Unveiling gamma-ray burst afterglows with SVOM/COLIBRÍ (F-GFT)[1]

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Context

Multiwavelength observations are essential in GRBs and other transient phenomena studies. The importance of a rapid follow-up is crucial as the analysis of GRB afterglow properties may be impacted by its quick fade. Since the Neil Gehrels Swift Observatory (*Swift*) era, early-time observations enable the study of GRBs up to the epoch of reionization. In addition, multiwavelength data from ground-based telescopes such as the seven-band filter Gamma-Ray Optical and Near-Infrared Detector (GROND), the Rapid Eye Mount telescope (REM) or The Reionization and Transients Infrared Camera/Telescope (RATIR), have a high enough sensitivity and wide-band coverage for identifying GRB afterglows and measuring rapidly their redshift.

Launched on June 22nd June, 2024 from the Xichang launch base, the Sino-French Space-based multi-band astronomical Variable Objects Monitor (SVOM) mission is a low earth orbit satellite dedicated to the study of GRBs. With its four main instruments of which two are French (*ECLAIRs* and *MXT*) and two are Chinese (*GRM* and *VT*), it significantly contributes to this scientific domain by improving our understanding of the GRB phenomenon and by allowing their use to understand the infancy of the Universe. In order to fulfill its scientific objectives, SVOM is complemented by a fast robotic 1.3 m telescope, SVOM/F-GFT named COLIBRÍ, with multiband photometric capabilities (from visible to infrared). The telescope has been inaugurated on September 7th, 2024.

COLIBRÍ: a robotic telescope

COLIBRÍ is the result of a very close collaboration between **France** and **Mexico**. The institutional partners are Aix-Marseille University, CNES and CNRS for France, and UNAM and CONACHyT for Mexico. The telescope is installed in the **Observatorio Astronómico Nacional (OAN)** in the **Sierra de San Pedro Mártir, Baja California**, at the highest point of the observatory at an altitude of about 2800 m.

The telescope has an alt-azimuth mount with a **1.3m primary mirror** which feeds an instrument composed of three channels: two operating in the visible (**DDRAGO**) and one in the near-infrared (**CAGIRE**) allowing us to observe in ***grizyJH*** from **400 to 1800 nm with three simultaneous cameras**.

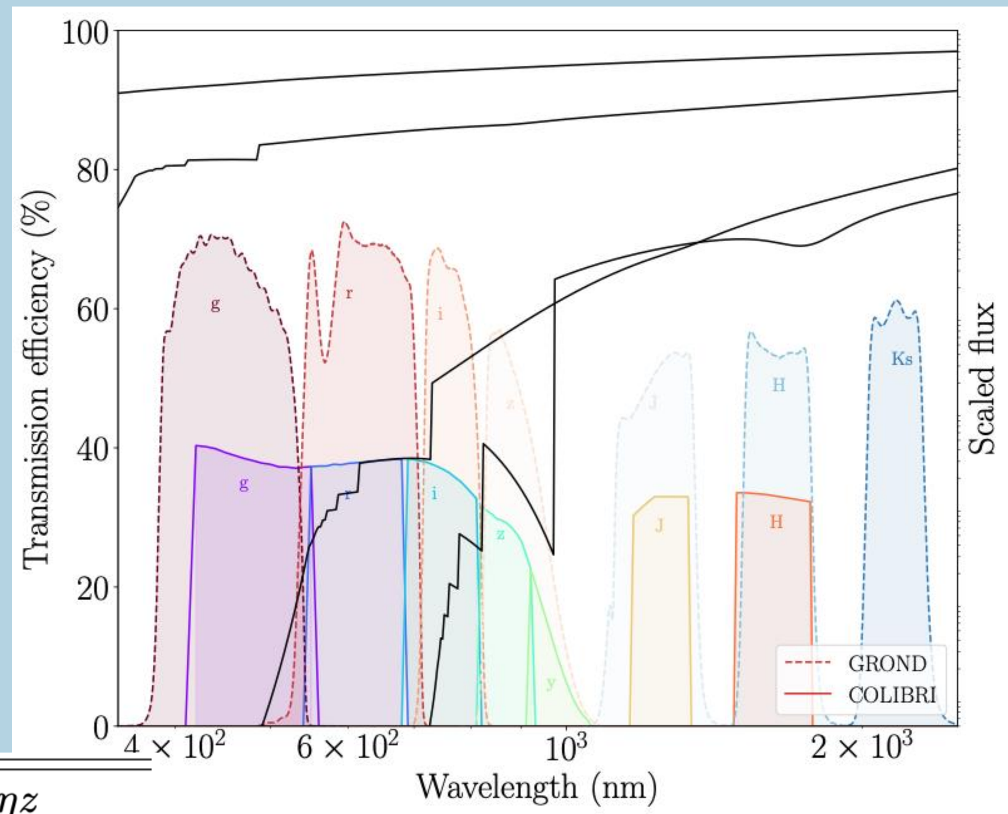
Table 1. Comparison between GROND, RATIR and DDRAGO/CAGIRE.

		GROND	RATIR	DDRAGO/CAGIRE
Direct-imaging channels	FoV	5.4 × 5.4 arcmin	5.3 × 5.3 arcmin	26 × 26 arcmin
	$f/\#$	$f/8$	$f/13.5$	$f/6.3$
	Detectors	4 CCDs for g, r, i, z	2 CCDs for ugr, i	2 CCDs for gri, zy
Reimaging channels	FoV	10 × 10 arcmin	10 × 10 arcmin	21.7 × 21.7 arcmin
	$f/\#$	$f/2.88$	$f/9$	$f/3.7$
	Detectors	3 H1 for J, H, K	2 H2RG for zy, JH	1 LYNRED for JH

The goal is to have a delay for **pointing of less than 20 s**, with a **precision of localization of 0.5 arcsec** and to provide **real-time data processing in less than 5 minutes** after the trigger.

Photometric redshift estimation

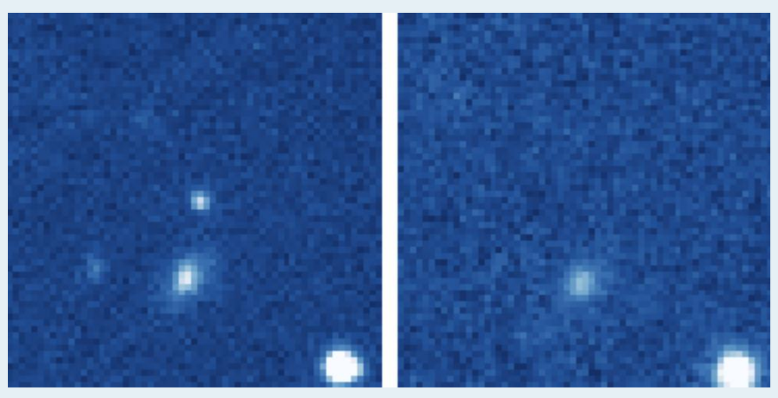
- **Photo-*z* (dropout technique) estimation in the first 5 minutes** of the observation
- Multiple observation strategies have been tested to optimize the detection rate and estimation accuracy
- Photo-*z* code open-source[2] and working not only with COLIBRÍ

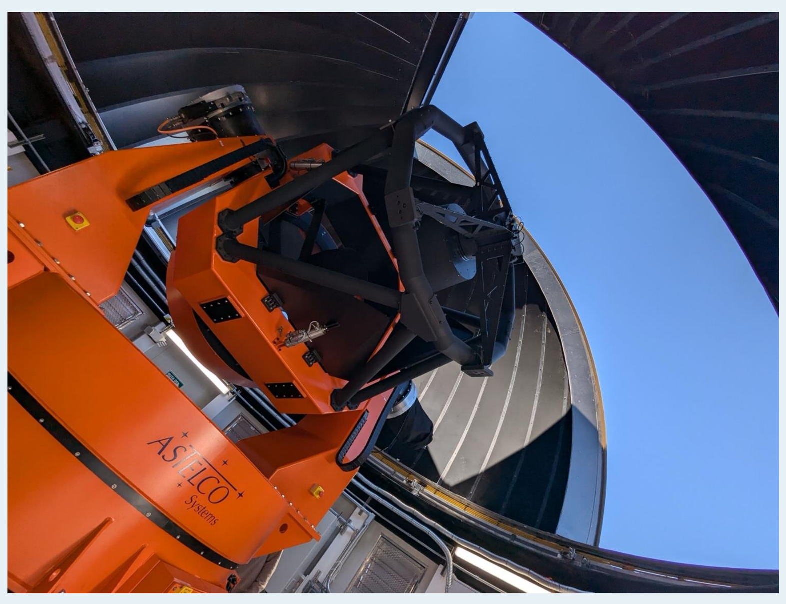


	nb of detections	ηz
$z < 3.5$	207 / 238 (87%)	0.0 ± 0.42
$3 \leq z \leq 8$	243 / 304 (80%)	-0.03 ± 0.10
$z > 8$	61 / 83 (73%)	-0.13 ± 0.14

Photometric-*z* accuracy tested on simulations of realistic GRB afterglow observations

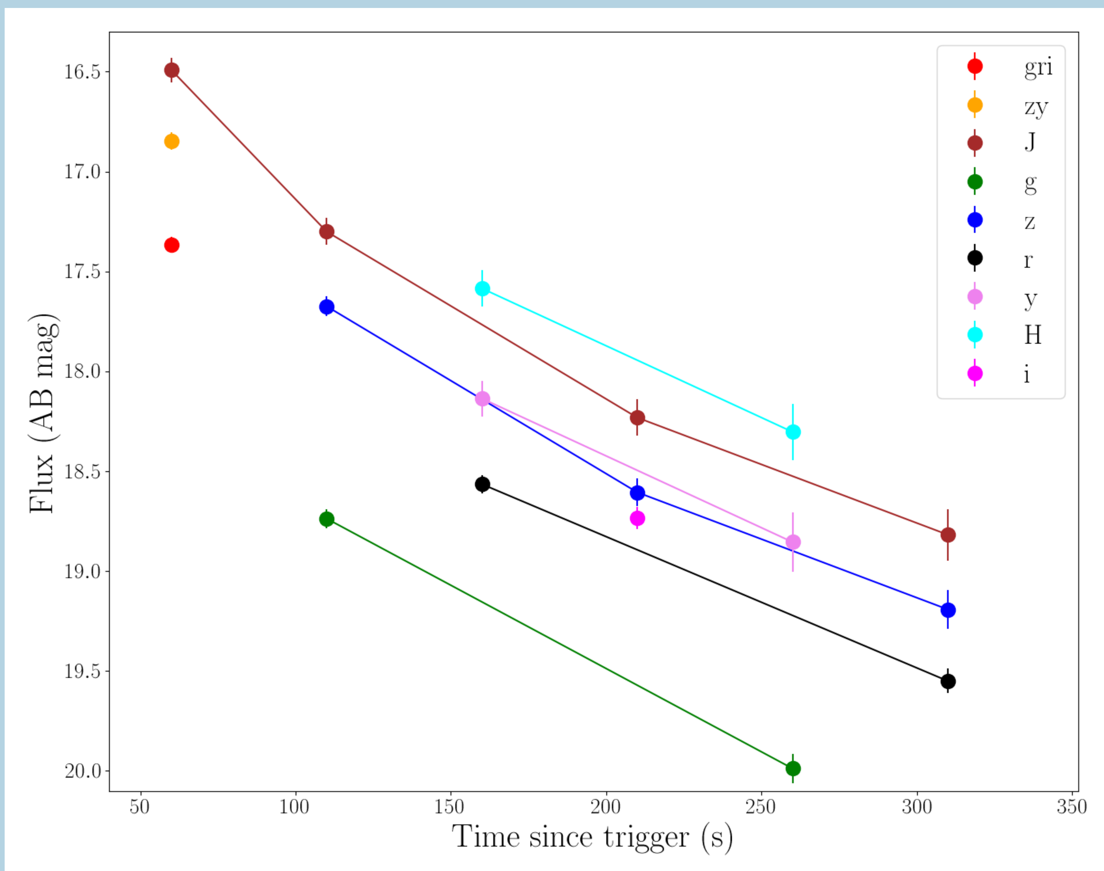
GRB 250129A: COLIBRÍ/DDRAGO first Afterglow Detection





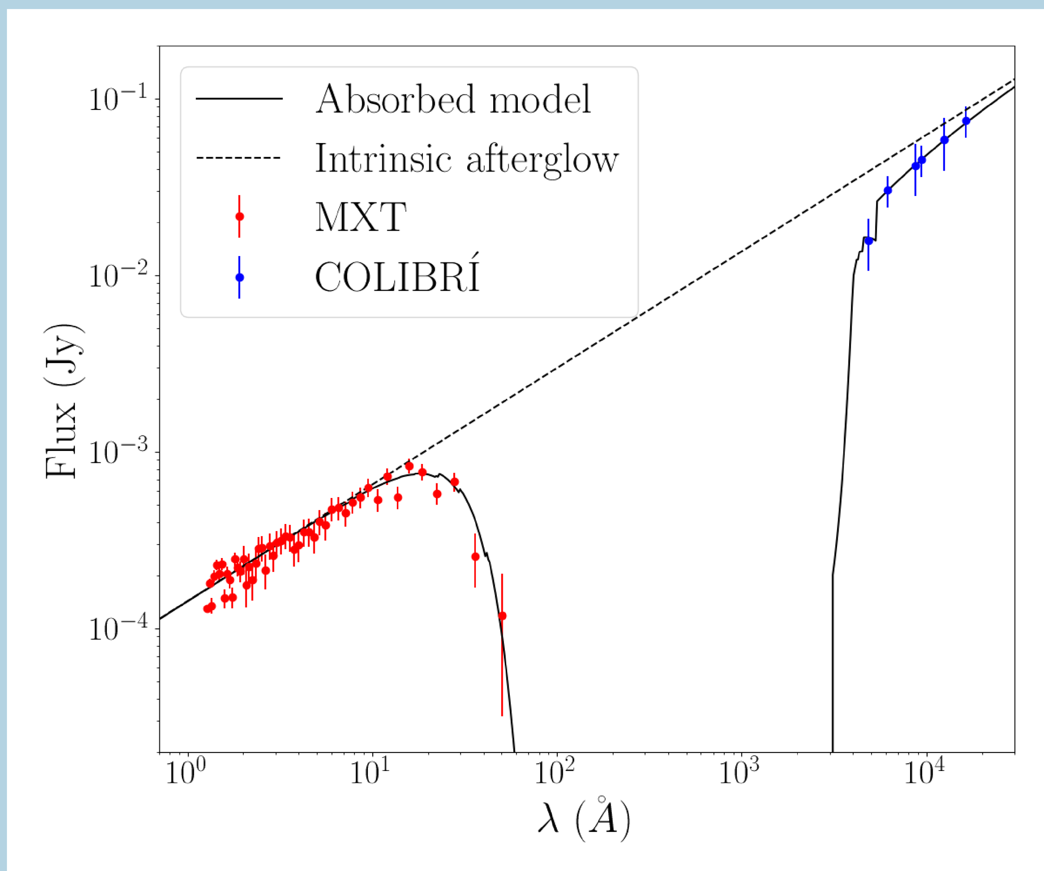
Multiwavelength light curve

Simulation of a COLIBRÍ GRB light curve



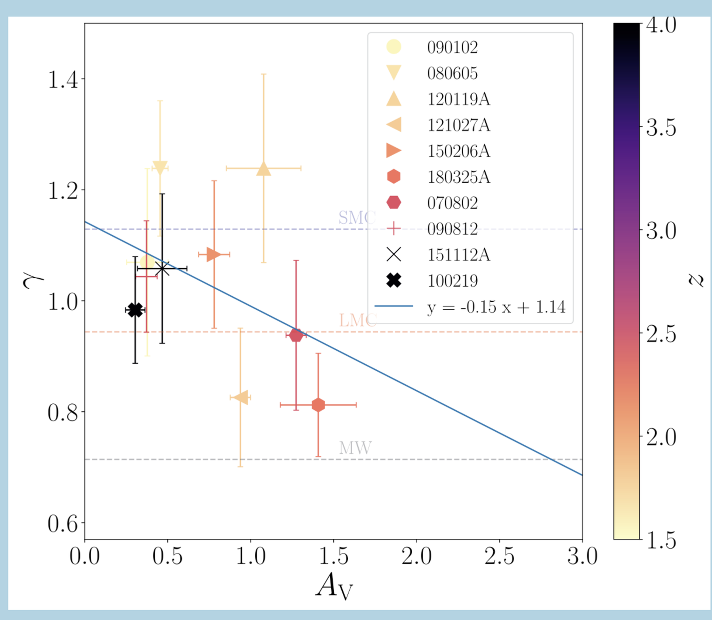
Spectral energy distribution

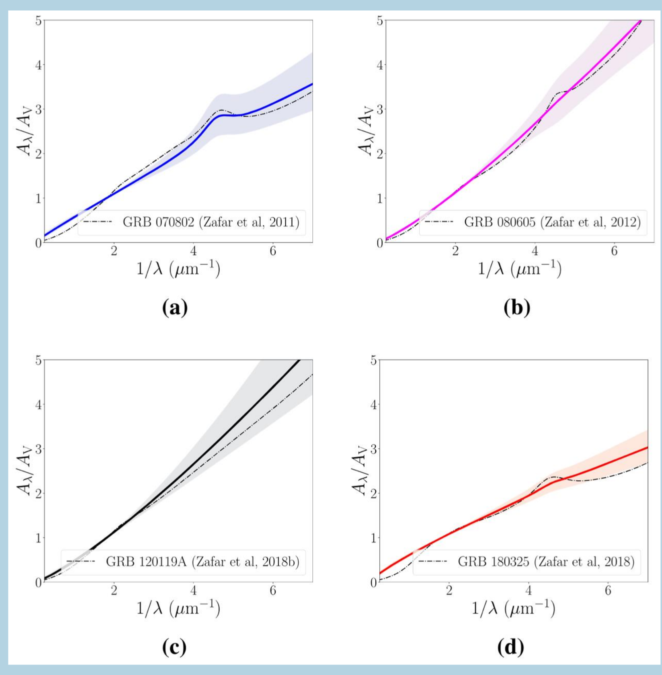
SVOMT/MXT COLIBRÍ synergy



A simple dust extinction law model

We have introduced a **simple model of dust extinction based on a power-law form and designed for photometric studies**. The singularity of our model is its independence from prior assumptions on the size and distribution of the dust grains. With this simple model, we are able to measure the general shape of GRB host galaxies extinction curves with only **two parameters: the extinction slope, γ, and the 2175 Å absorption amplitude, E_b**





Conclusion

- The association of SVOM/COLIBRÍ (F-GFT) will allow us to observe dusty and highly redshifted GRBs and to study the color evolution of their afterglows during the next decade
- COLIBRÍ will automatically point at GRB alerts in < 20 s and provide an estimate of the photometric-*z* in the first 5 min
- Open not only to GRB sciences: X-ray binaries, Fast Blue Optical Transients, interacting supernovae, KN not detected by GWs, GRB host galaxies, AGN, …
- COLIBRÍ in full operation with DDRAGO/CAGIRE by ~December 2025

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References: Corre et al. 2018, Fuentes-Fernandez et al. 2020, Basa et al. 2022, Rakotondrainibe et al. 2024. Useful links: https://www.colibri-obs.org/, https://pygrbz.readthedocs.io/