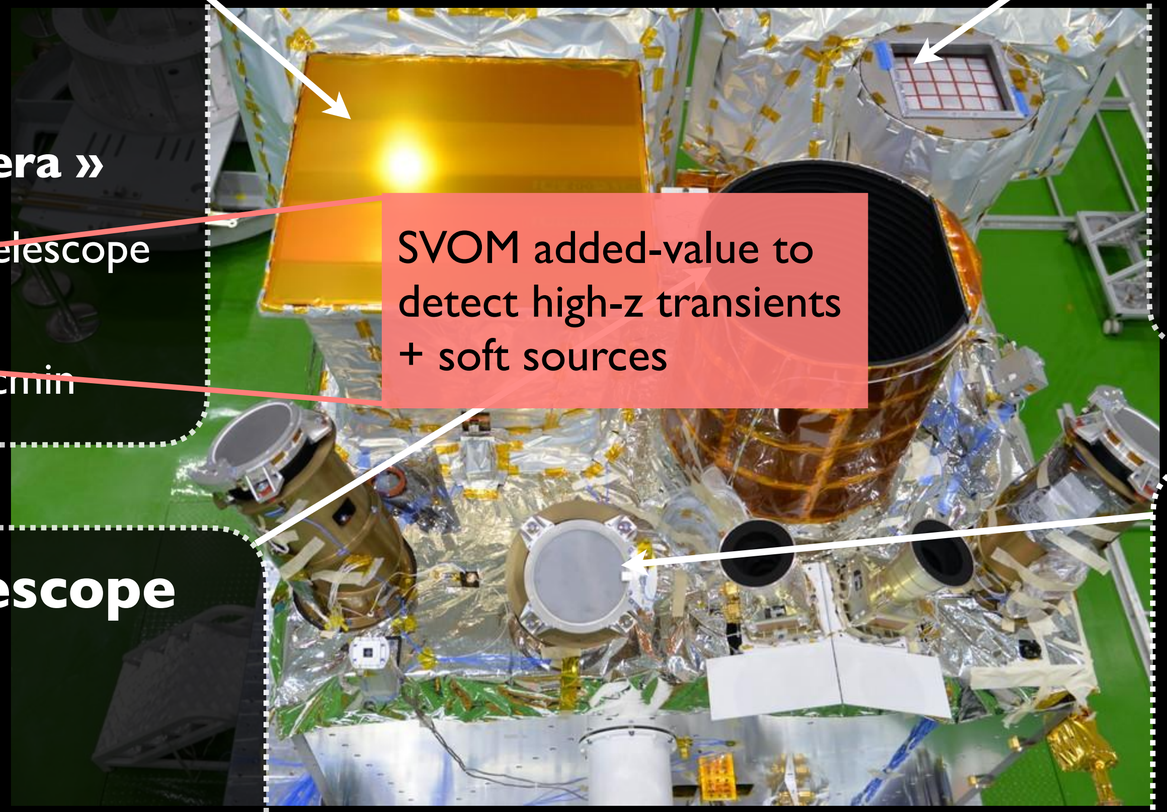

SVOM added-value to detect high-z transients + soft sources

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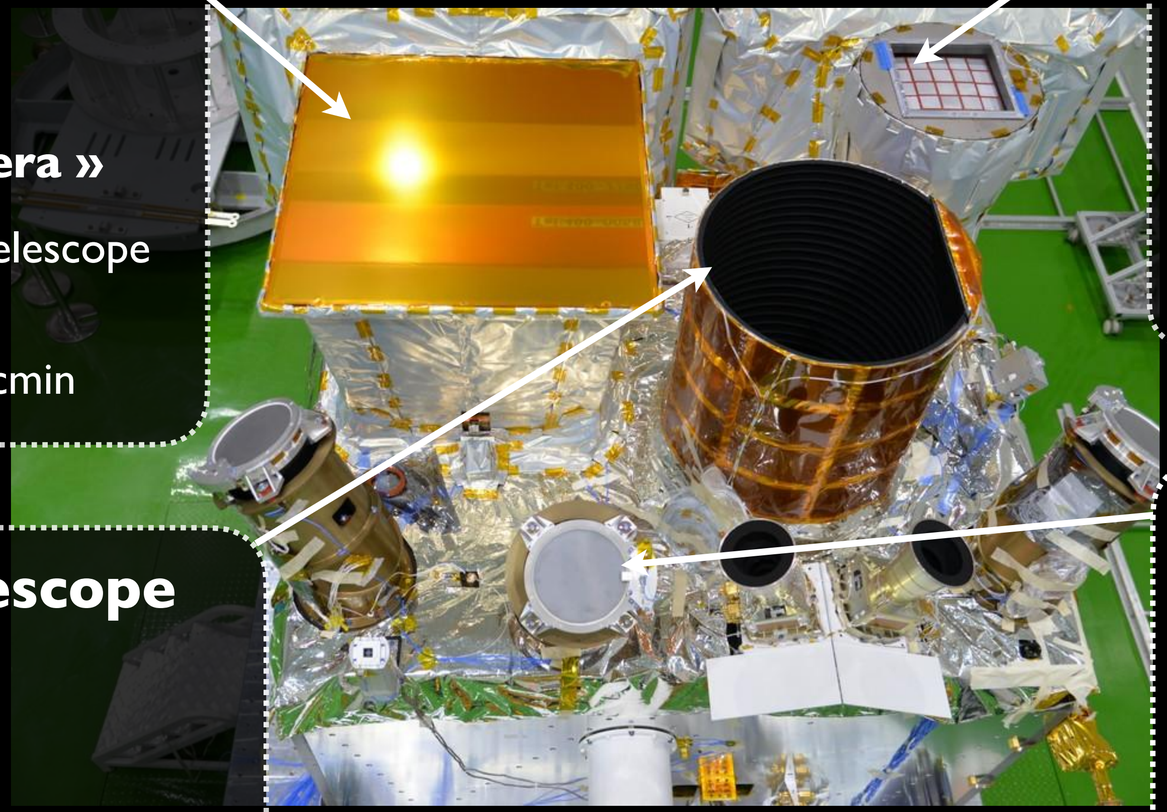

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15 keV - 5 MeV

Ground-based telescope network

Ground telescopes to ensure multi-wavelength follow-up

San Pedro Martir

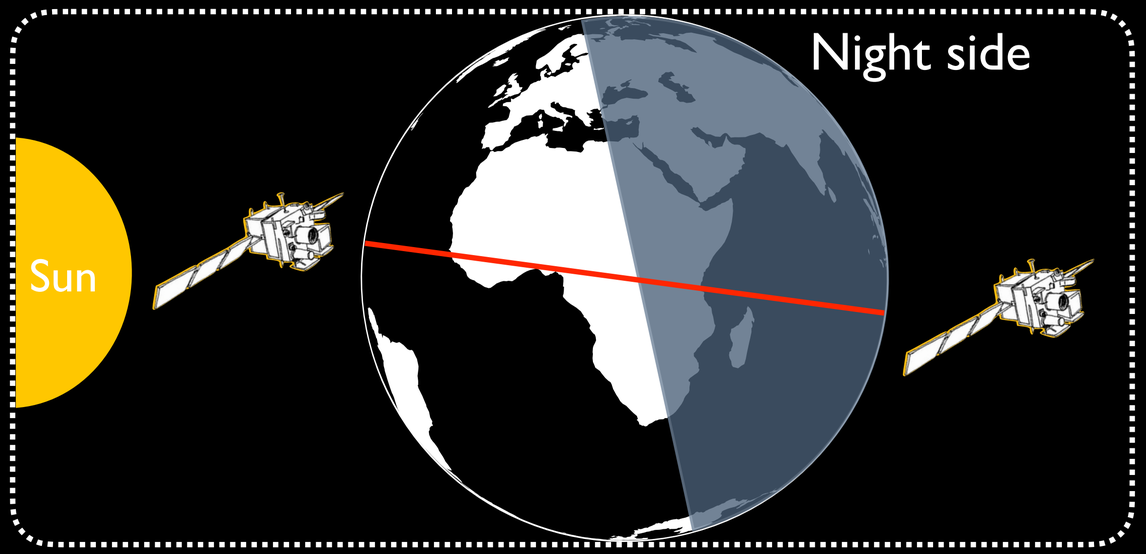
Jiling
Xinglong

Observing strategy

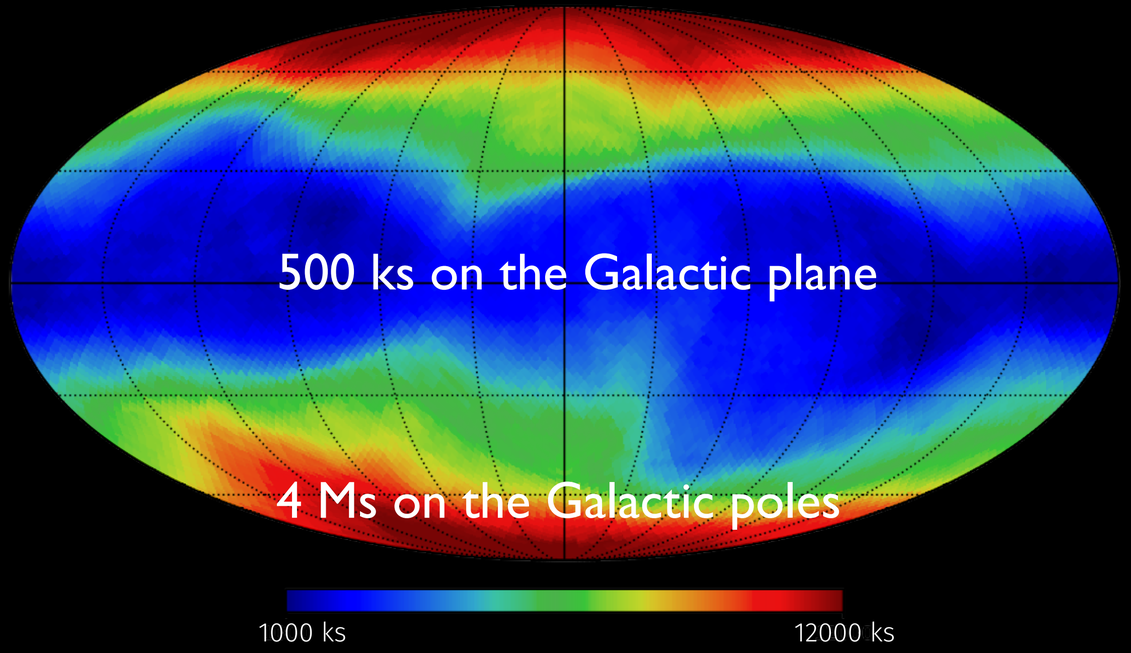
- Nearly anti-solar pointing (instruments point toward the night side of Earth)

  ⇒ Early follow-up from ground-based facilities

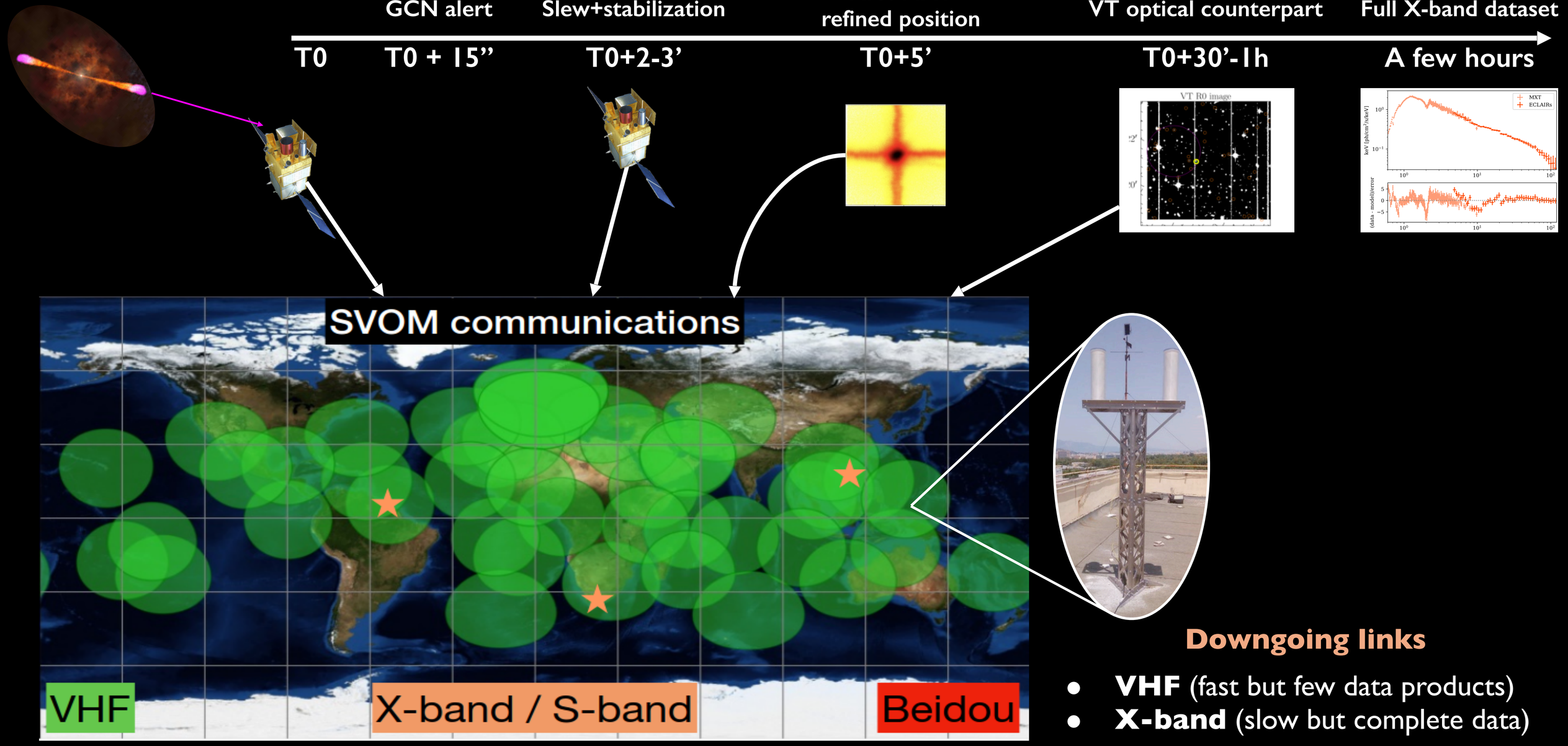
  ⇒ Earth in the FoV: 65% duty cycle for ECLAIRs, ~50% for MXT and VT
- Avoidance of the Galactic plane and bright sources as Sco X-1



ECLAIRs one year exposure map



A powerful transient detection and alerting machine

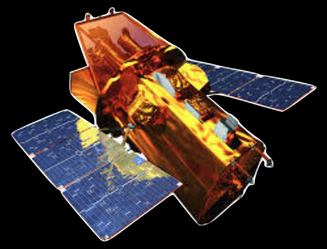


Downgoing links

- **VHF** (fast but few data products)
- **X-band** (slow but complete data)

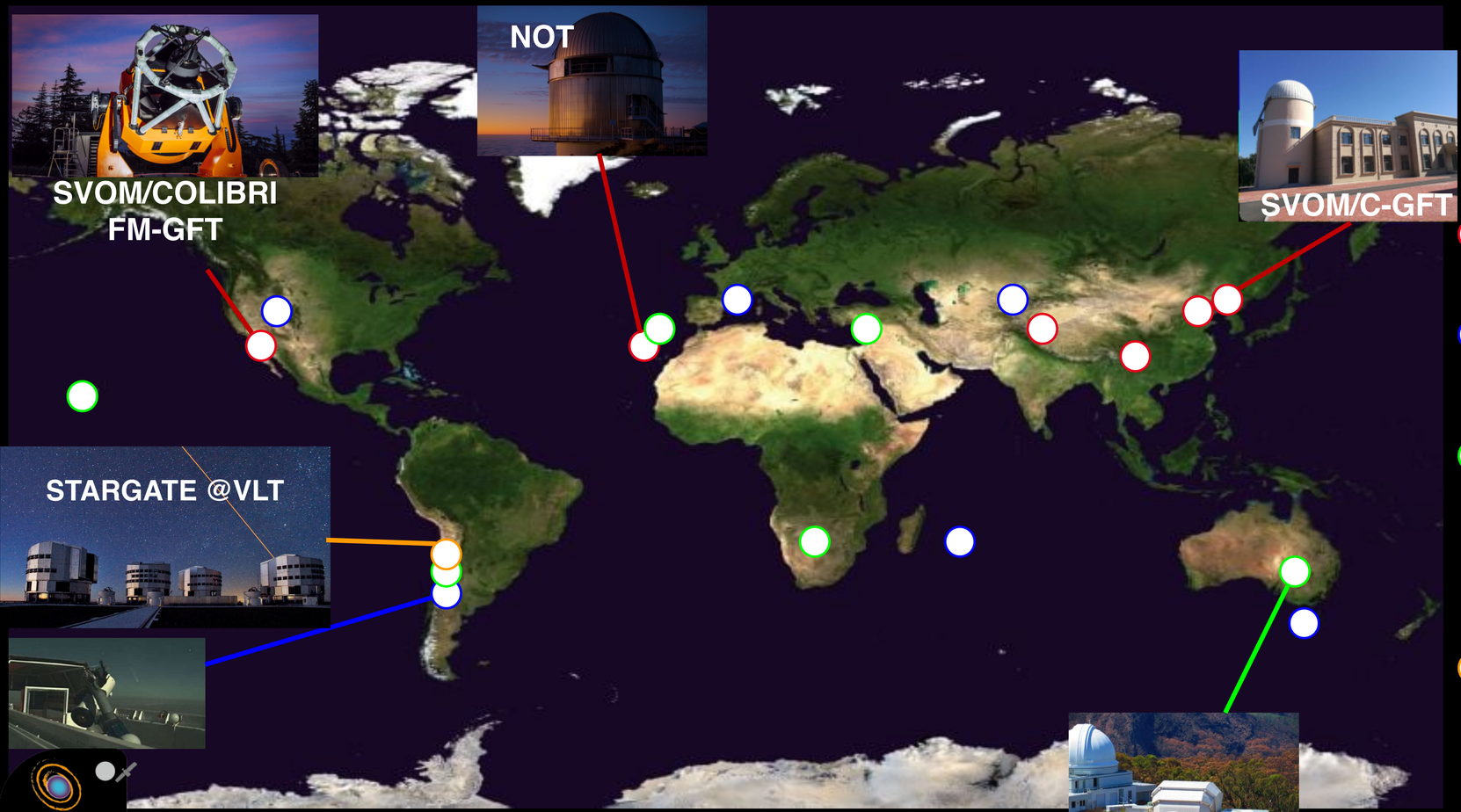
Space and ground-based telescope synergies

Strong synergies with Einstein Probe and Swift teams



Automatic ToO request to EP-FXT
(since April 2025)
and
Swift-XRT
(since Feb. 2025)

A dedicated ground-based follow-up segment
from 25 cm to the 8m class telescopes

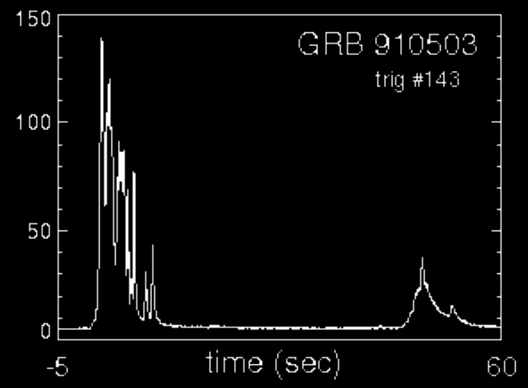


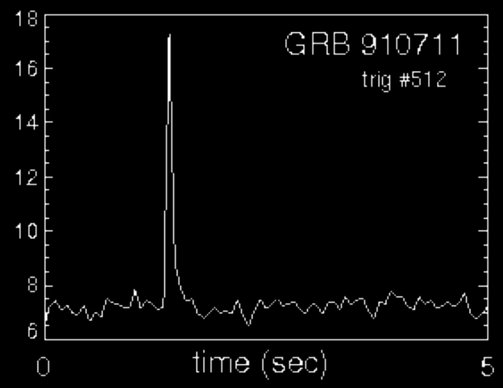
- Official Partners
- Associate Partners
- Purchase of time (LCOGT time coming 2025B)
- Close collaboration

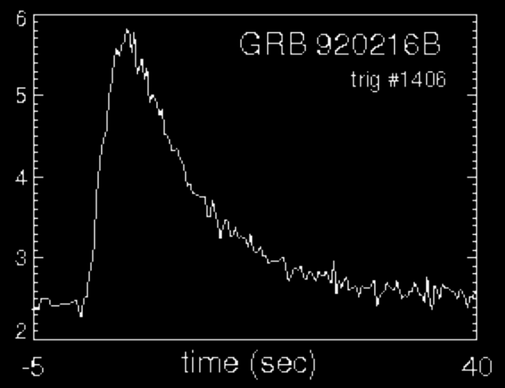
Scientific programs and selected results

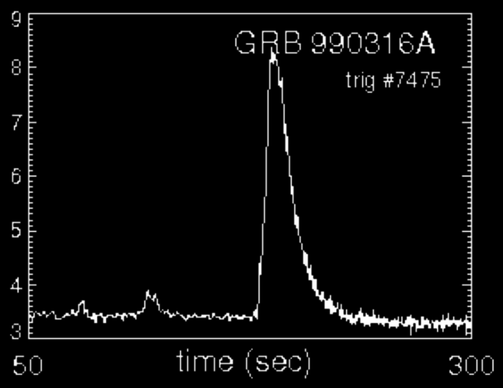
Gamma-ray burst science

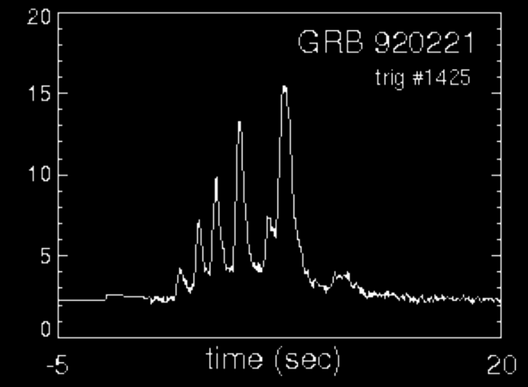
Gamma-ray bursts - prompt emission (10 keV - MeV)

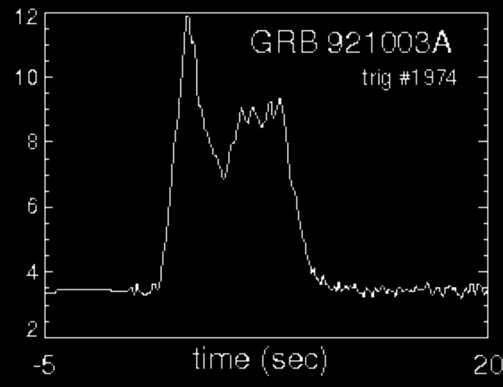


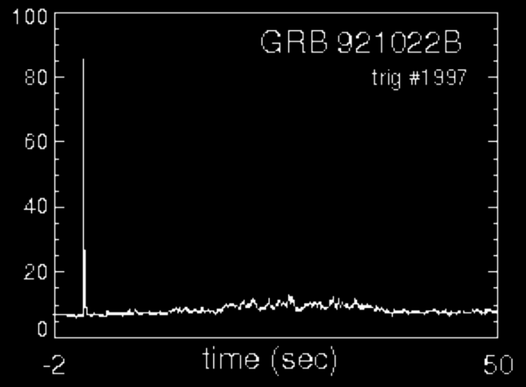


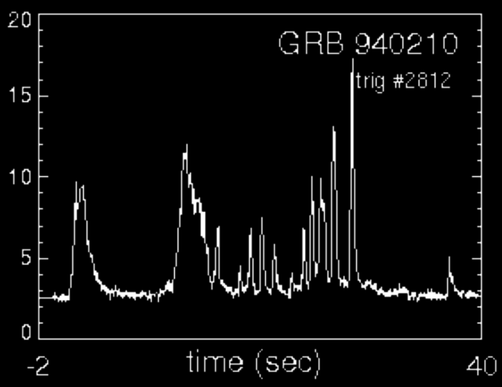


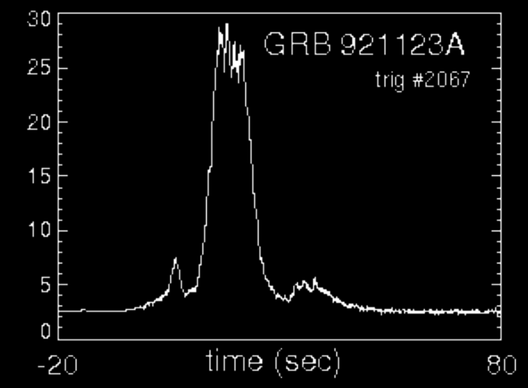


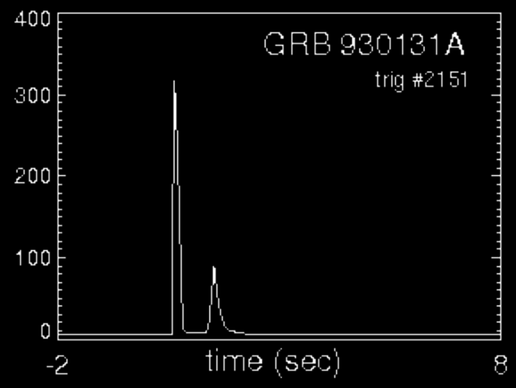


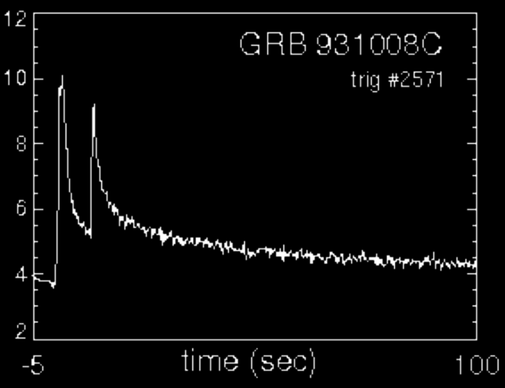


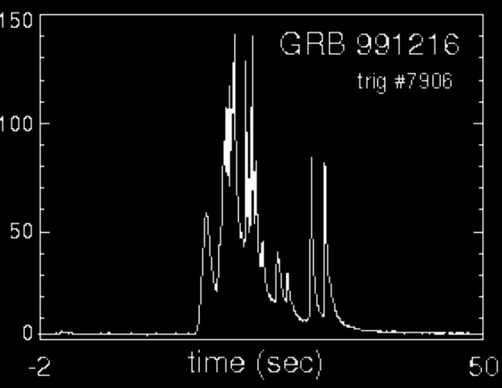




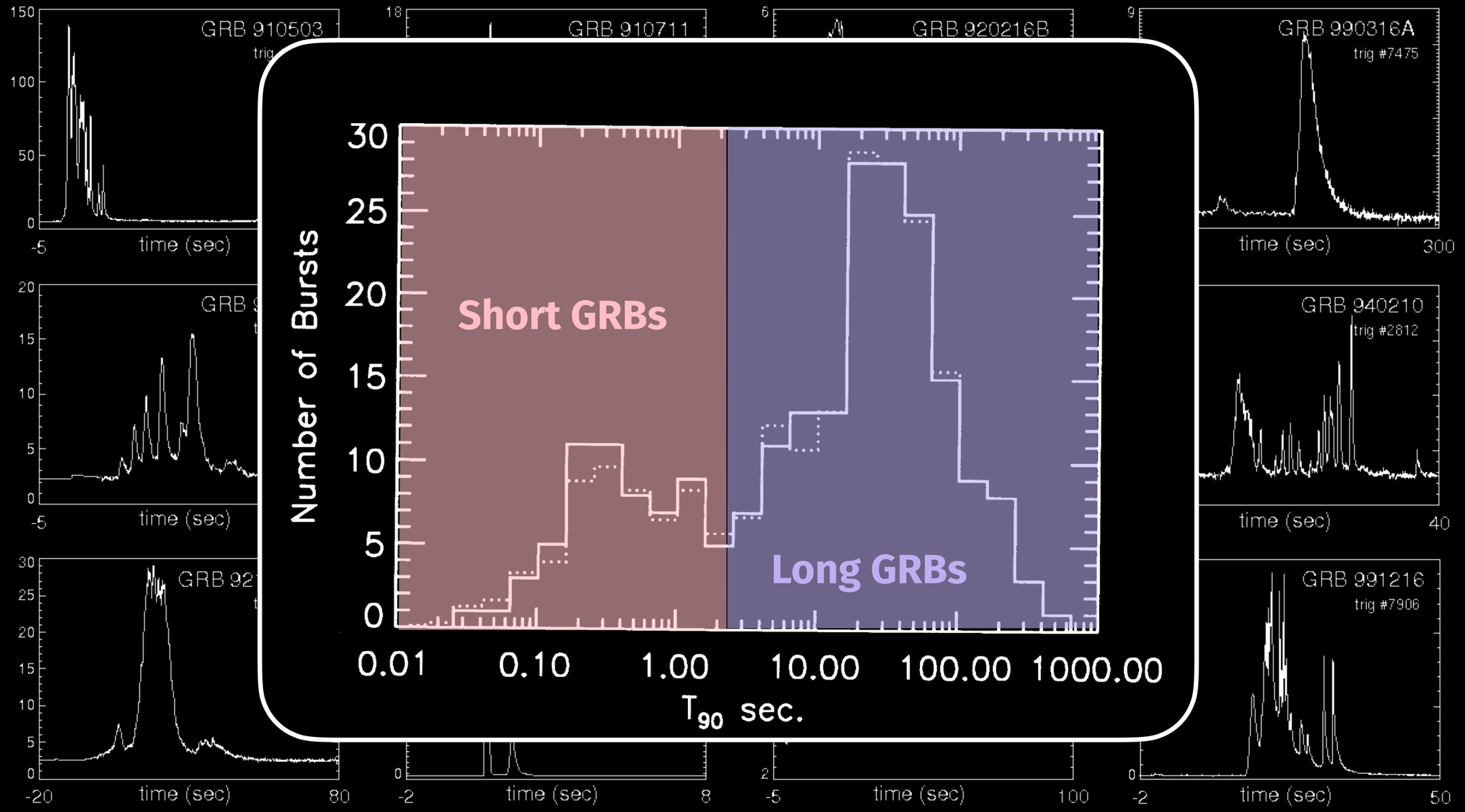








Gamma-ray bursts - prompt emission (10 keV - MeV)



Gamma-ray bursts - afterglow

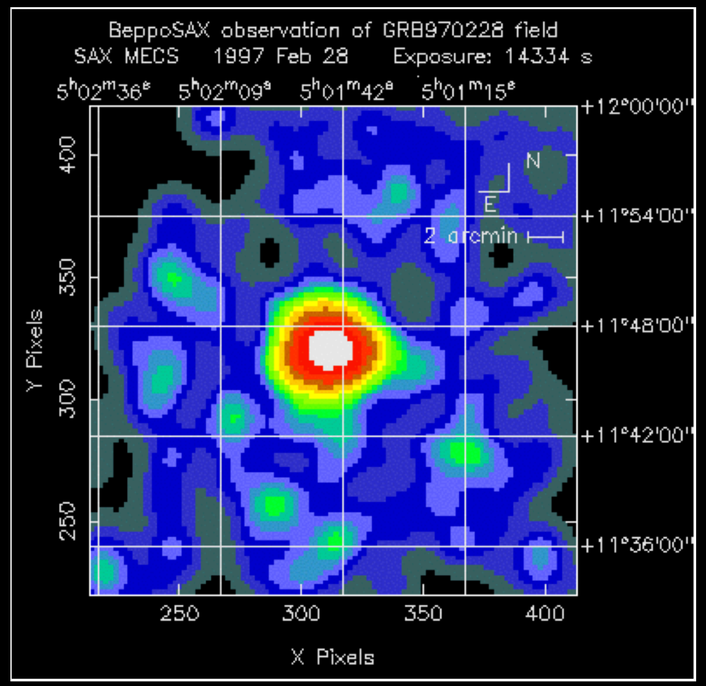
- From GeV to radio
- Power-law decay
- Duration hours to days

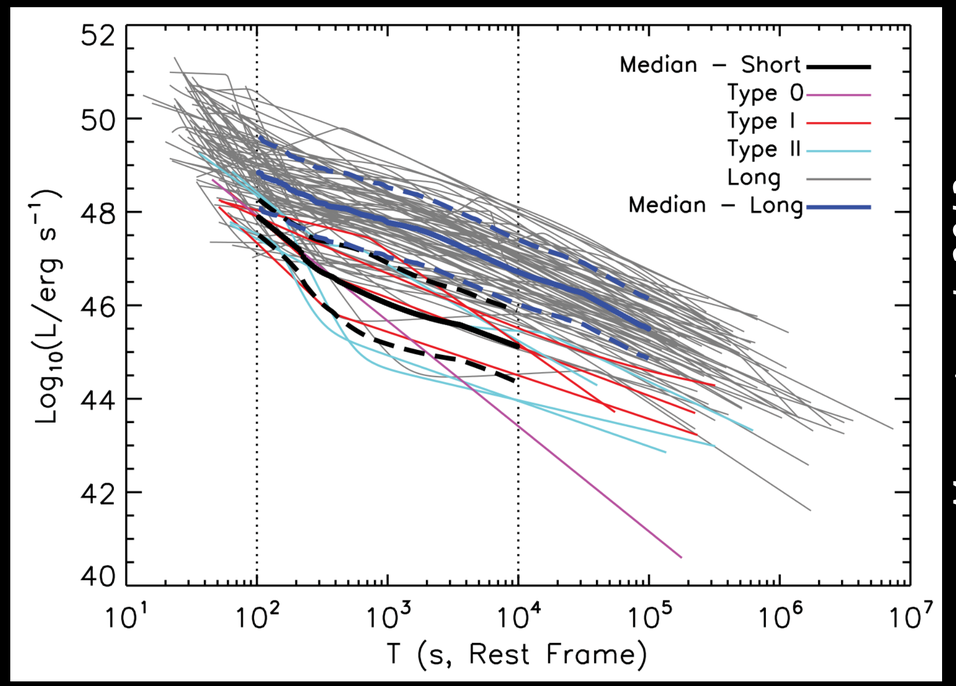
- **Long GRBs are distant:** $< z > = 2.1; z_{max} = 8.2$ (spectroscopically confirmed)

⇒ **Most powerful objects** in the Universe ($E_\gamma \sim 10^{52}$ erg)

- **Short GRBs are fainter** than long GRBs but similar when rescaling by total energy

BeppoSAX (1996): discovery of counterpart and localization of LGRBs

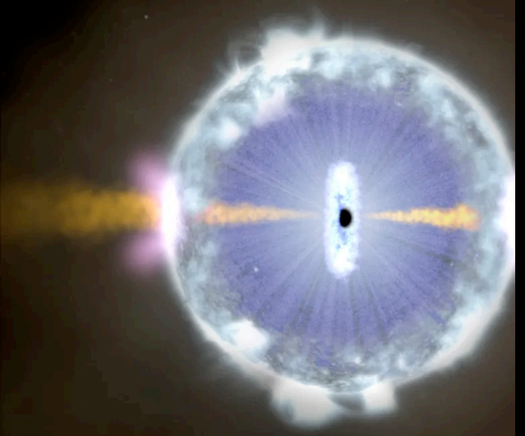




Margutti et al., 2013

⇒ **Long/short GRBs ⇒ similar physical mechanisms but arising from different progenitors**

GRBs - Proposed theoretical scenario

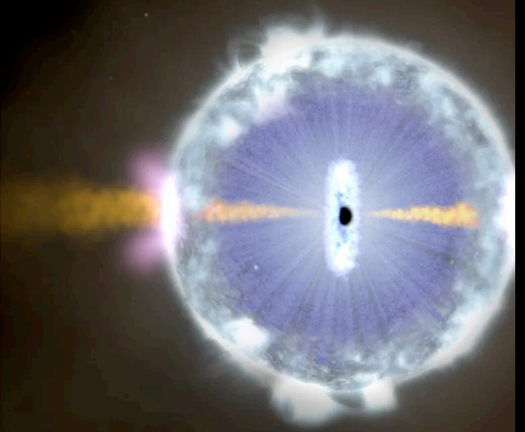


Central engine
(compact object)

Short variability timescale ⇒ central engine of small size

$$l \lesssim c\Delta t$$

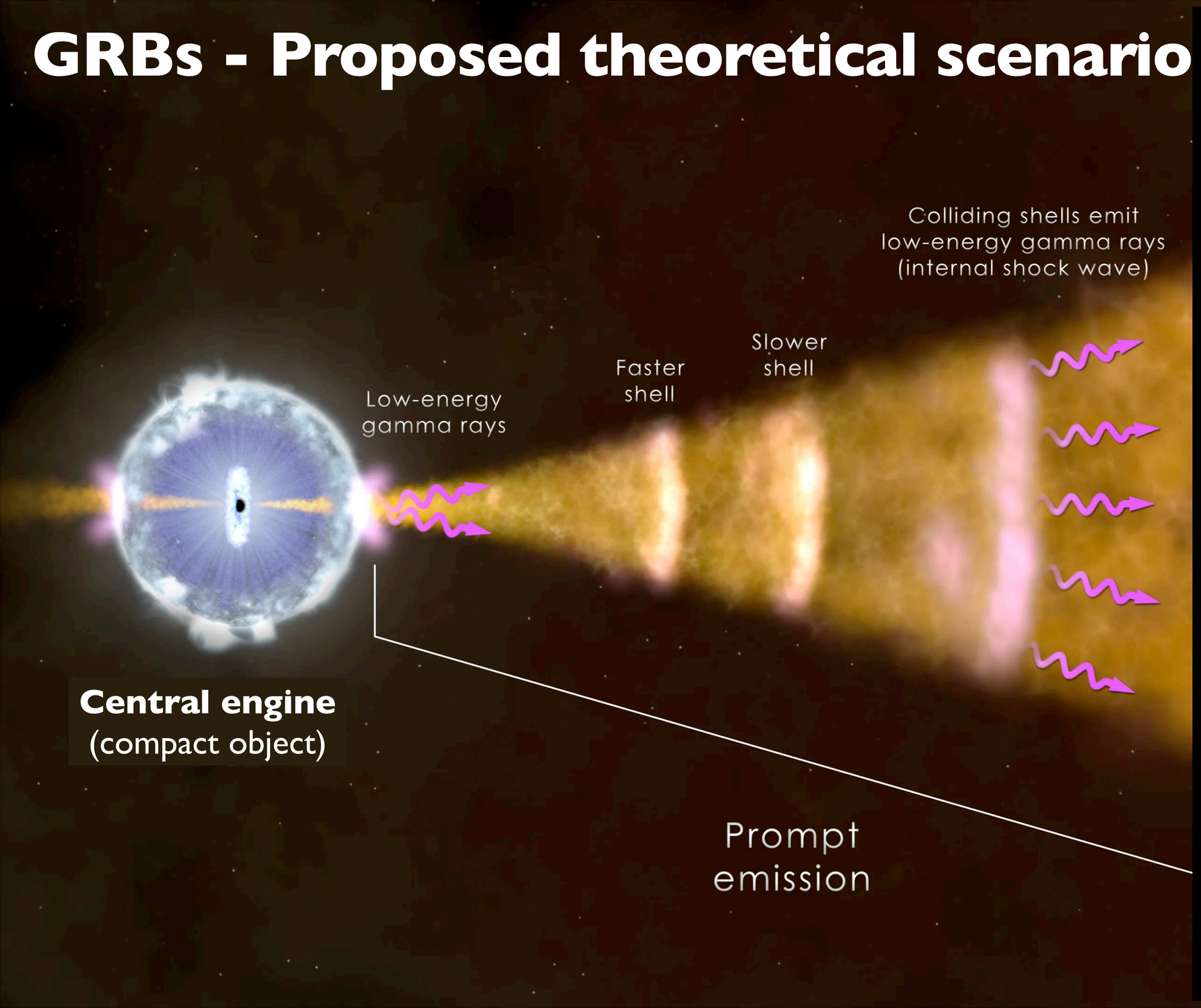
GRBs - Proposed theoretical scenario



Central engine
(compact object)

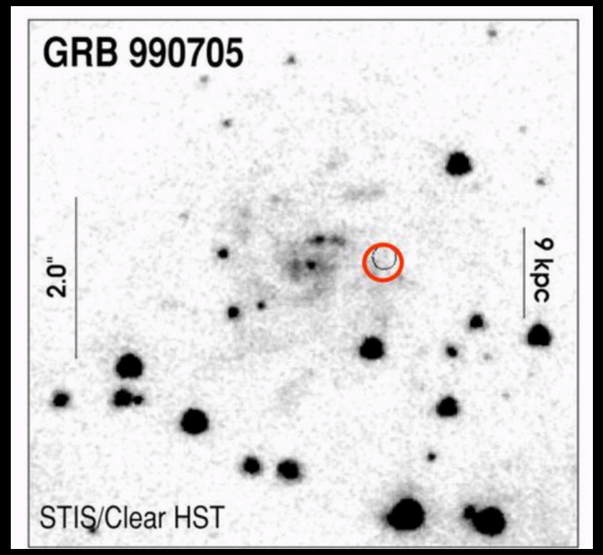
Ultra-relativistic & optically thick outflow

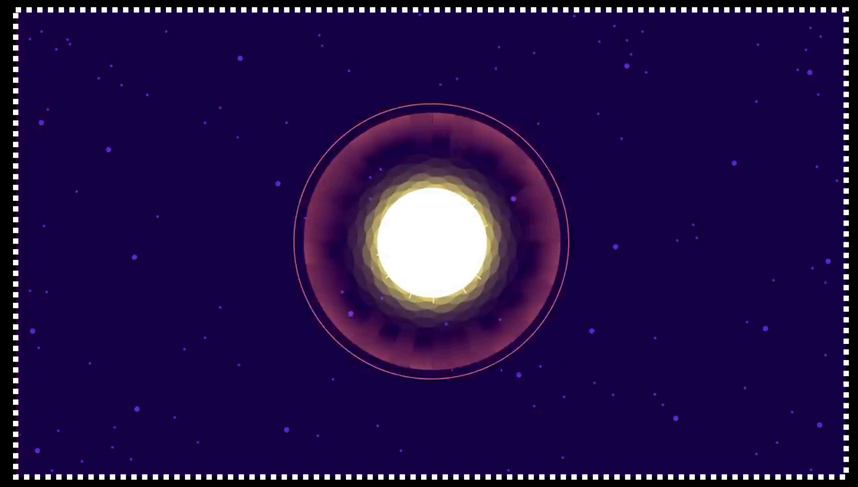
GRBs - Proposed theoretical scenario



GRBs - Proposed theoretical scenario

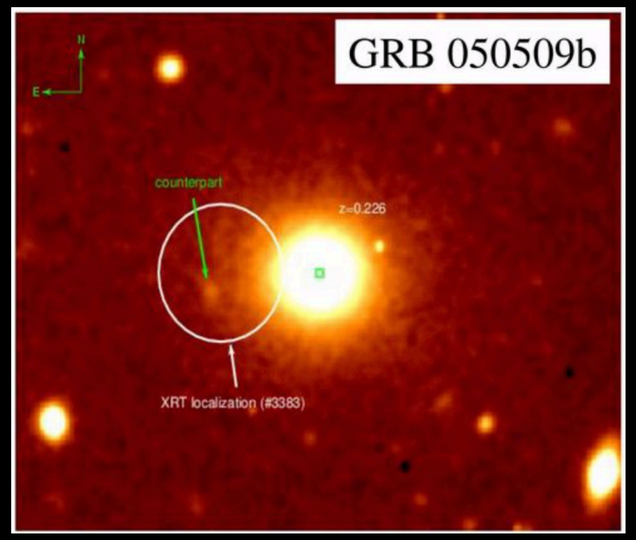
Long GRBs

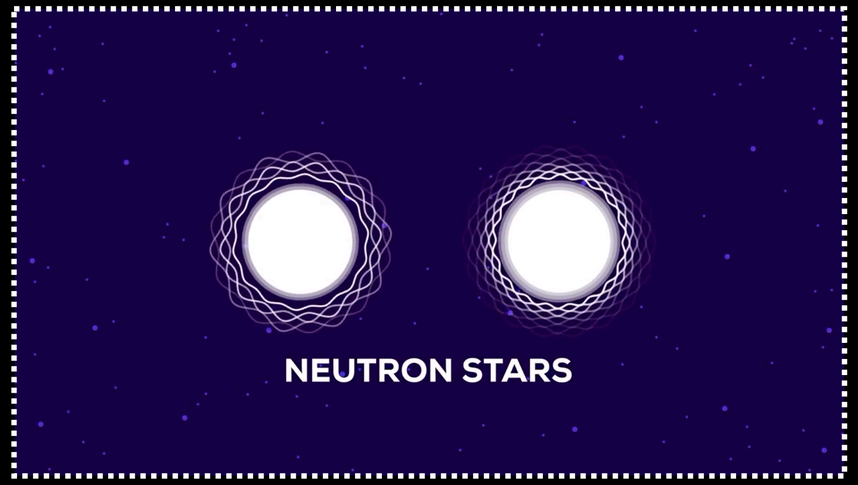




Connection between long GRB and CCSN confirmed

Short GRBs





GW170817: confirmation of the merger scenario

GRBs - Open questions

- What powers the central engine: black hole vs magnetar ?

- Prompt emission radiation mechanisms: synchrotron, thermal, … ?

- Particle acceleration mechanisms: internal shocks, magnetic reconnections, hadronic processes ?

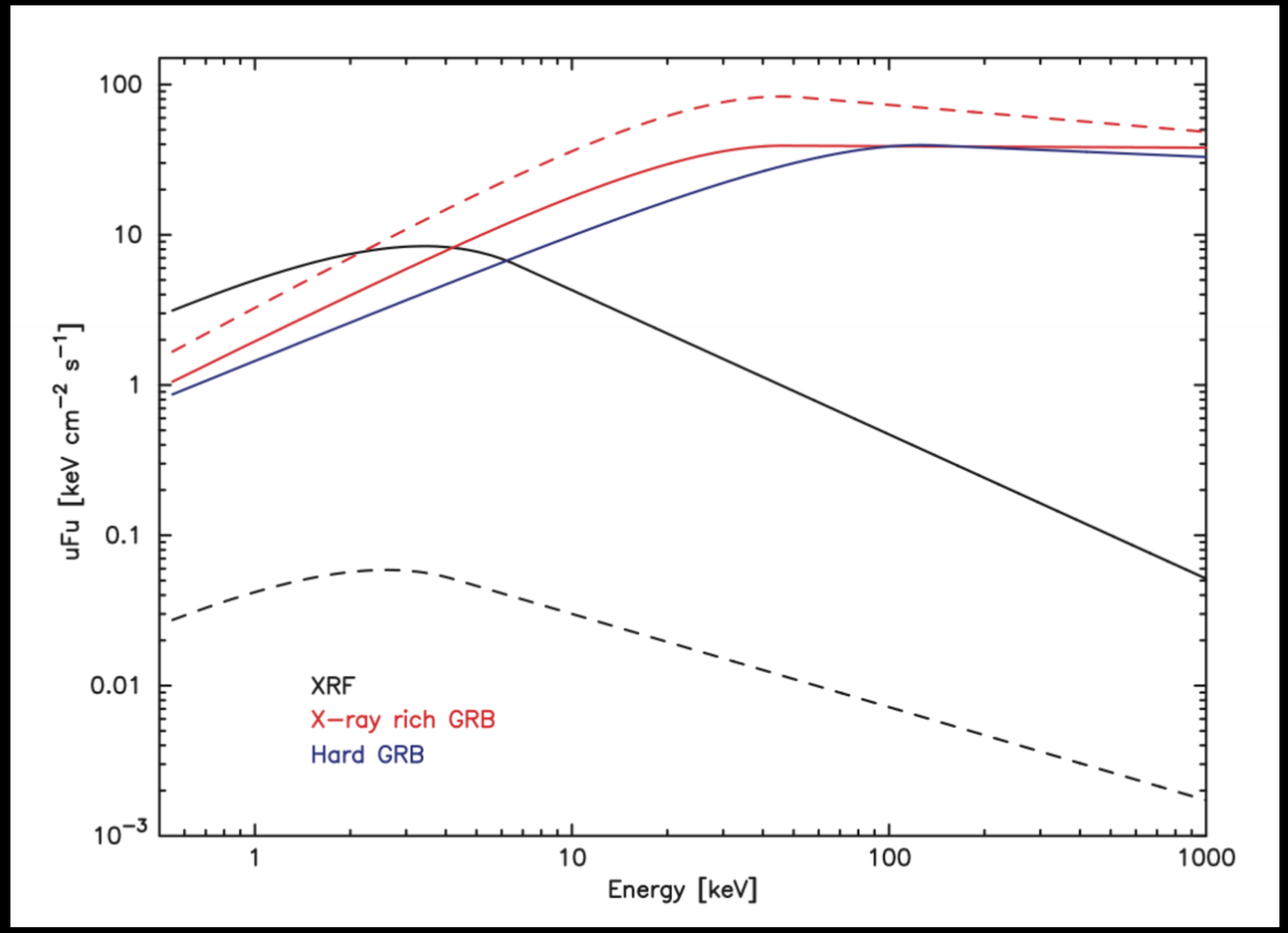
GRBs - Open questions

- **Study GRBs in the early Universe**

  First population of stars / Did the first stars produce GRBs / Can GRB probe reionization ?

- **Origin of the X-ray flashes**

  Softer events characterized by lower Epeak and smaller energy output than standard GRBs (Sakamoto et al., 2005)

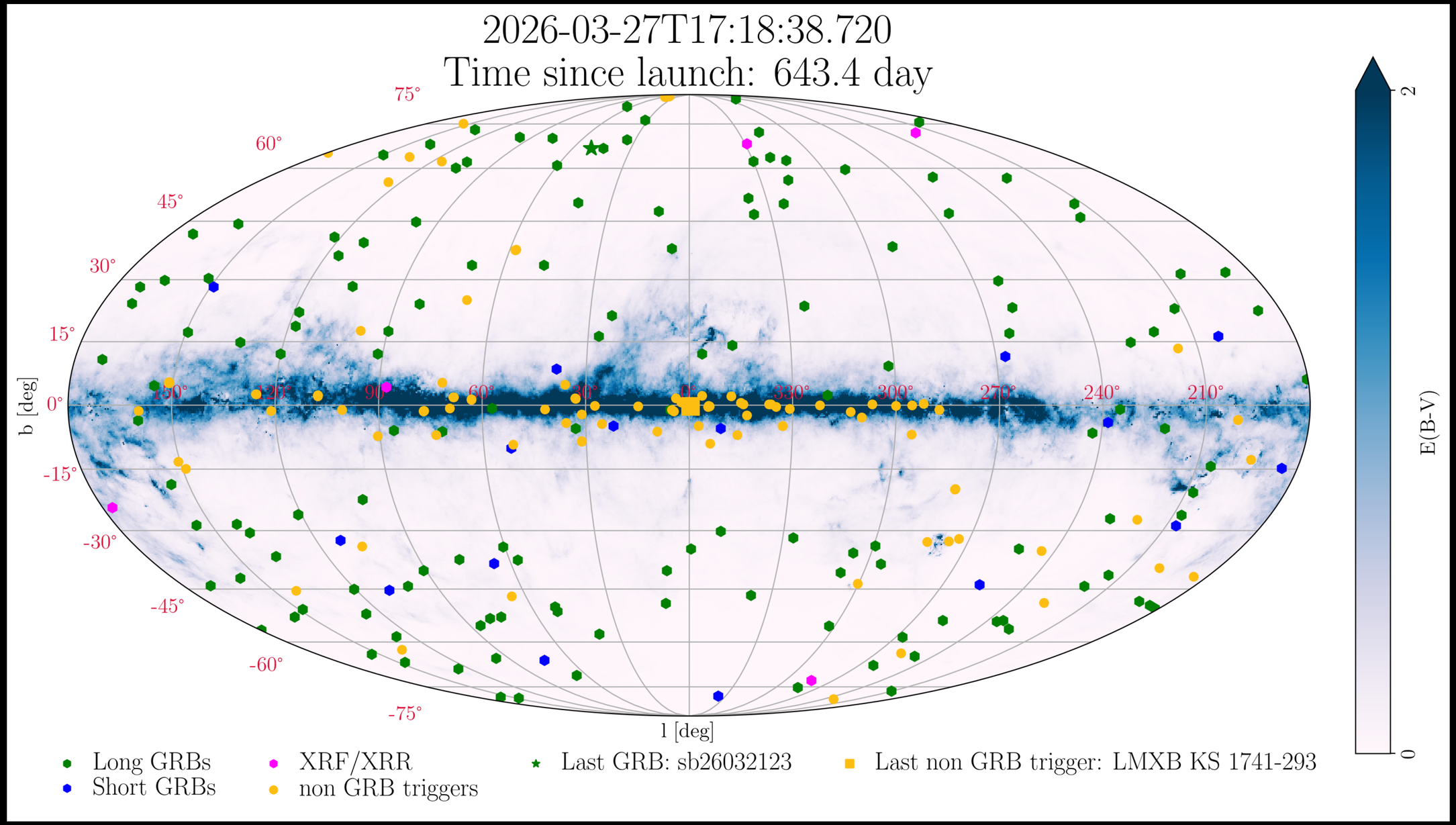


Sakamoto et al., 2005

- **SVOM designed to study these GRB populations** (ECLAIRs 4 keV threshold, multi-wavelength follow-up network, …)

GRBs: selected results

A year of SVOM observations



GRB detections with SVOM

- **General statistics (on 27 March 2026)**

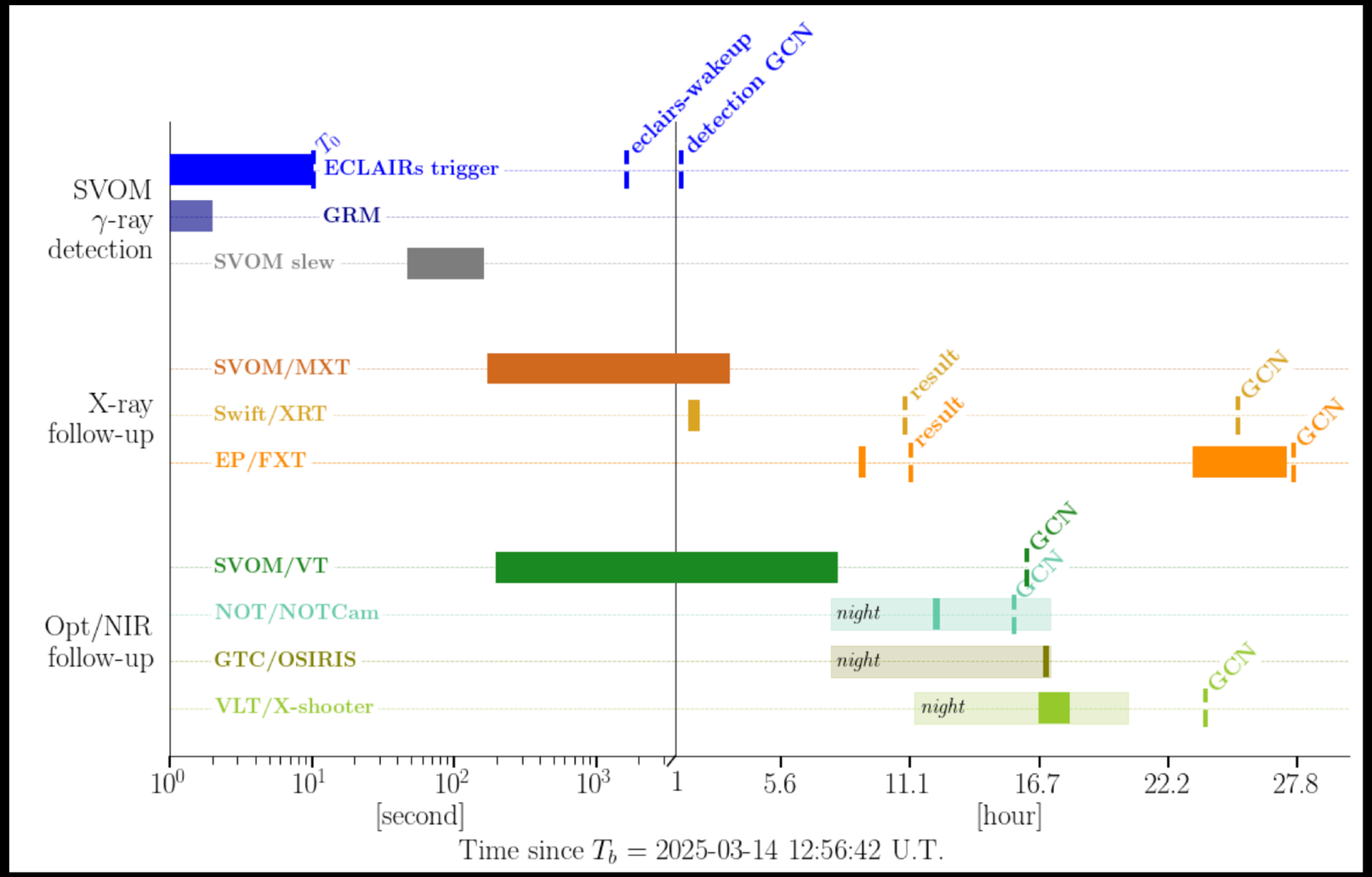
Total ECLAIRs+GRM	GRM detections	ECLAIRs detections	# redshift
258 (211 long GRBs, 43 short GRBs, 5 XRFs/XRRs)	214	91 (~75% with afterglow detection)	48 (~20%) ~50% of ECLAIRs detected bursts

Redshift measurement: ~25% for Swift and ~5% for Fermi

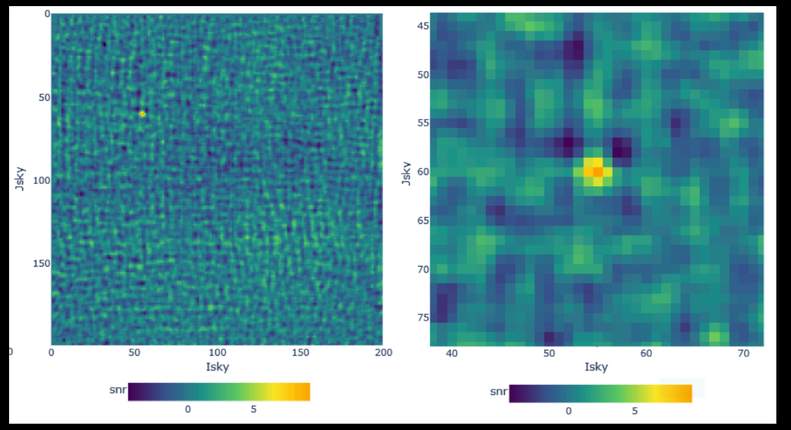
~25 single GRB articles under review…

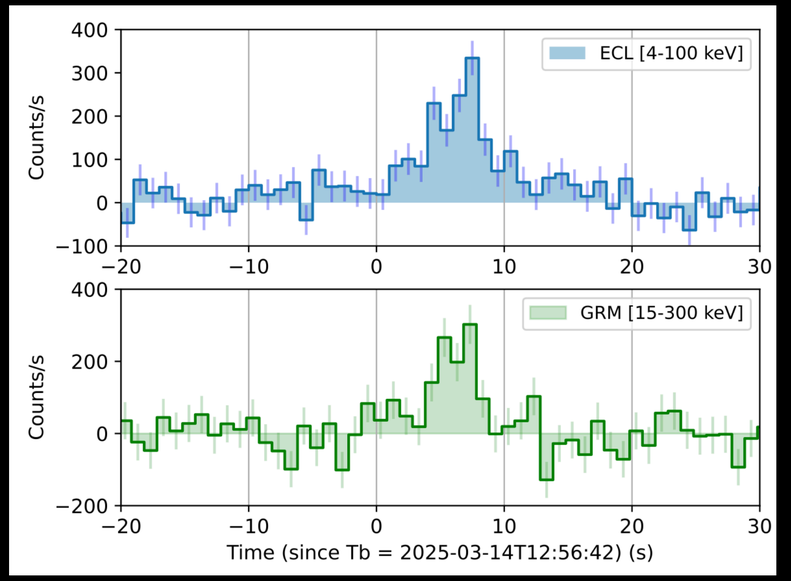
Exploring the high-z GRB population

GRB 250314A: 5th most distant GRB - *B. Cordier et al., 2026*



SVOM/ECLAIRs+GRM detection





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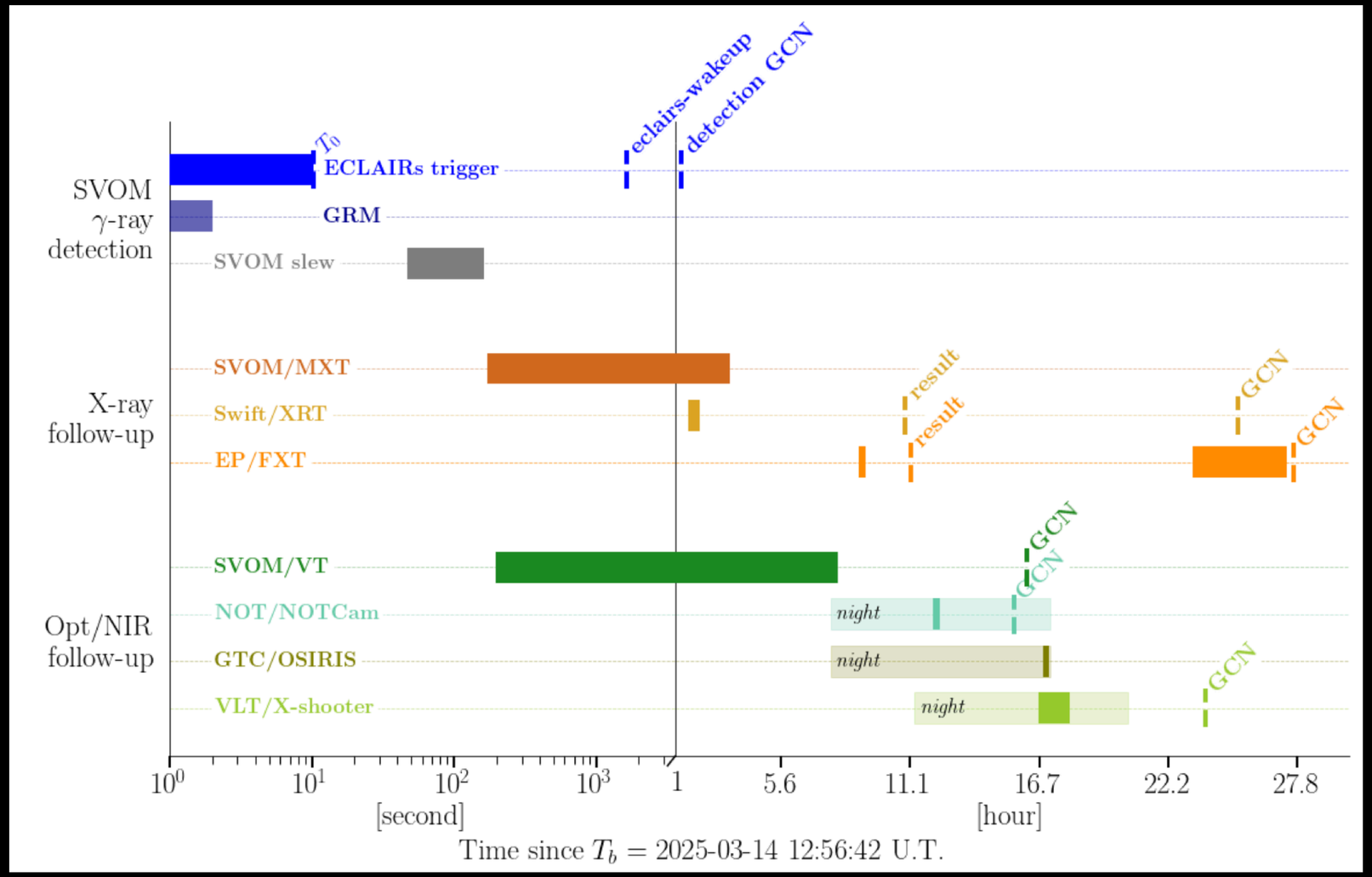
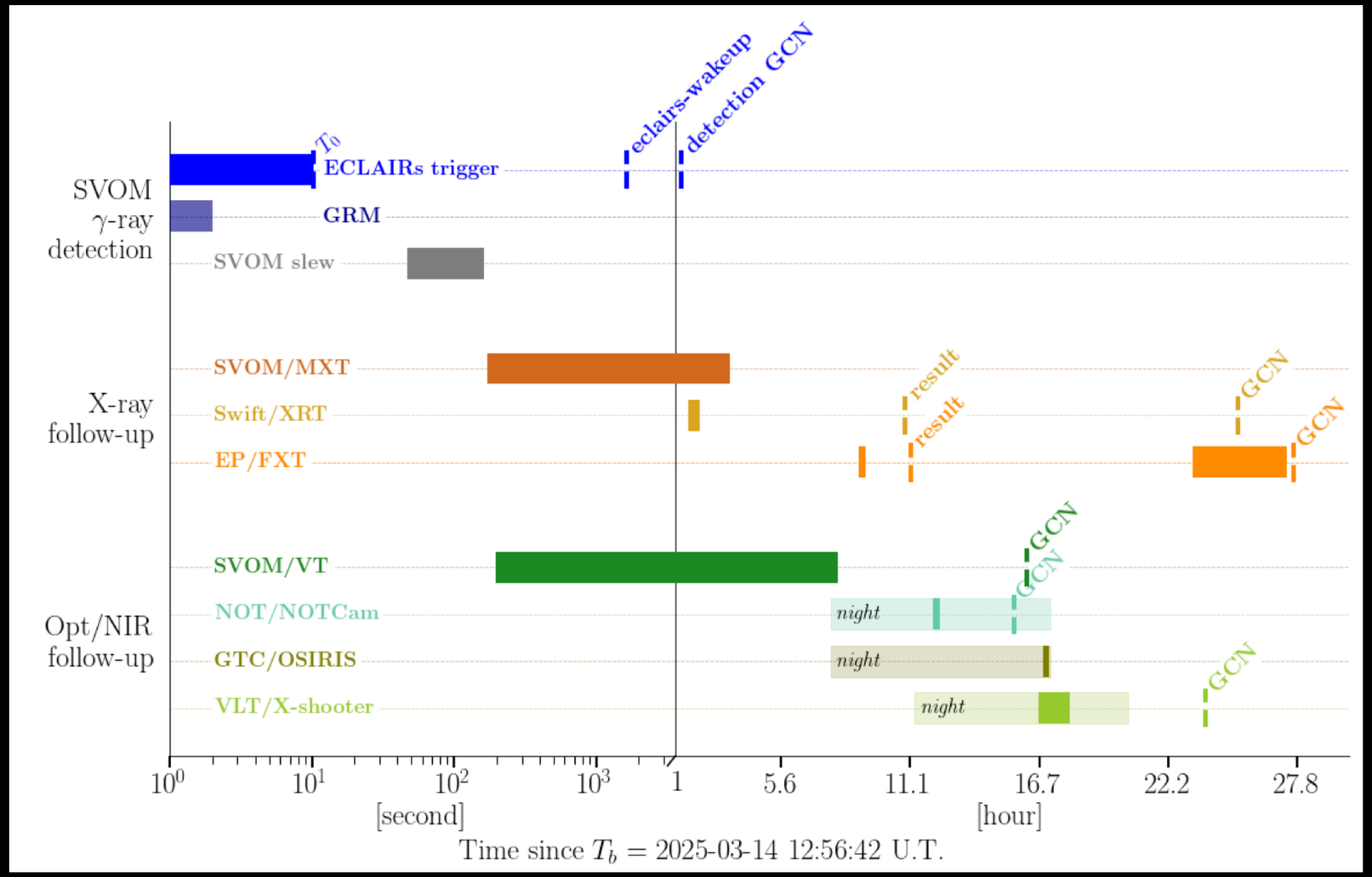


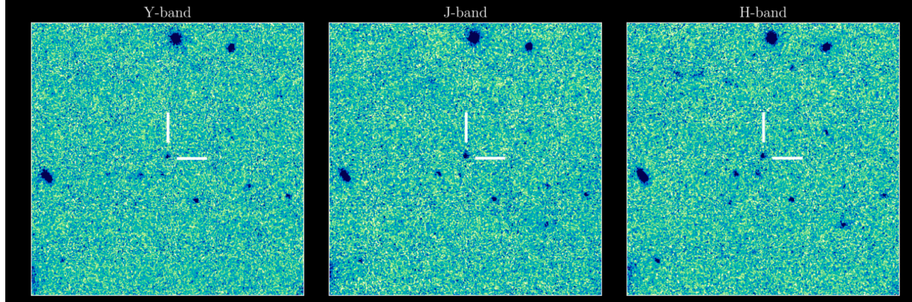
No MXT and VT counterpart but Einstein Probe/FXT and Swift/XRT detection of an uncatalogued fading soft X-ray source

Exploring the high-z GRB population

GRB 250314A: 5th most distant GRB - *B. Cordier et al., 2026*



Optical afterglow detection by VLT, GTC and NOT

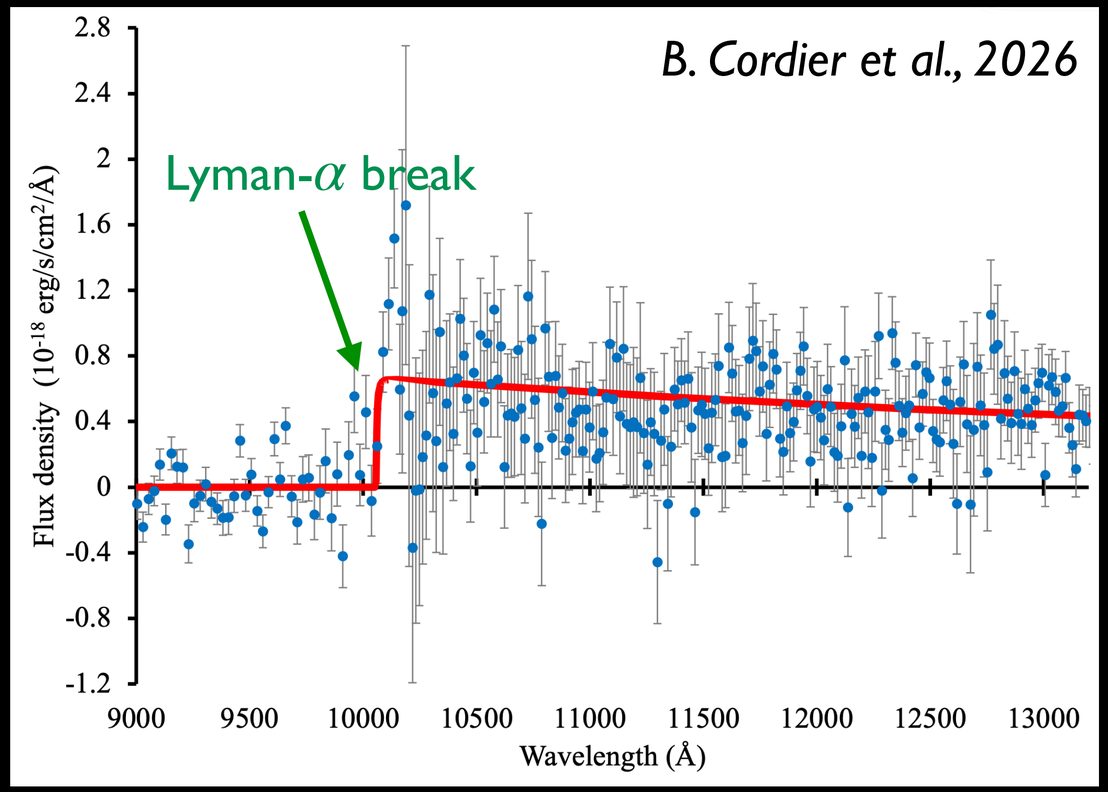


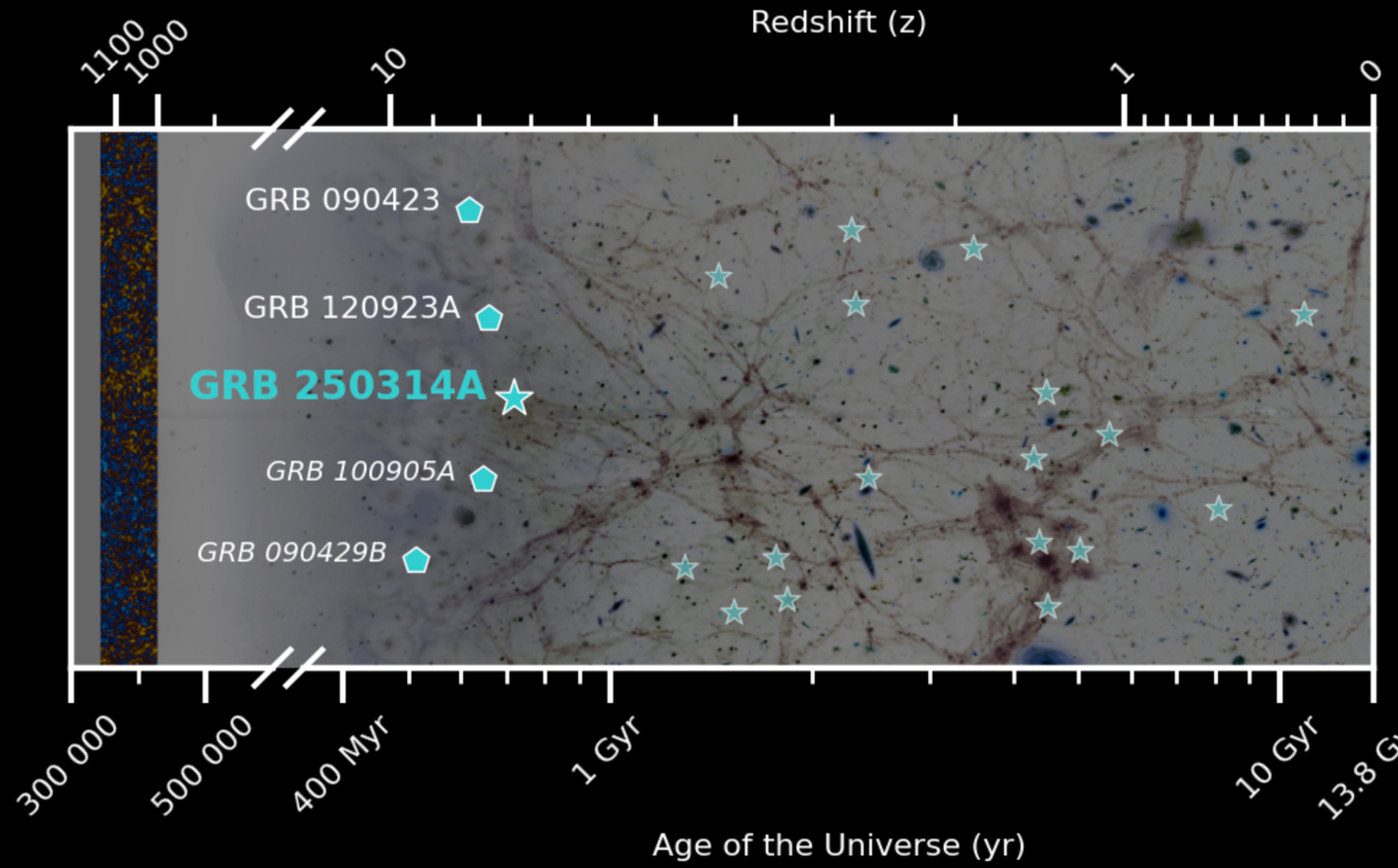
Exploring the high-z GRB population

GRB 250314A: 5th most distant GRB - *B. Cordier et al., 2026*

VLT/X-Shooter spectrum

⇒ Redshift measurements at z = 7.27 (VLT/X-Shooter)
5th most distant GRB - 3rd spectroscopic redshift



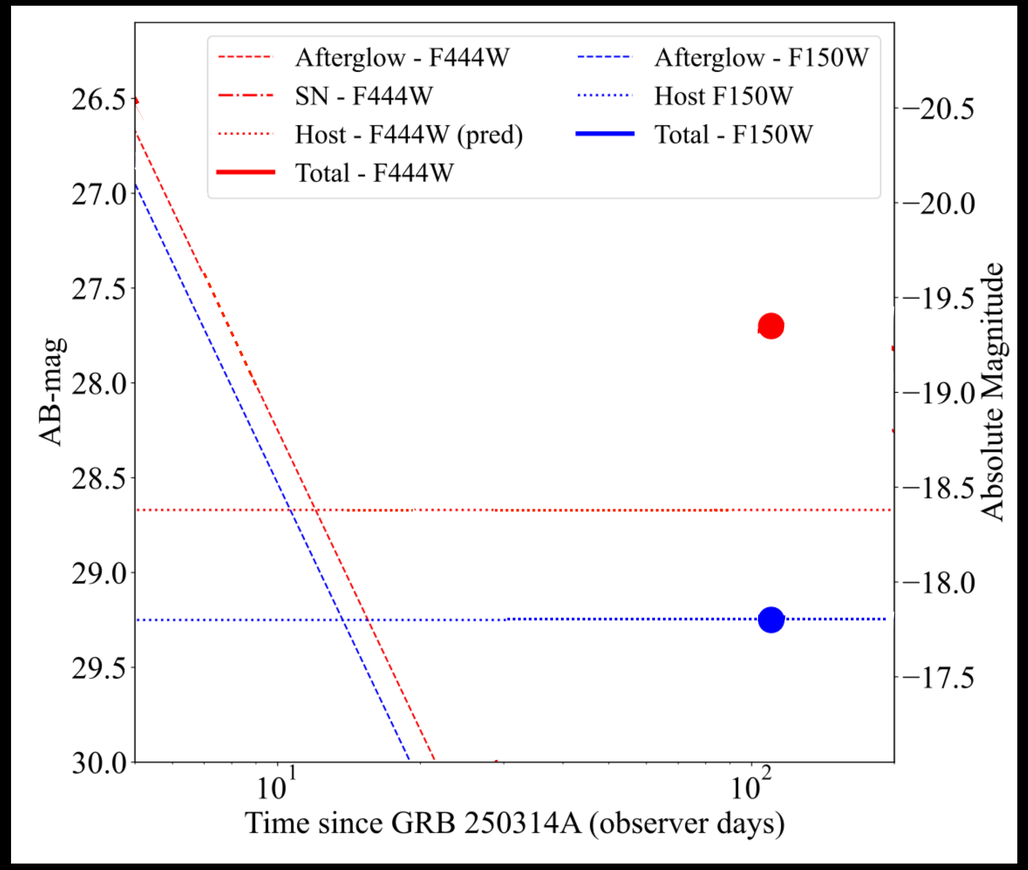


Exploring the high-z GRB population

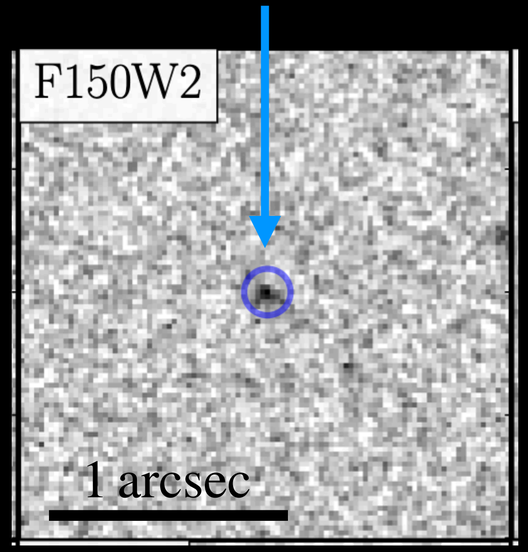
GRB 250314A: 5th most distant GRB - *B. Cordier et al., 2026*

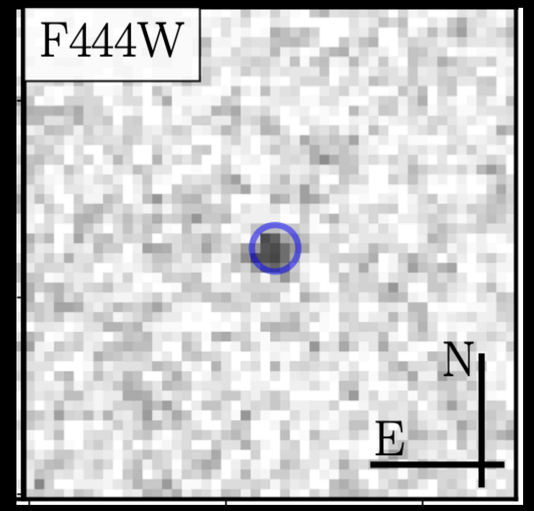
JWST/NIRCAM observations on July 1st, 2024 (~110 days after GRB detection)

Levan et al., 2026



Marginally extended
faint host galaxy detection (~1μm)



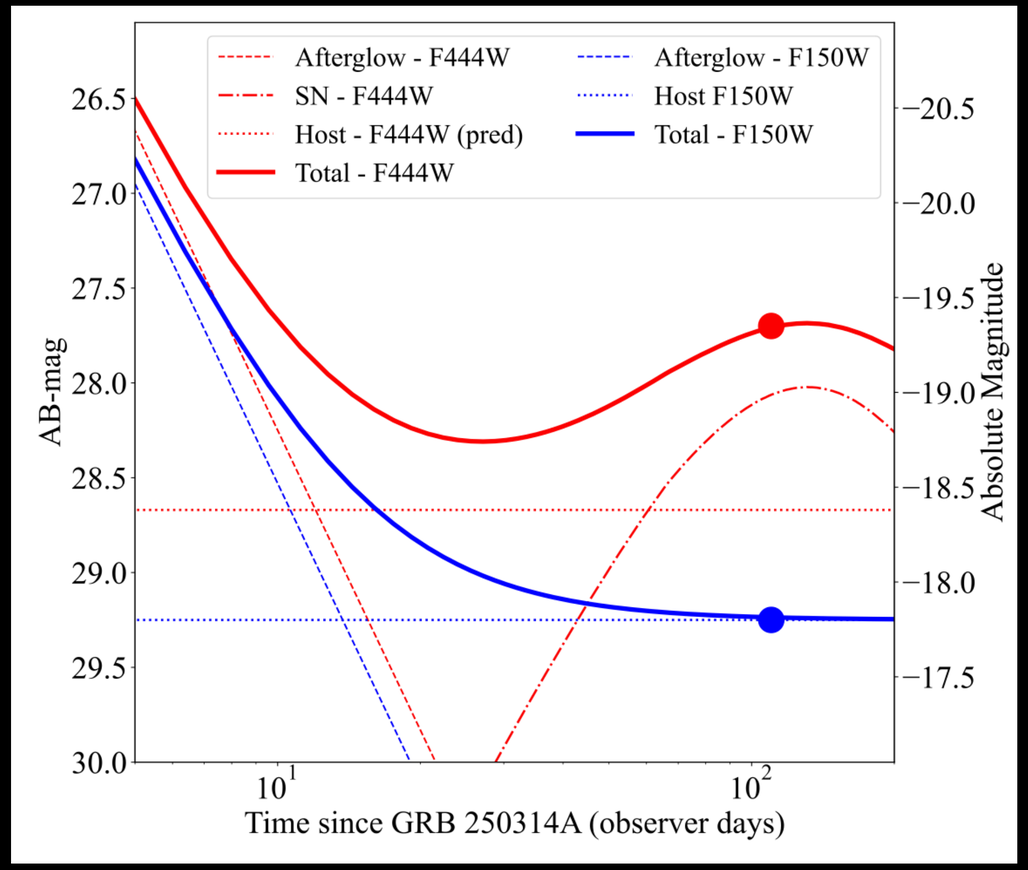


Exploring the high-z GRB population

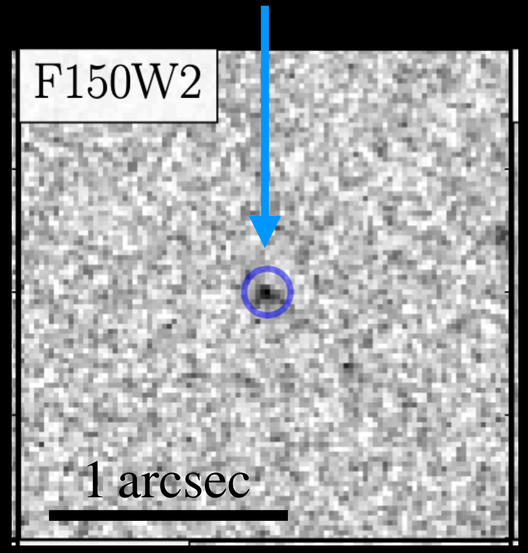
GRB 250314A: 5th most distant GRB - *B. Cordier et al., 2026*

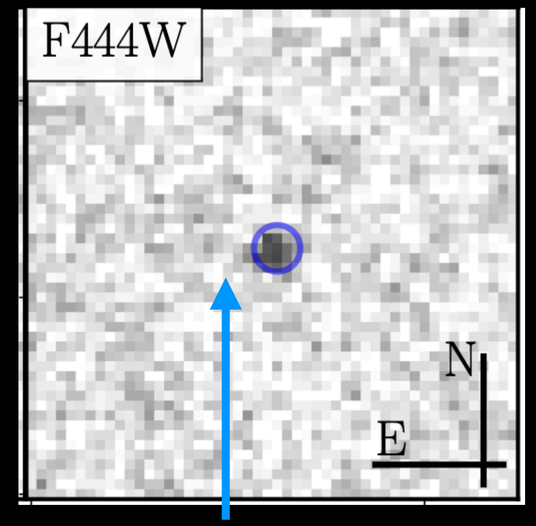
JWST/NIRCAM observations on July 1st, 2024 (~110 days after GRB detection)

Levan et al., 2026



Marginally extended
faint host galaxy detection (~1μm)





CCSN detection (~4 μm)

- Most distant SN detected ⇒ direct probe of massive stars in the early Universe
- Properties consistent with SNe seen in local GRB/SN associations ⇒ progenitor looks similar to local Universe GRBs/CCSNe
- Larger sample needed to test high-z vs local Universe GRBs/CCSN associations

Exploring the high-z GRB population

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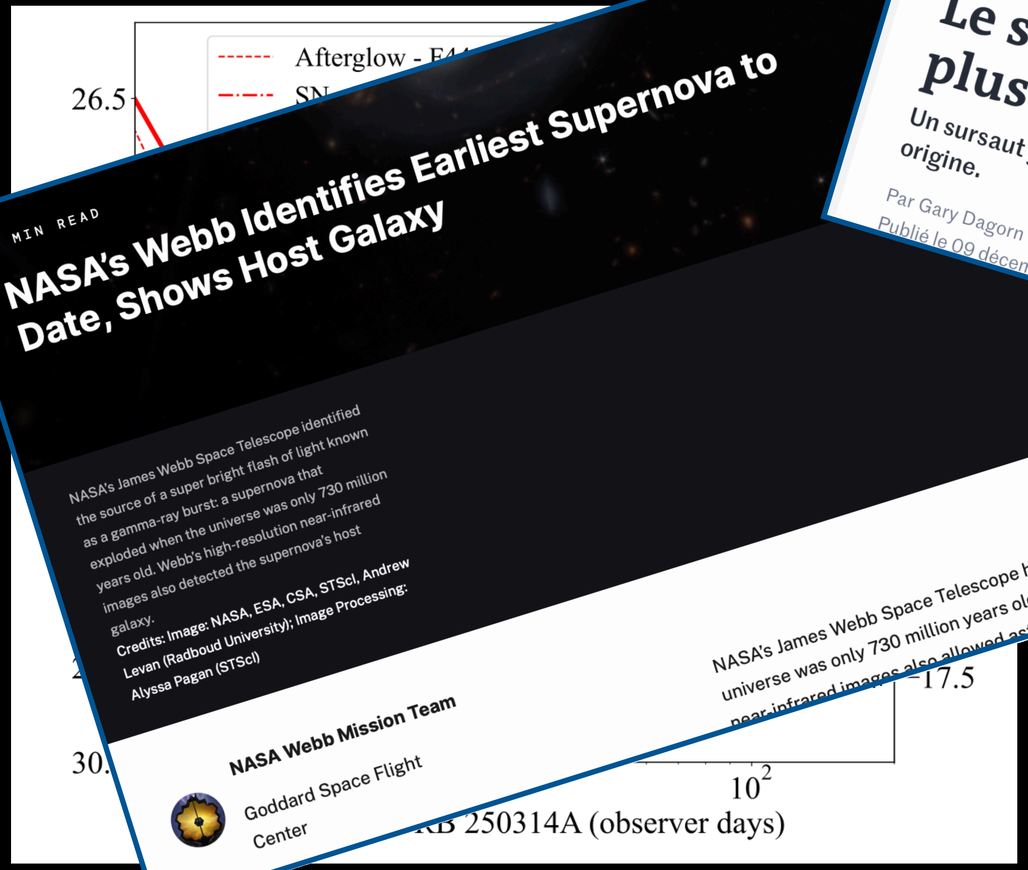

6 MIN READ

NASA's Webb Identifies Earliest Supernova to Date, Shows Host Galaxy

NASA's James Webb Space Telescope identified the source of a super bright flash of light known as a gamma-ray burst: a supernova that exploded when the universe was only 730 million years old. Webb's high-resolution near-infrared images also detected the supernova's host galaxy.

Credits: Image: NASA, ESA, CSA, STScI, Andrew Levan (Radboud University); Image Processing: Alyssa Pagan (STScI)

NASA Webb Mission Team

Goddard Space Flight Center

NASA's James Webb Space Telescope has observed a supernova that exploded when the universe was only 730 million years old — the earliest detection of its kind to date. Webb's crisp near-infrared images also allowed astronomers to locate the supernova's faint host galaxy. The

SCIENCES • ASTROPHYSIQUE

Le satellite franco-chinois SVOM détecte les traces de la plus vieille supernova jamais observée

Un sursaut gamma, repéré en mars par les instruments du satellite, a permis aux télescopes au sol d'observer rapidement son origine.

Par Gary Dagorn

Publié le 09 décembre 2025 à 09h00, modifié le 09 décembre 2025 à 13h56 · Lecture 4 min.

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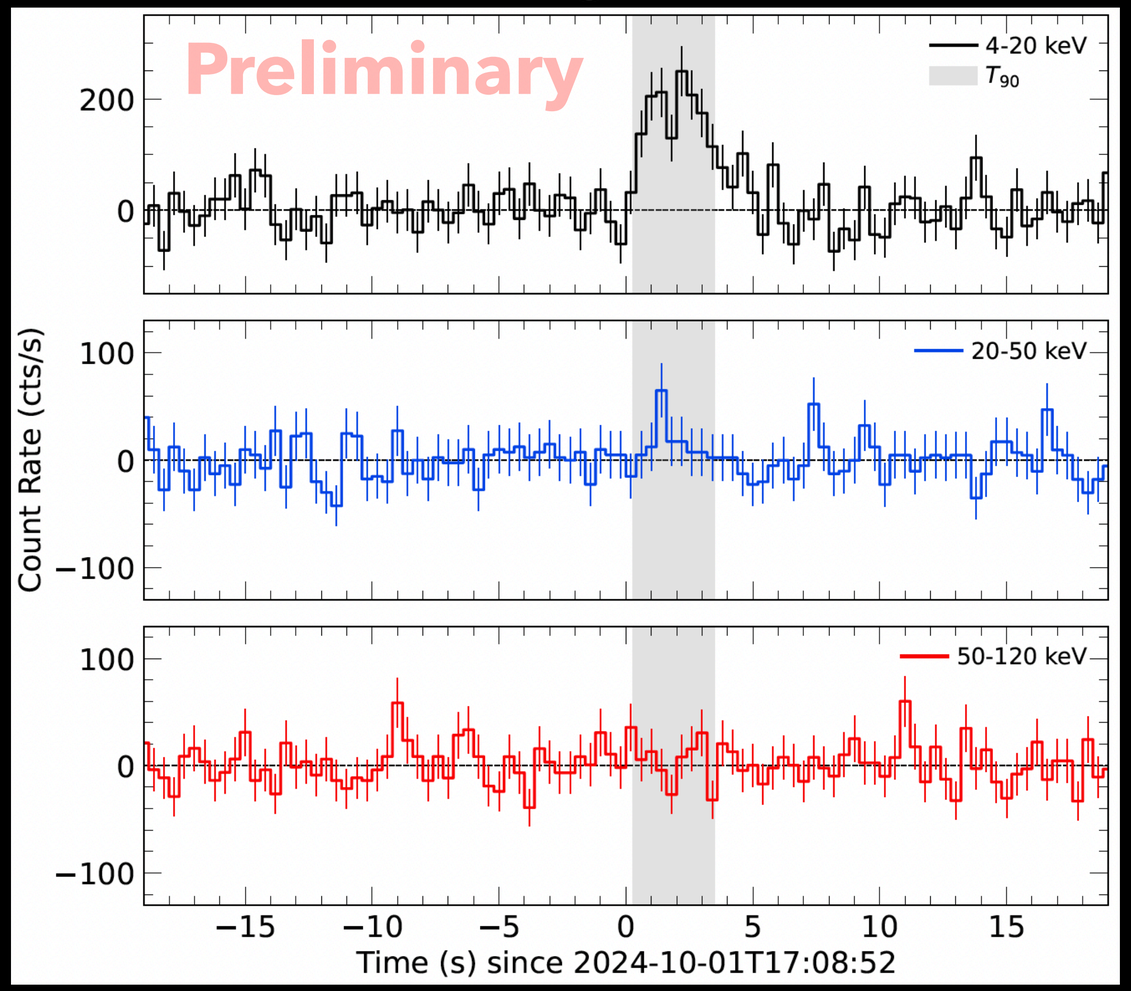
Unveiling the poorly known XRR/XRF burst population

GRB 241001A (SVOM) : a very soft X-ray burst associated with a type Ic supernova (seen by JWST)

B. Schneider et al. (in prep)

ECLAIRs lightcurves



SVOM/ECLAIRs, M. Brunet

- First soft X-ray transient (X-ray flash) detected by SVOM
- Demonstrates SVOM/ECLAIRs ability to detect XRFs

Unveiling the poorly known XRR/XRF burst population

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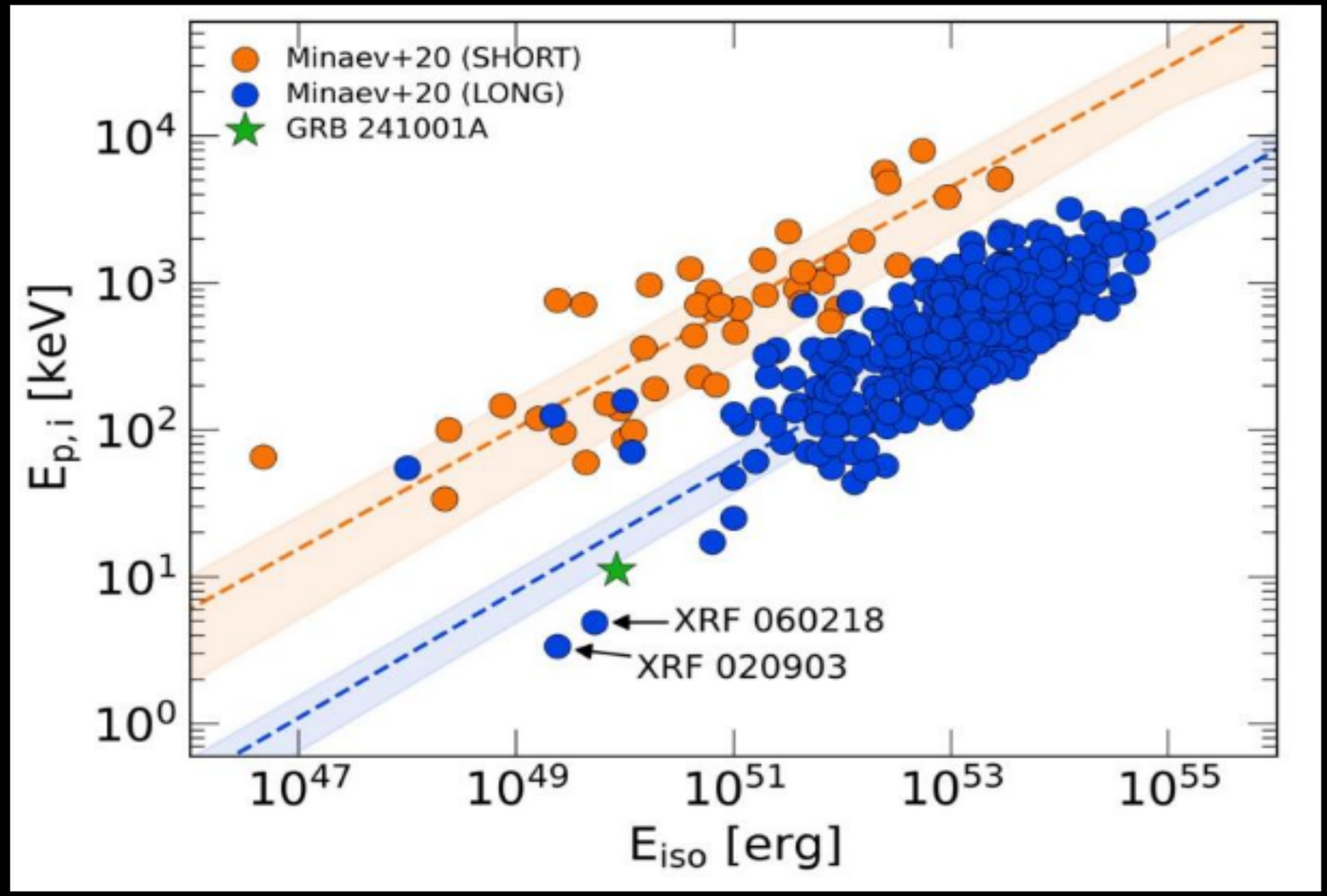
- Correlation between Epeak and Eiso for long GRBs
- Epeak gives typical photon energy governed by e- acceleration, $\vec{B}$ strength, radiation mechanism, …)
- Eiso probes the global energetics of the burst - related to the global power of the central engine



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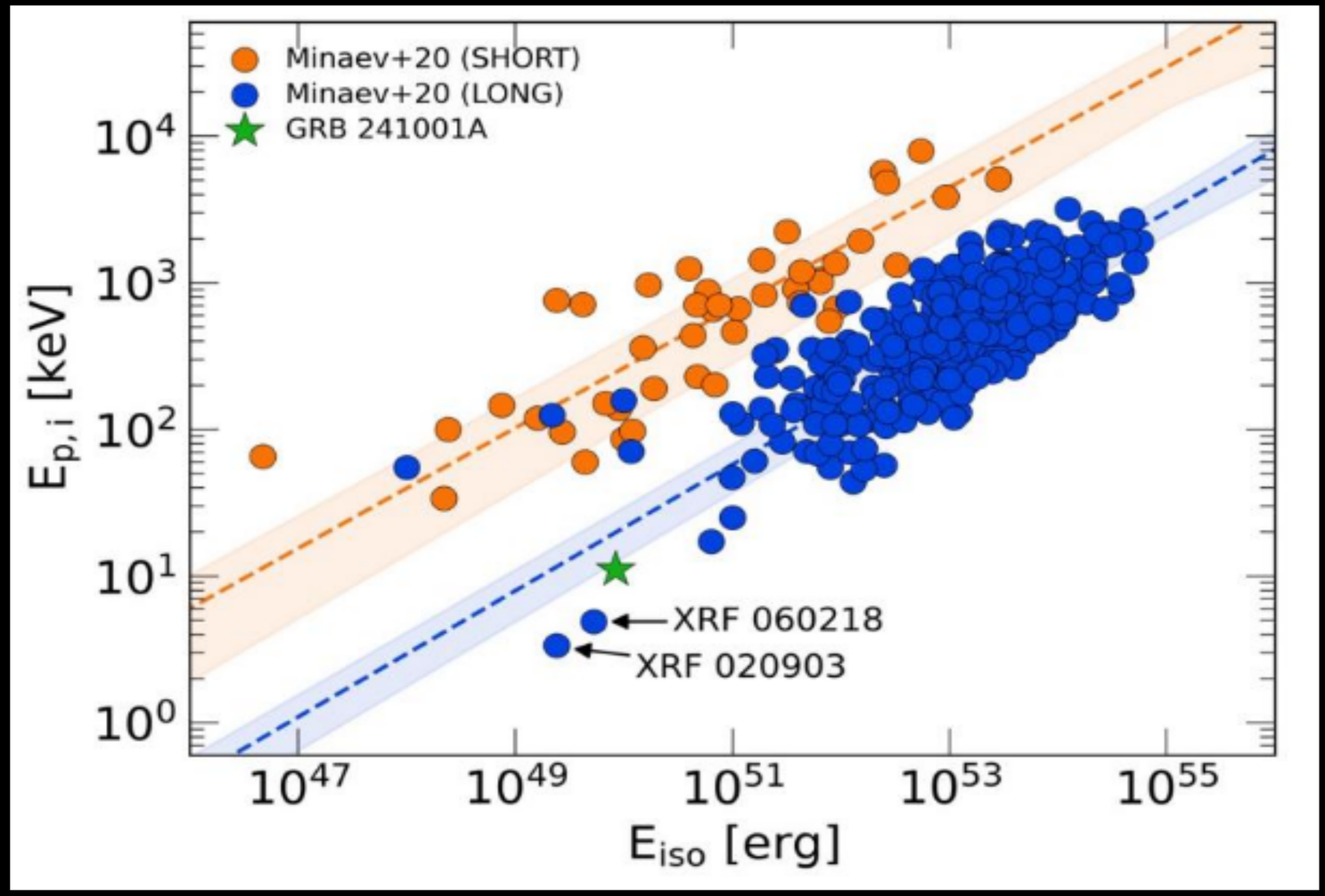
- GRB 241001A occupies a region of the Epeak-Eiso plane sparsely explored
- GRB 241001A follows the Epeak-Eiso correlation
- Afterglow emission consistent with on-axis GRB



⇒ GRB 241001A may represent low-energy tail of standard long GRBs

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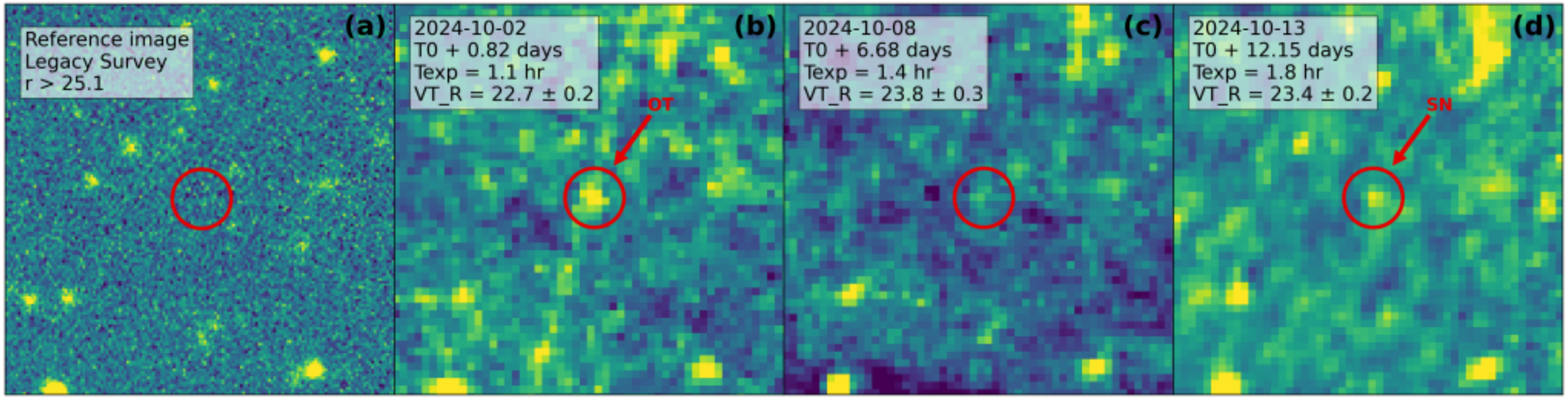
Time series of SVOM/VT observations

From T_{GRB}+0.82d (afterglow) - T_{GRB}+12.15d (Supernova rise)

SVOM/VT, H. Li & B. Schneider



- CCSN detected by SVOM/VT
- JWST/NIRSpec observations reveal a Type Ic SN similar to CCSN events in standard long GRBs

⇒ (some) XRFs seem to be related to core collapse of massive stars = low-energy tail of standard long GRBs

Observatory science

Astrophysical sources of interest

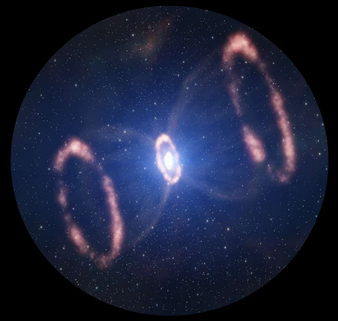
CVs, X-ray binaries

Flaring stars

TDE, FRB, etc.

Magnetar Giant flares

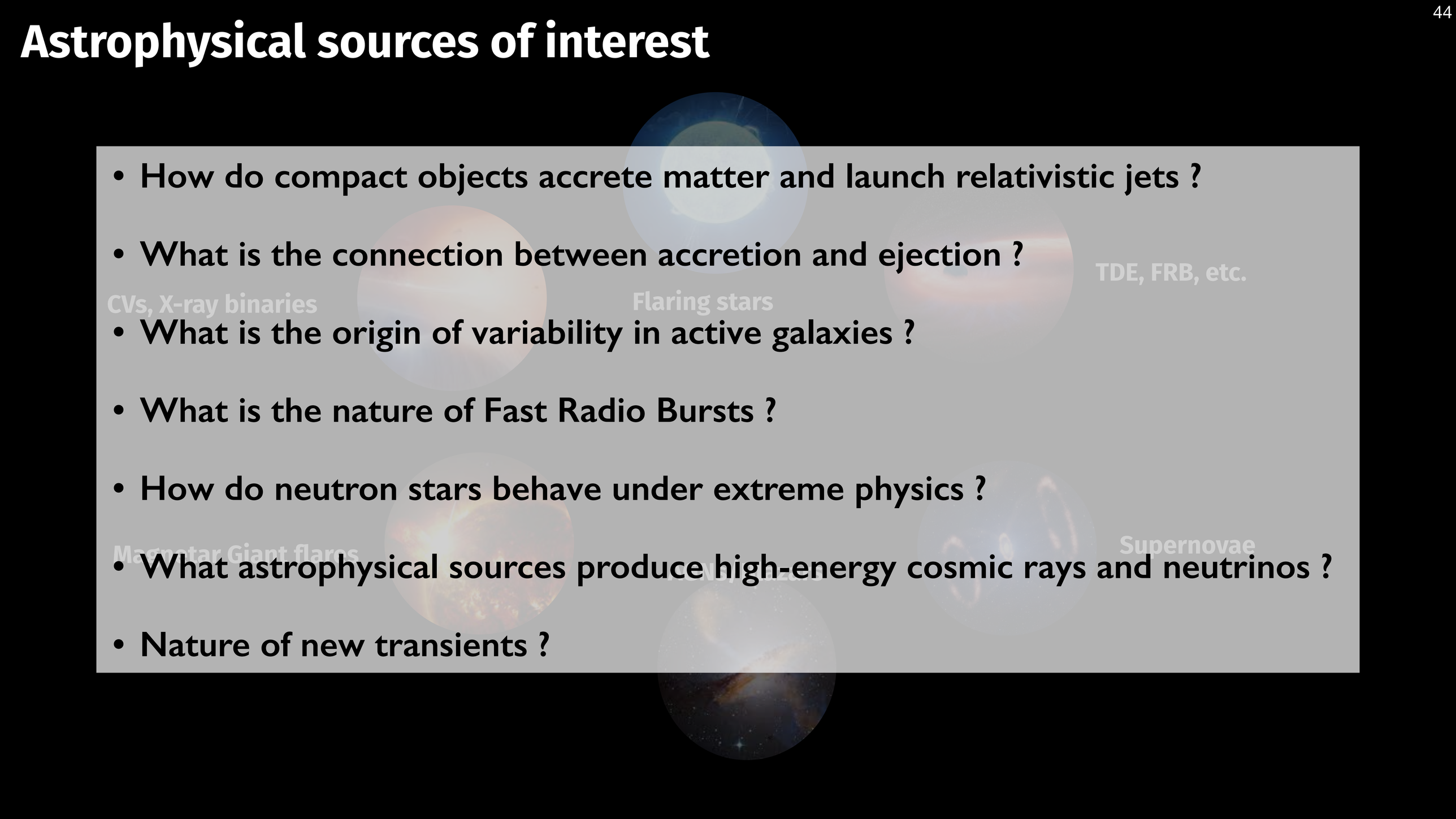
AGNs/Blazars



Supernovae

Astrophysical sources of interest

- How do compact objects accrete matter and launch relativistic jets ?
- What is the connection between accretion and ejection ?
- What is the origin of variability in active galaxies ?
- What is the nature of Fast Radio Bursts ?
- How do neutron stars behave under extreme physics ?
- What astrophysical sources produce high-energy cosmic rays and neutrinos ?
- Nature of new transients ?



SVOM General Program and ToOs

Serendipitous detections

High-energy source monitoring when present in the ECLAIRs field-of-view by chance

General Program (GP)

Observation proposals awarded by a TAC (proposals have to include a SVOM Co-I) - Yearly call for proposals (spring/summer 2026)

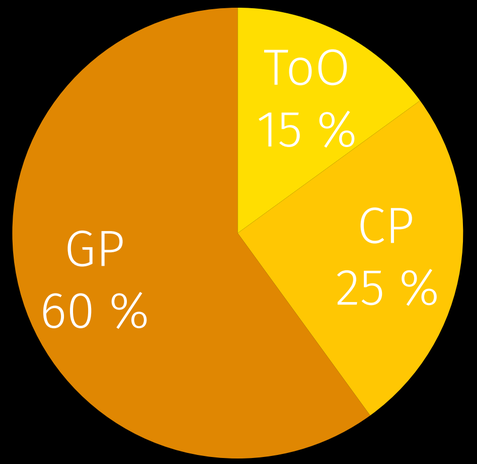
Targets of Opportunity (ToO)

ToO-NOM — Normal ToO

ToO-Ex — Fast ToO

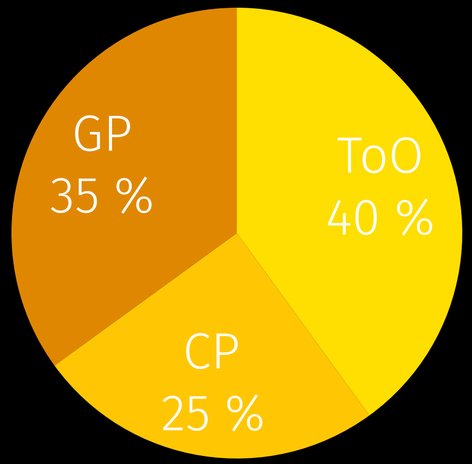
ToO-MM — For large error boxes, with a tiling strategy

Nominal mission



1 ToO per day, 15 % GP outside B1 law

Extended mission

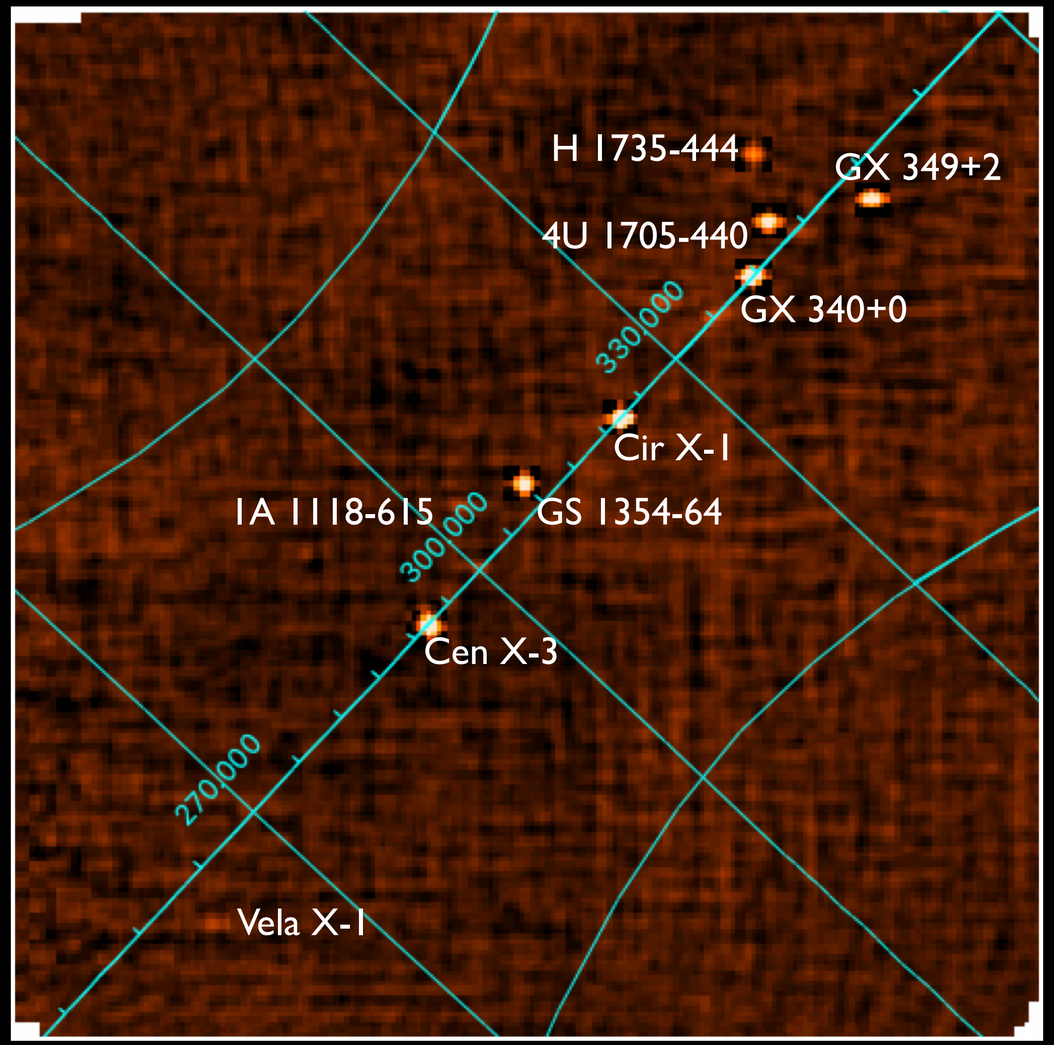


5 ToOs per day, 50 % GP outside B1 law

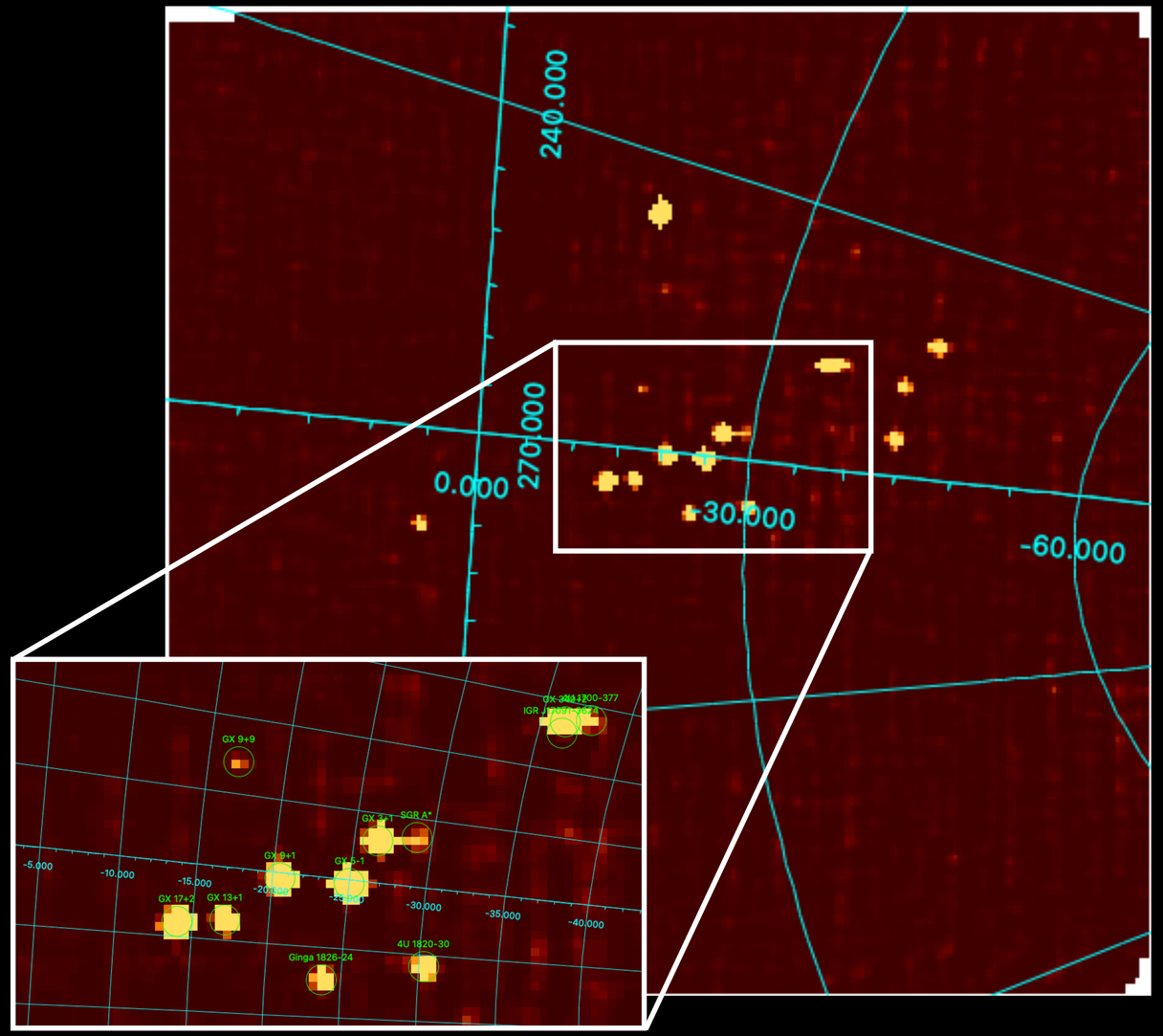
	ToO-NOM	ToO-EX	ToO-MM
Frequency	Nominal mission : 1/day Extended mission : 5/day	1/month => 1/day	1/week
Priority	Low	Highest	Very High
Upload Delays	< 48h (regular X-band)	< 12h (requested X-band)	< 12h (requested X-band)
Duration	Base: 1 orbit => 2.7 ks Max: 14 orbits => 38 ks SAA optimized	Max : 14 orbits => 38ks	Max : 14 orbits => 38ks SAA optimized

ECLAIRs monitoring of the hard X-ray sky

ECLAIRs 4-10 keV view of the Galactic plane



ECLAIRs 4-10 keV view of the Galactic center



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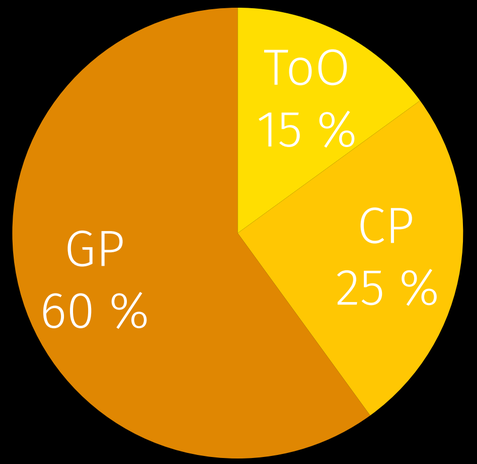

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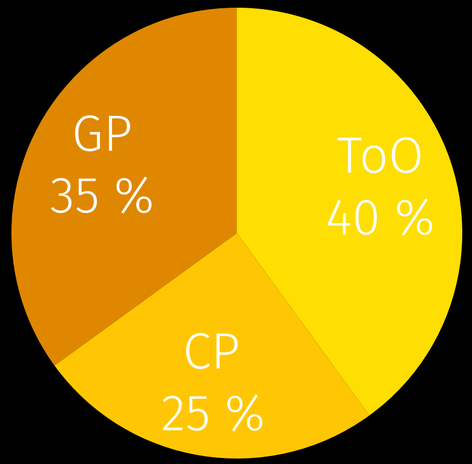

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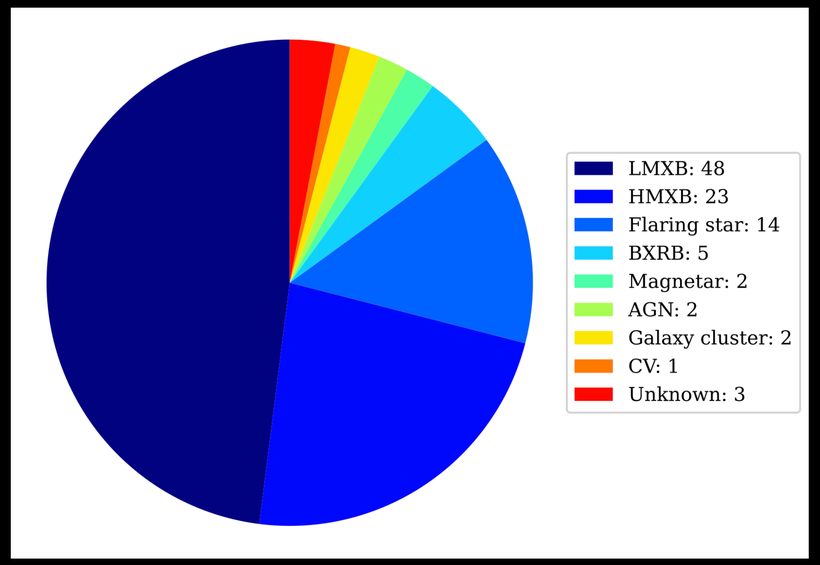
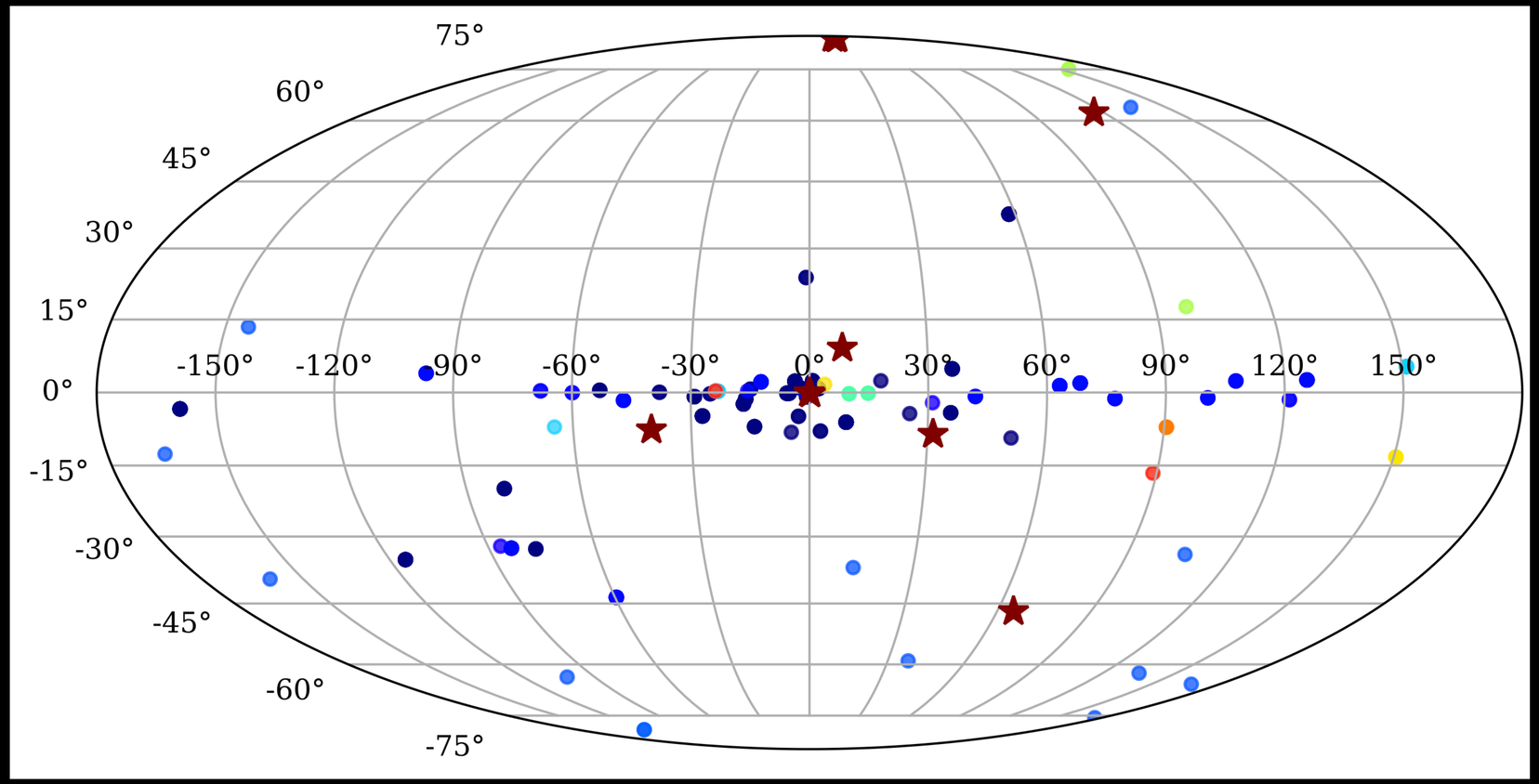
ECLAIRs monitoring of the hard X-ray sky

- **General statistics (on 24 March 2026)**

448 non-GRB triggers (mostly galactic sources) → 30 Astronomer's Telegrams

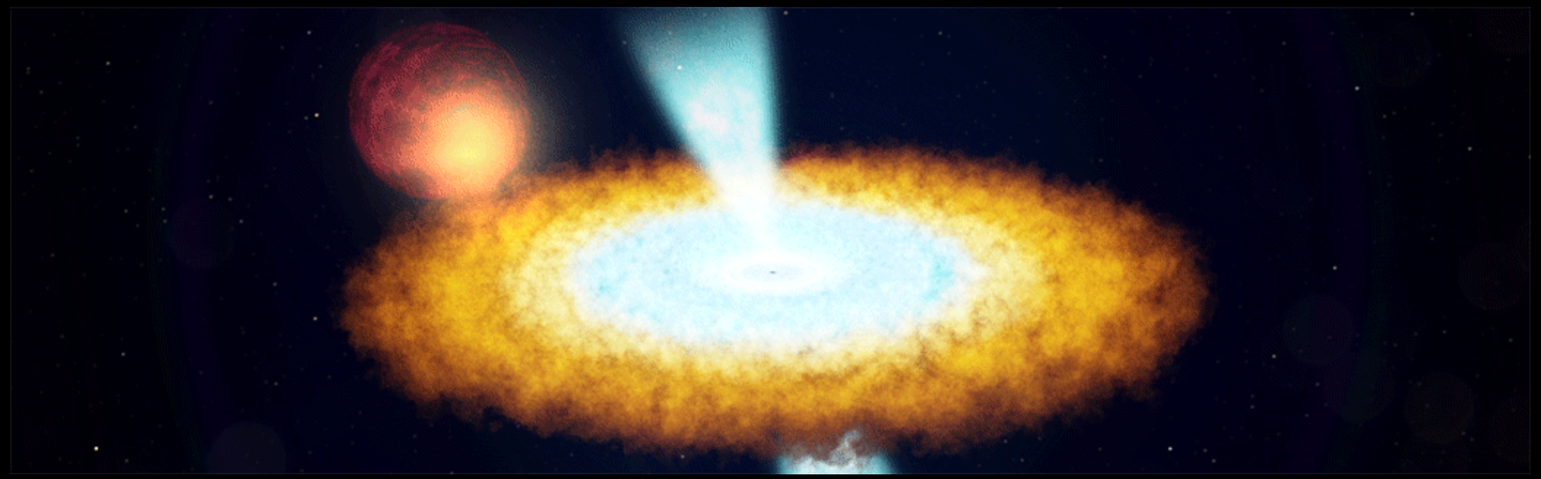




Thermonuclear X-ray bursts

ECLAIRs: a Type I X-ray burst hunter !

~160 bursts from 37 different sources detected so far



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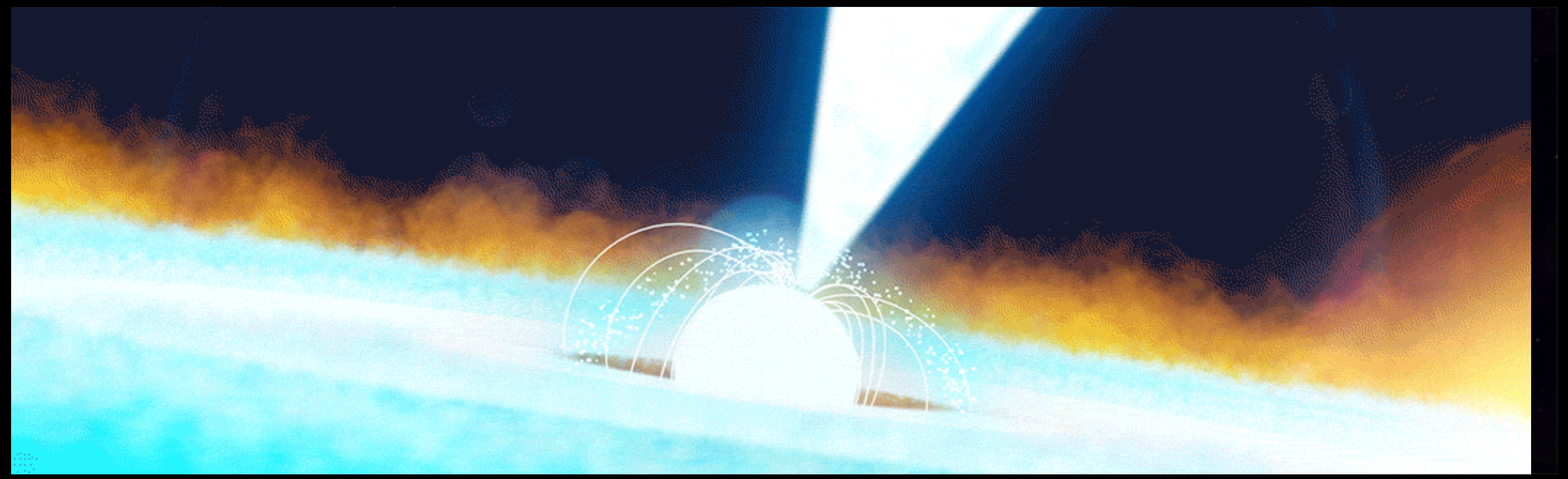

- Gas accumulating at the surface of the neutron star

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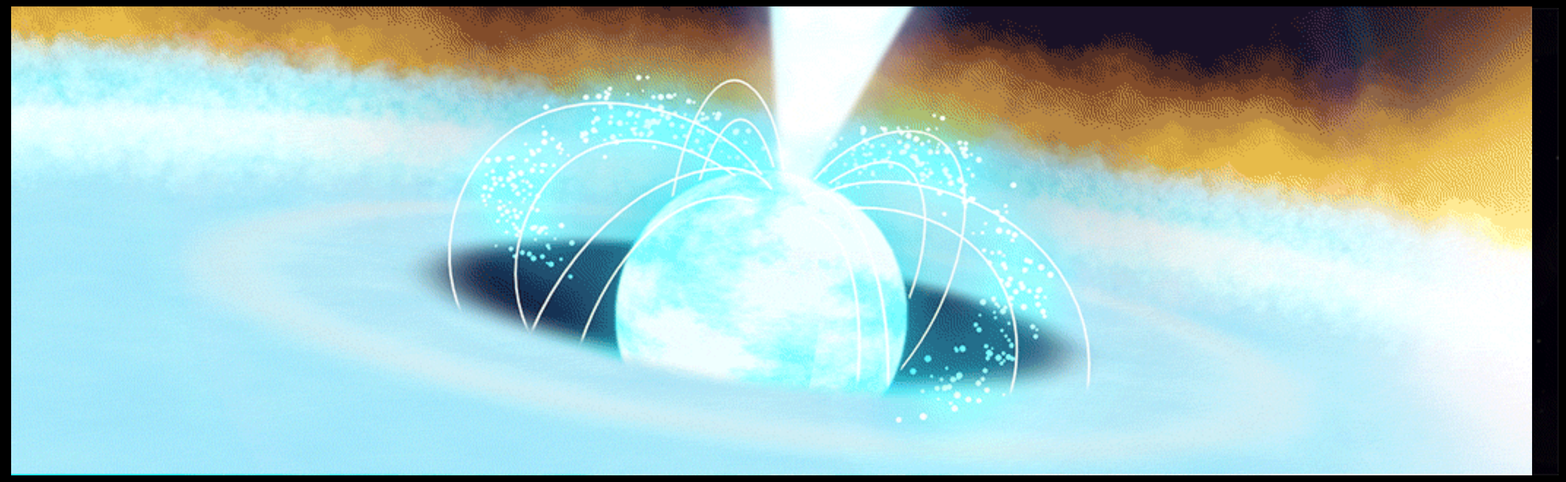

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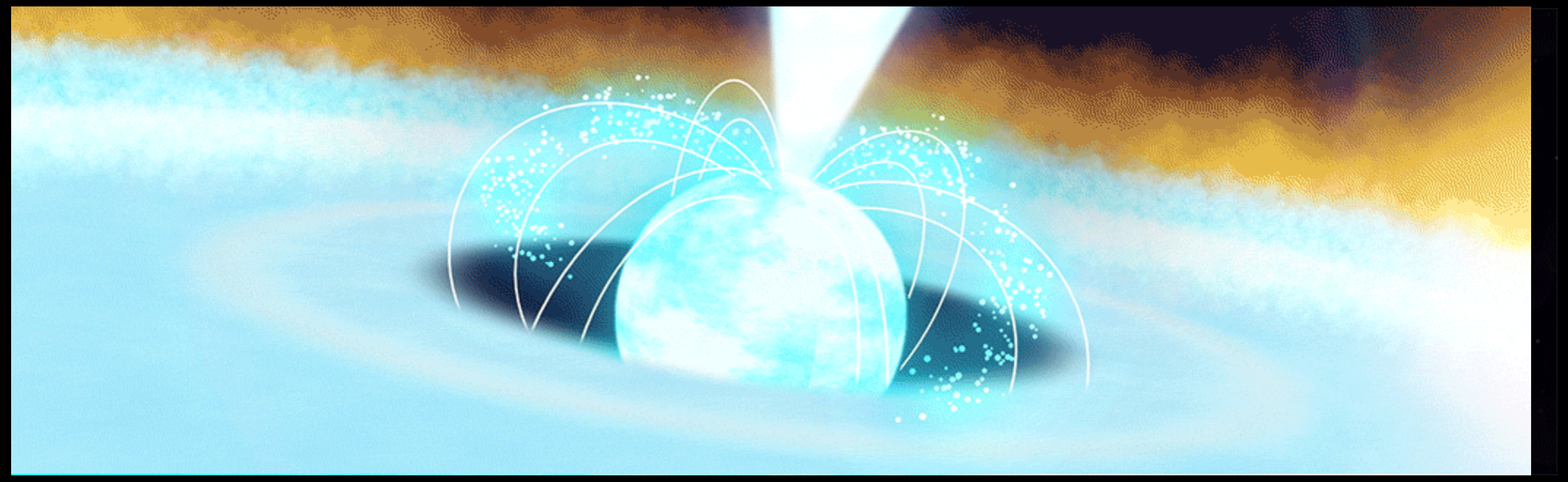
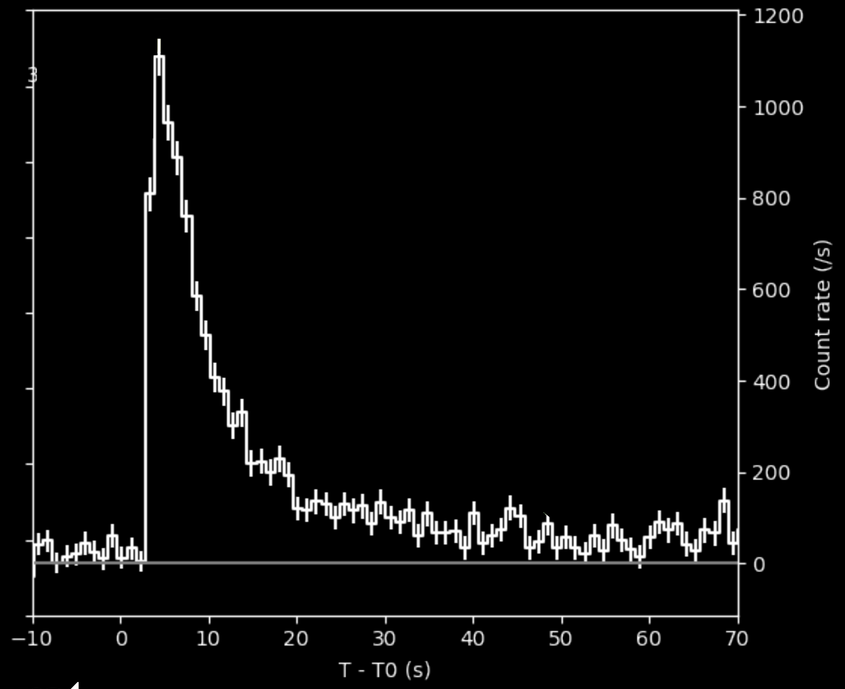


Le Stum et al., 2026



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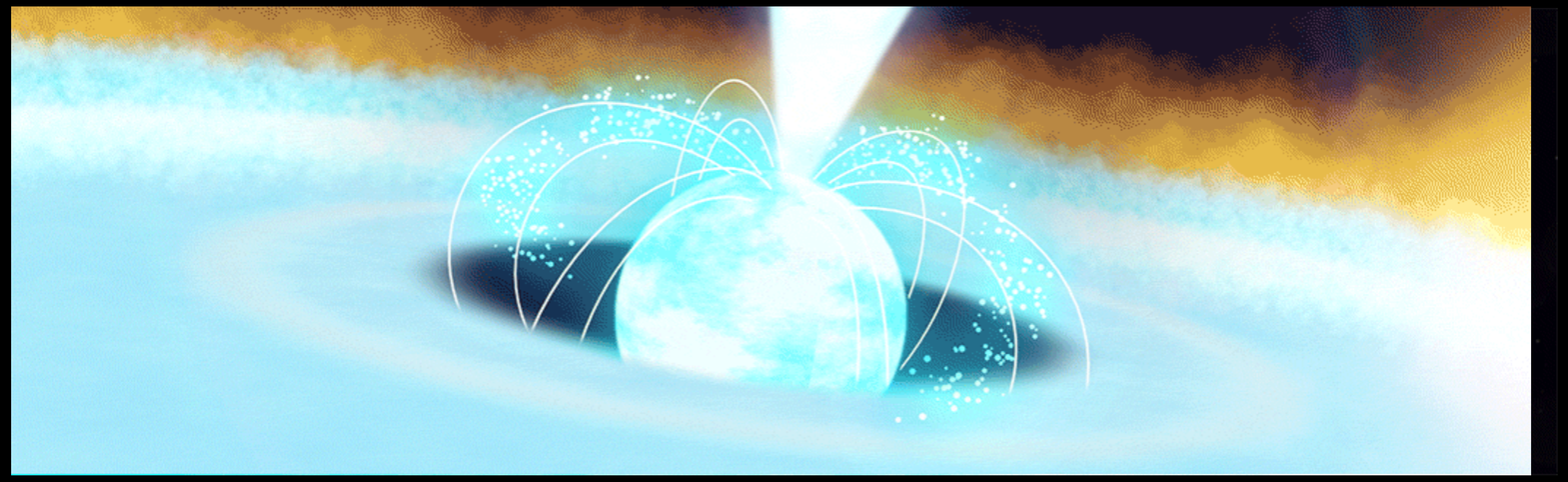

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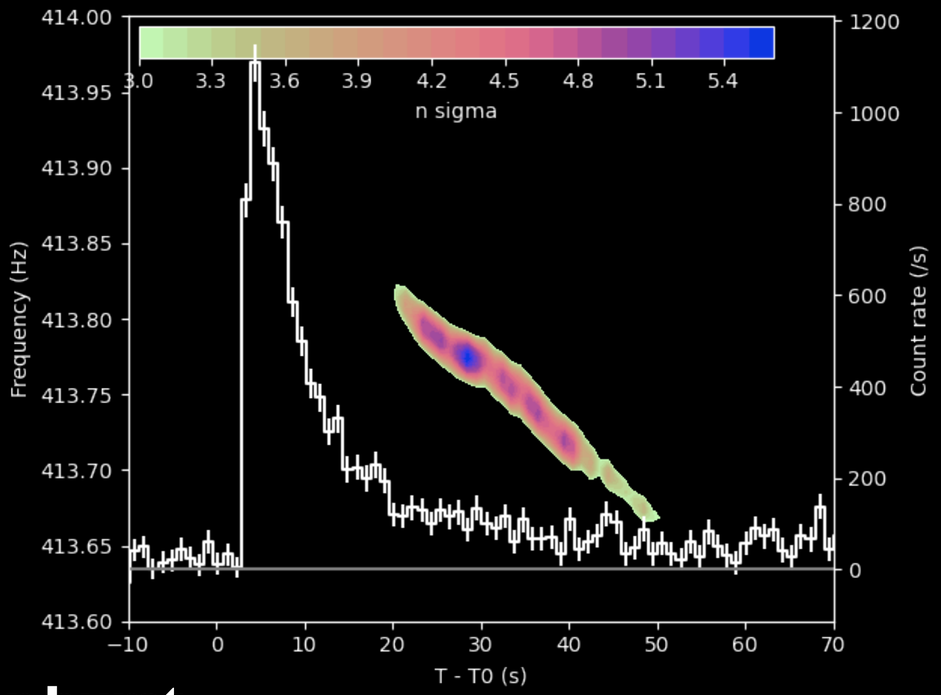

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- **If orbital Doppler effect → orbital period < 20 min (verification binary for LISA ?)**

Thermonuclear X-ray bursts

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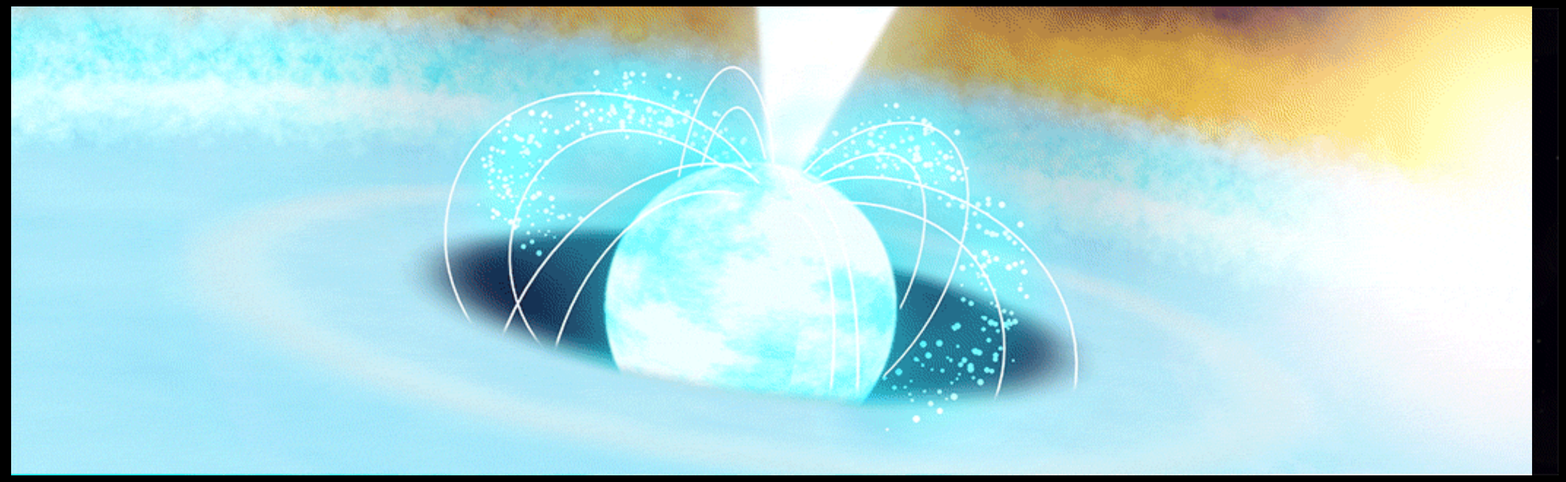
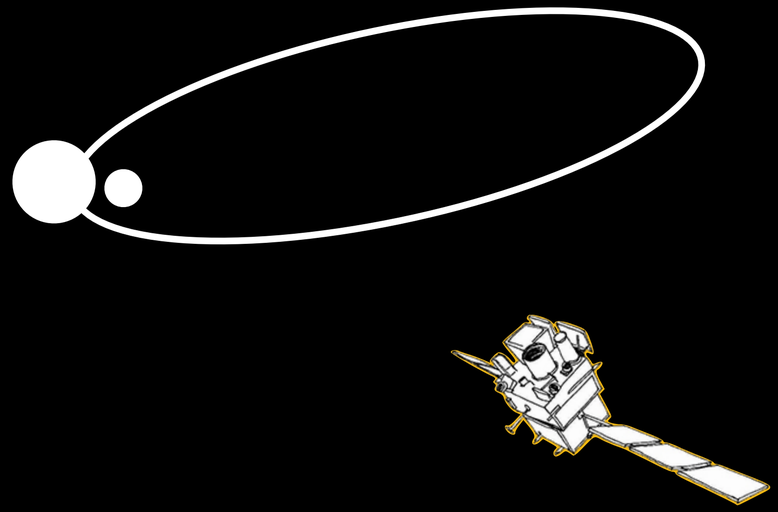
Le Stum et al., 2026





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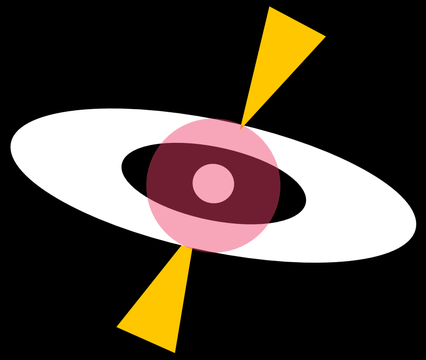

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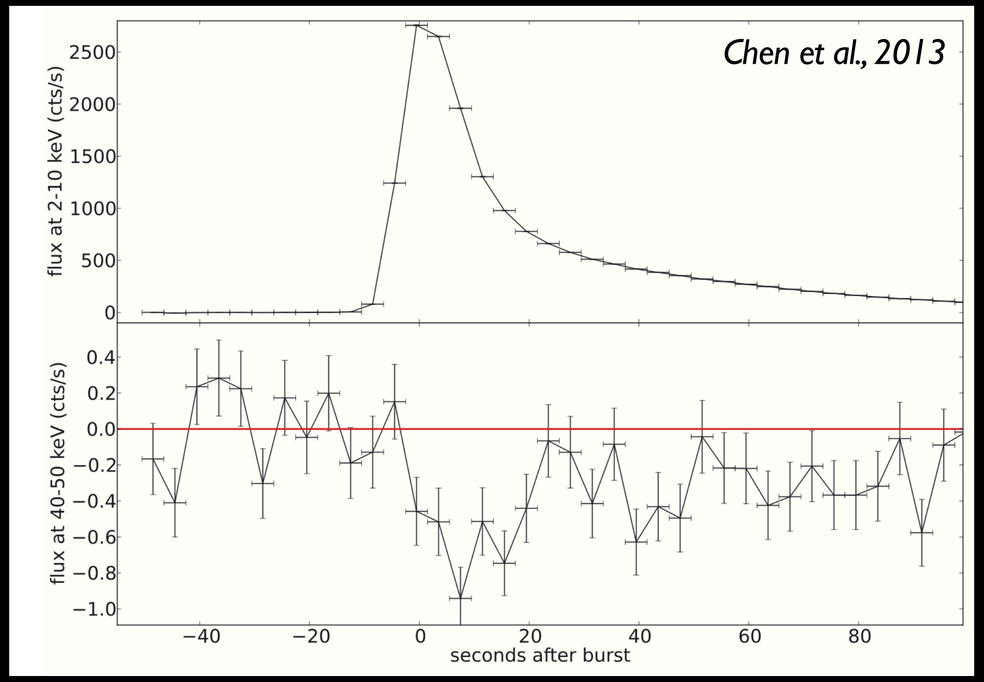

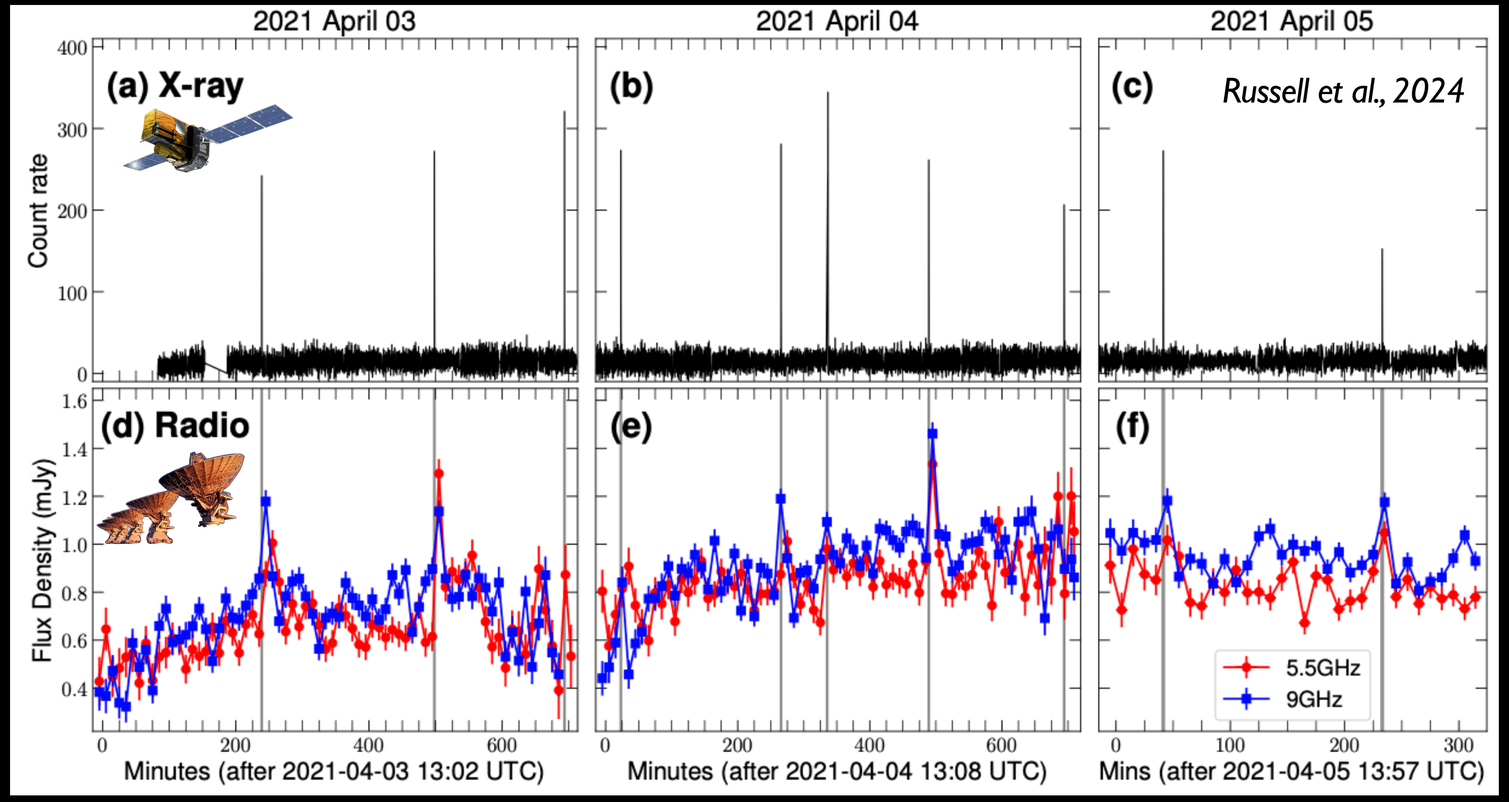

- Type I bursts are known to impact corona + jet ⇒ jet velocity measurement
- Measure jet speed from a population of LMXBs with different spins, masses, … ⇒ opens a new window into the jet launching mechanisms

Thermonuclear X-ray bursts

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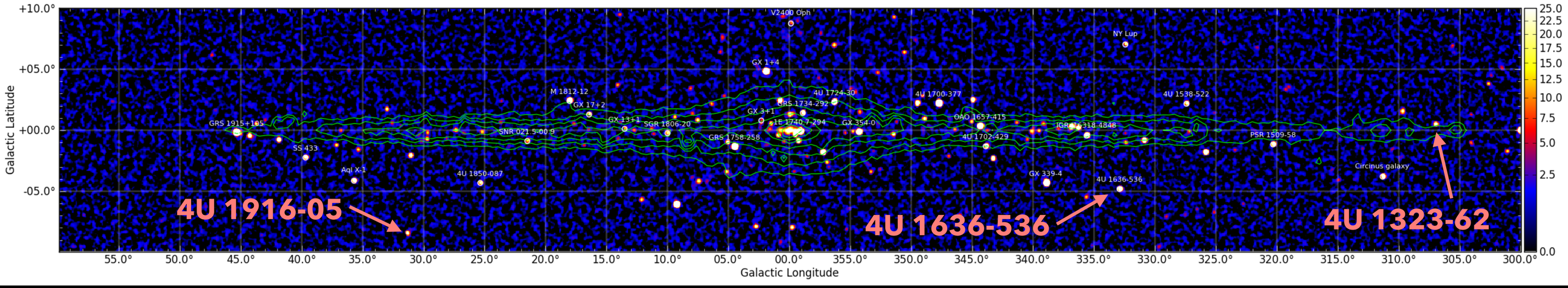
- **300 ks monitoring of the Galactic Plane** (accepted program for SVOM General Program 2026)

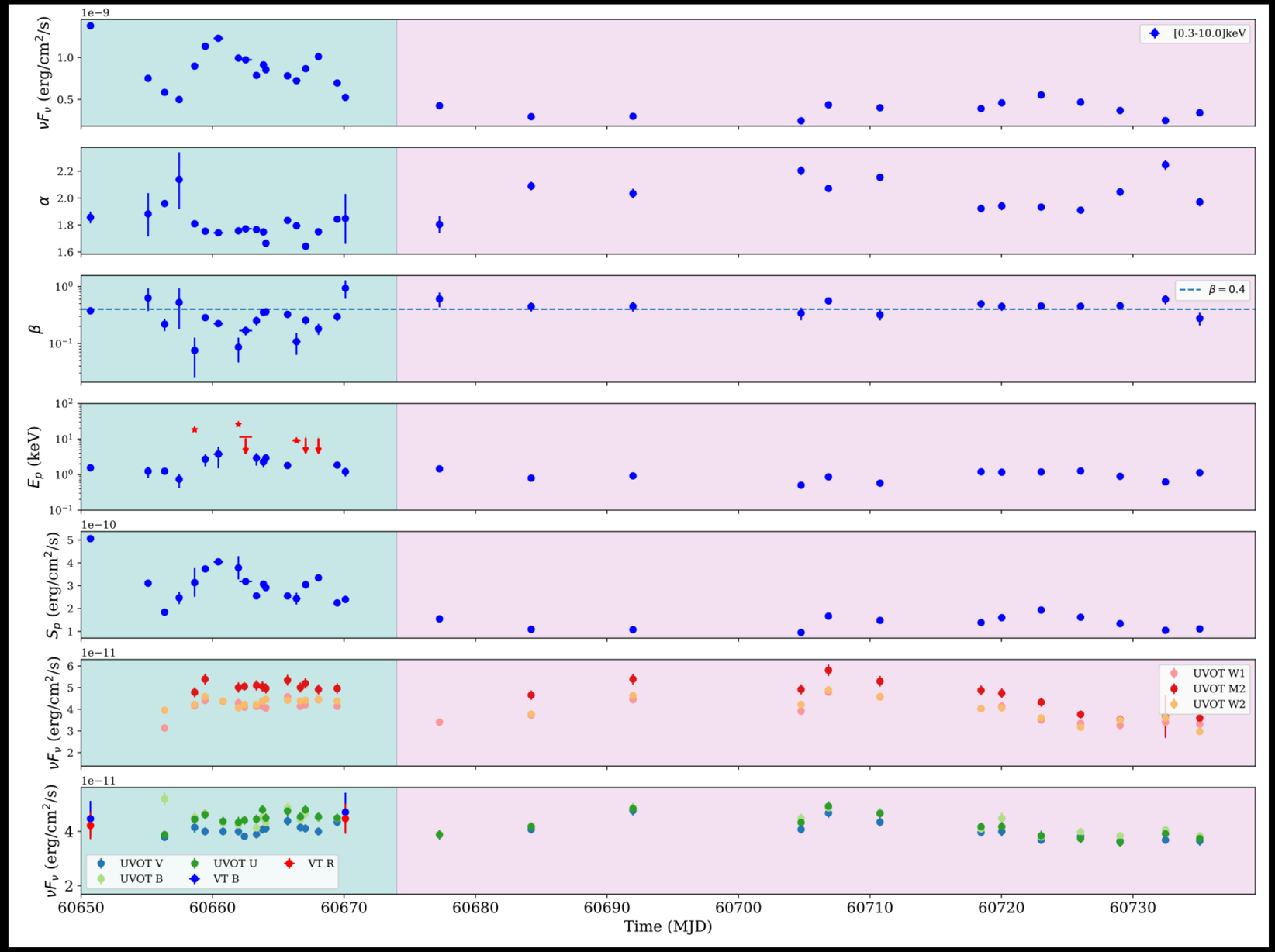


INTEGRAL Galactic Plane survey, Krivonos et al., 2014

- Monitoring of Galactic source variability
- Pointed observations on 3 LMXBs with high type I X-ray burst rate
- Simultaneous observations with radio facilities to probe accretion/ejection processes

Blazar high-energy outbursts

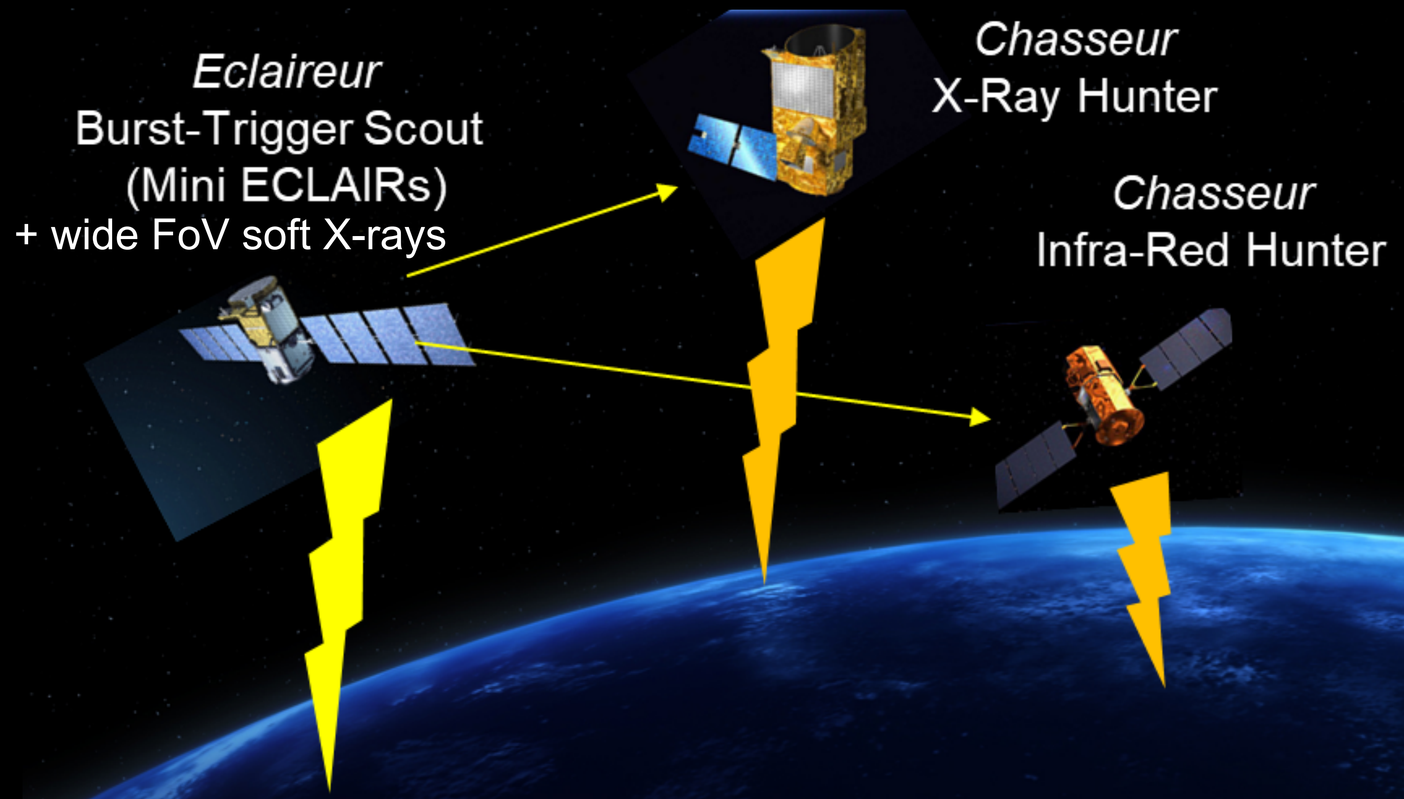
- **SVOM discovery of an X-ray outburst of 1ES 1959+650**
- Multi-wavevelength follow-up
- Constrain acceleration processes



Foisseau et al. (2026)

The future: CATCH

- **Constellation of satellites to monitor the transient sky**: miniECLAIRs using SVOM/ECLAIRs detector spares
- Joint China/France study ongoing
- Development 2026 - 2030
- **Launch in ~2030**



Objectives:

- Simultaneous monitoring from 0.5 keV to ~MeV
- Longer-term monitoring of X-ray transients (both for GRBs and Observatory Science sources)
- IR observations to search for absorbed/distant sources
- Soft X-ray + IR telescopes will benefit a broader community

SVOM first results in a nutshell

- SVOM/ECLAIRs wide field-of-view + 4 keV low energy threshold: a clear impact to better explore the transient sky
- Efficient monitoring network allows to characterize transient sky on multi-wavelength point-of-view
- General Program & ToO: open to a larger community
- SVOM publications already out + SVOM Special issue in preparation
- The future: CATCH

3 first Obs-SWG articles already published

25 single GRB papers under review

A SVOM special issue under preparation