Damien Turpin (CEA)

The TAROT network and the OHP/1.93m telescope

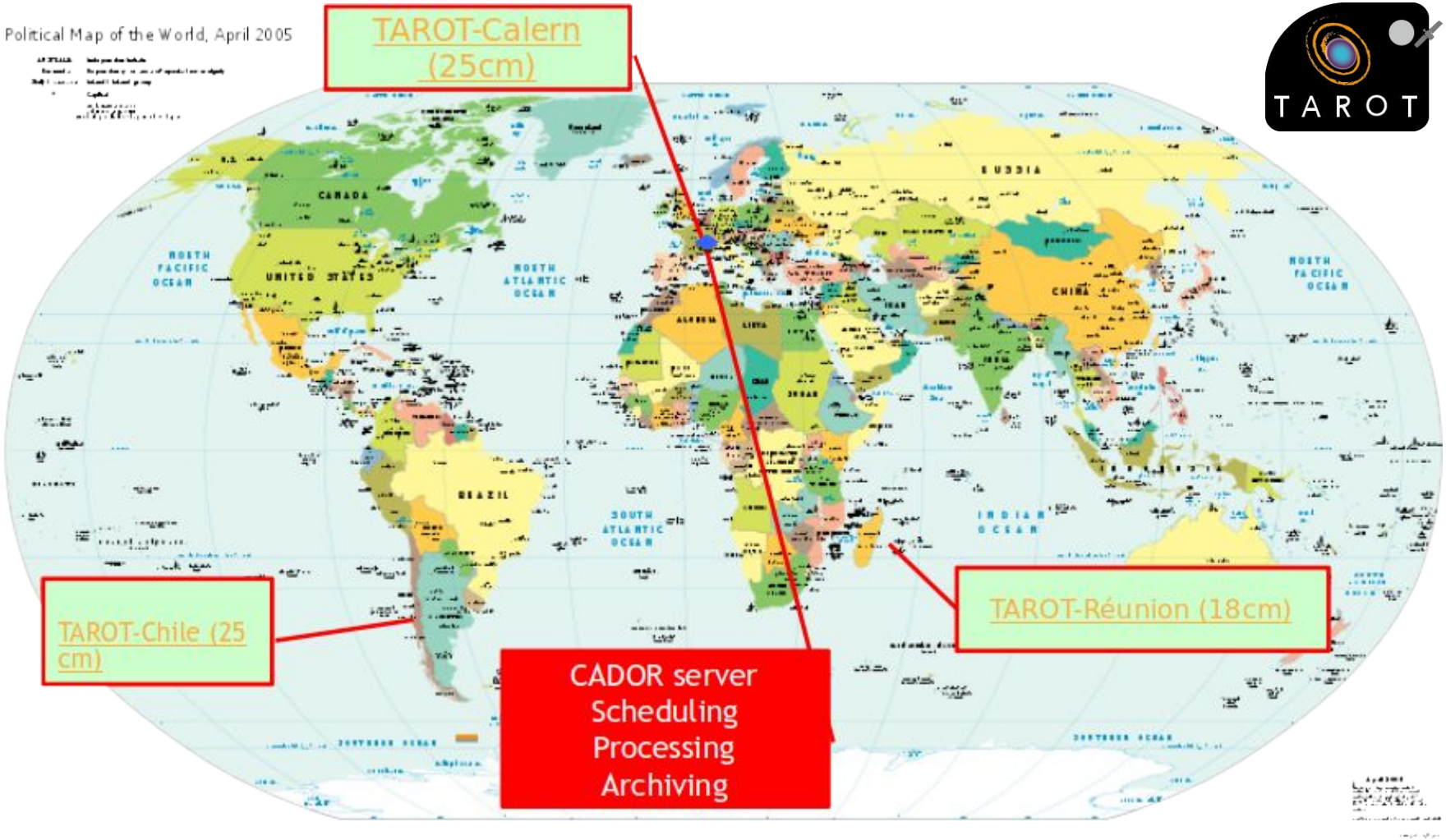
An example of two associate partners of SVOM

Télescopes à Action Rapide pour les Objets Transitoires

S. Antier (OCA) & A. Klotz (IRAP)

Since 1997, PI A. Klotz

At Calern (Nice) Observatory


Political Map of the World, April 2005
TAROT-Calern (25cm)
TAROT-Chile (25 cm)
CADOR server
Scheduling
Processing
Archiving
TAROT-Réunion (18cm)
TAROT

New TAROT (oct 2024) : Installed in New-Caledonia

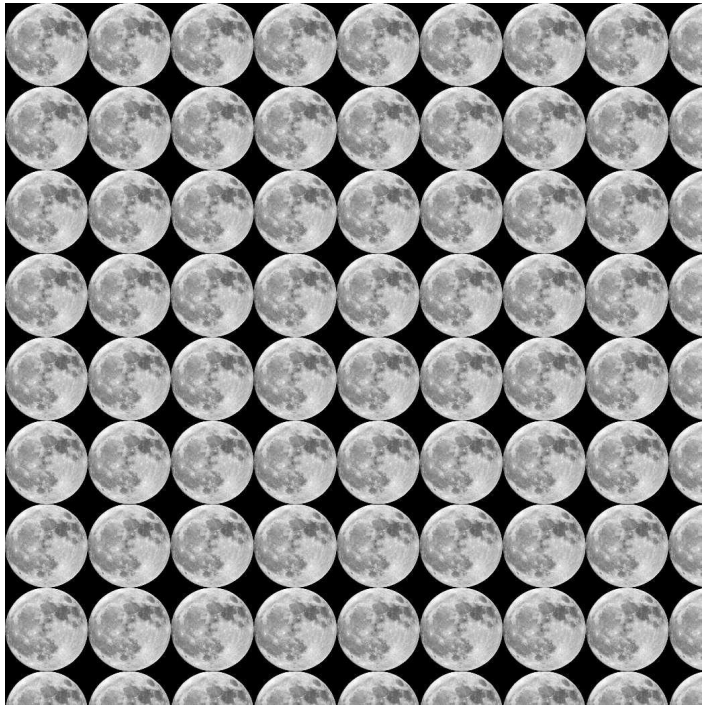
A transportable observatory

Characteristics

	TCA	TCH	TRE	TNC
First light	1997	2006	2016	10.2024
Magnitude limit	18	18	17	18
Diameter	25cm	25cm	18cm	~36cm
Focale	85cm	85cm	50cm	50 cm
Monture	Equatorial			
Pointing speed	~10s			
Optique system	Newton hyperbolique			

TCA/TCH
1.8x1.8 deg2

TRE/TNC
4.2x4.2 deg2



Organisation

PI A. Klotz

50%
Satellite Tracking
CNES

Team IRAP

A. Klotz
Professor

A. Koralewski
Technicien
Scheduler Software

E. Pallier
Engineer
Software manager

Team OCA

S. Antier
Professor Associate
Respo. Science

C. Limonta
Technicien
Network and
Architecture manager

M. Böer
Director of Research

S. Gervasoni
Engineer
Project Assistant

GRANDMA
SVOM
…

Partners

Help

E. Le Floch for TRE
ESO

TAROT science: about 2 pub/year

Publications and students over the last 5 years

GRB : Rapid follow-up of GRBs to investigate the early time of the optical afterglow

Ready for O4 II: GRANDMA Observations of Swift GRBs during eight-weeks of Spring 2022, A&A, Tosta e Melo et al
Understanding the Nature of the Optical Emission in Gamma-Ray Bursts: Analysis from TAROT, COATLI, and RATIR Observations, MNRAS, 2023 R. L. Becerra et al
GRANDMA and HXMT Observations of GRB 221009A -- the Standard-Luminosity Afterglow of a Hyper-Luminous Gamma-Ray Burst, ApJL, 2023, Kann et al.
Modeling GRB 170202A fireball from continuous observations with the Zadko and the Virgin Island Robotic Telescope, ApJ, 2022, Gendre et al.
GRB 160410A: the first Chemical Study of the Interstellar Medium of a Short GRB, MNRAS, 2021, Fernandez et al
Modelling the prompt optical emission of GRB 180325A: the evolution of a spike from the optical to gamma-rays ApJL, 2020, Becerra et al.
Reverse Shock Emission Revealed in Early Photometry in the Candidate Short GRB 180418, ApPj, 2020, R. Becerra

GW : Search of optical counterpart of GW events

GRANDMA Observations of Advanced LIGO's and Advanced Virgo's Third Observational Campaign, Antier et al., MNRAS, 2020
The first six months of the Advanced LIGO's and Advanced Virgo's third observing run with GRANDMA, Antier et al., MNRAS, 2020
Limits on the Electro-Magnetic Counterpart of Binary Black Hole Coalescence at Visible Wavelength, K. Noysena et al., ApJ 2019

Other sources

Scaling slowly rotating asteroids by stellar occultation, A&A 679, A60 (2023)
MUPHOTEN : a MUlti-band PHOtometry Tool for TElescope Network, 2022, Duverne et al., PASP, 134, 114504.
A large topographic feature on the surface of the trans-Neptunian object (307261) 2002 MS4 measured from stellar occultations, A&A 678, A167 (2023)
Observations of the RRc variable LINEAR 1169665 with the robotic telescope TAROT, F. Le Borgne et A. Klotz, GEOS RR, 2019

PhD students

2017 – 2020 : K. Noysena (sup. A. Klotz & Boer), 100 % du temps dédié à l'exploitation scientifique de TAROT
2019 – 2022 : P. A. Duverne (sup. Antier & Hello) 10 % du temps dédié à l'exploitation scientifique de TAROT

Science program

We hope to image the GRB ECLAIRs sources in less than 60s post alert reception and follow-up during the first night in average (further if bright)

Will immediately triggered when it is possible using the 4 TAROT telescopes on SVOM ECLAIRs GRBs (significant)

Data will be delivered to the science team (fits, with astrometry) within a week

Images will be taken with a sequence of clear with different exposure times, (possibly r, g, i for TCA and TCH)

Photometry will be performed on the best time scales and sent to science team.

<u>Status of the telescope for the date of the SVOM launch</u>

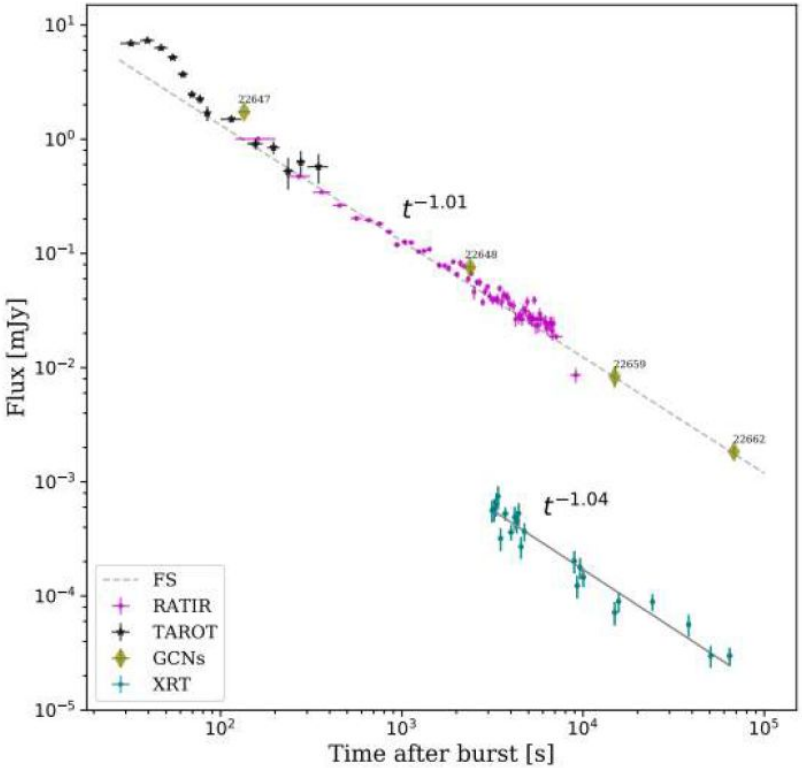
TCA, TCH operational

TRE for August 2024

TNC for October 2024

We need SVOM ECLAIRs Gcn events to run smoothly our observational strategy during commissioning

GRB science : Example of GRB 180418A



Light curve of GRB 180418A (short GRB candidate)

Prompt measures by TAROT, late measures by RATIR

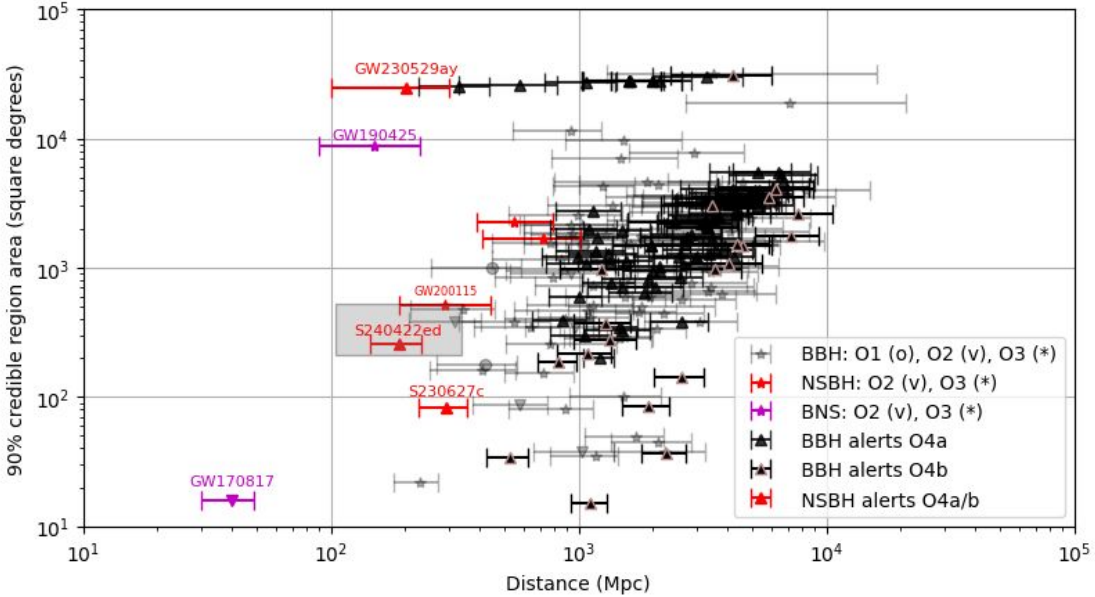
TAROT shows a flux excess before 100 seconds
Interpretation: Reverse shock emission

Reference: Becerra et al., 2019

Science program Gravitational waves

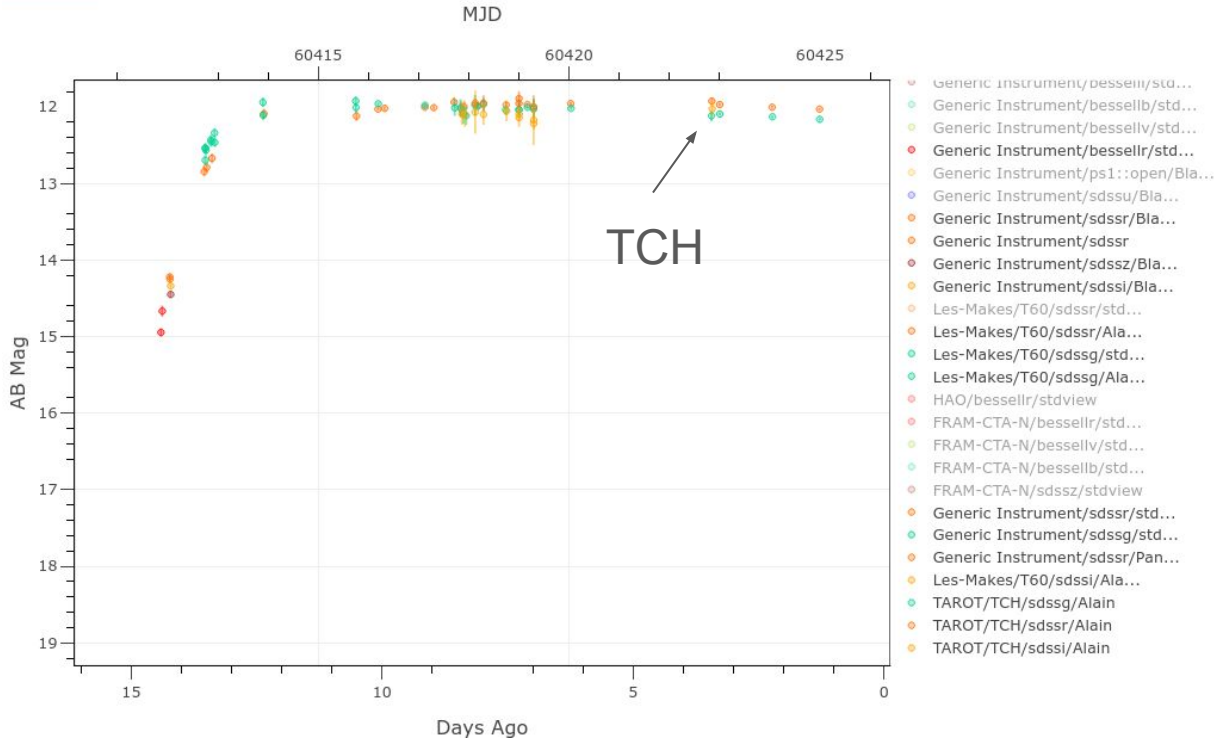
Campaign O3 (2019-2020) : TAROT observed more than 50 alerts of GWs

Campaign O4 (2023-2025) - No follow-up of TAROT since no interesting NS-BH/BNS alerts



Pillas, Antier et al., 2024

Other scientific program - Supernovae



Follow-up of SN2024ggi~IIb at 7 Mpc, data in g, r, in April, Wang et al., in prep

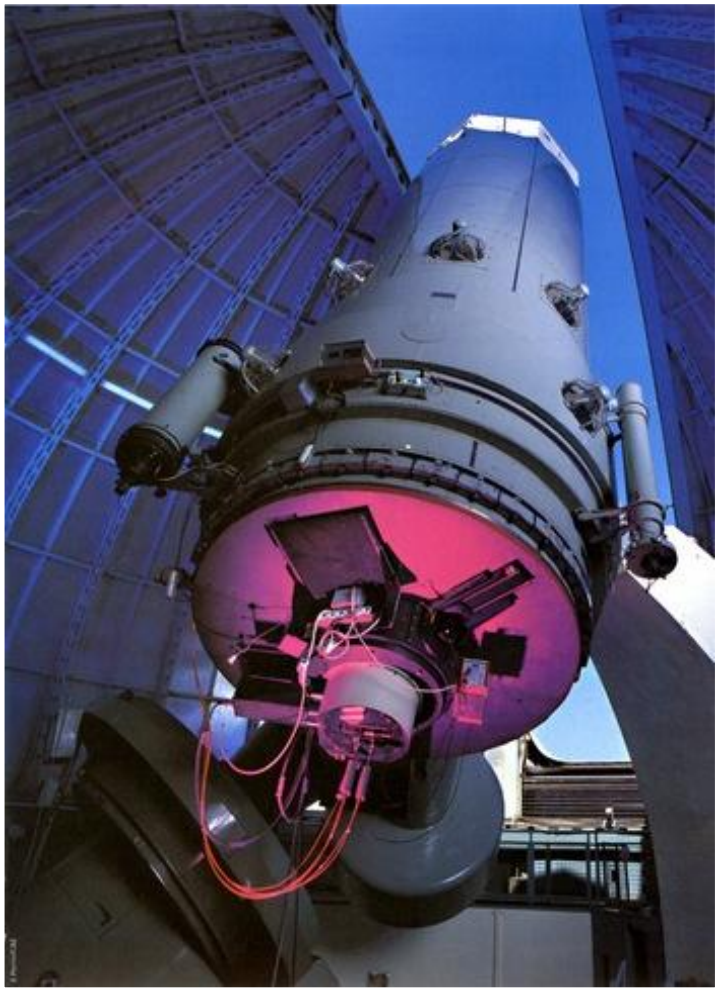
Xie Xie

Looking forward for

cf Tandem

Spectro-imaging follow-up of GRB afterglows with MISTRAL

PI: E. Le Floc'h



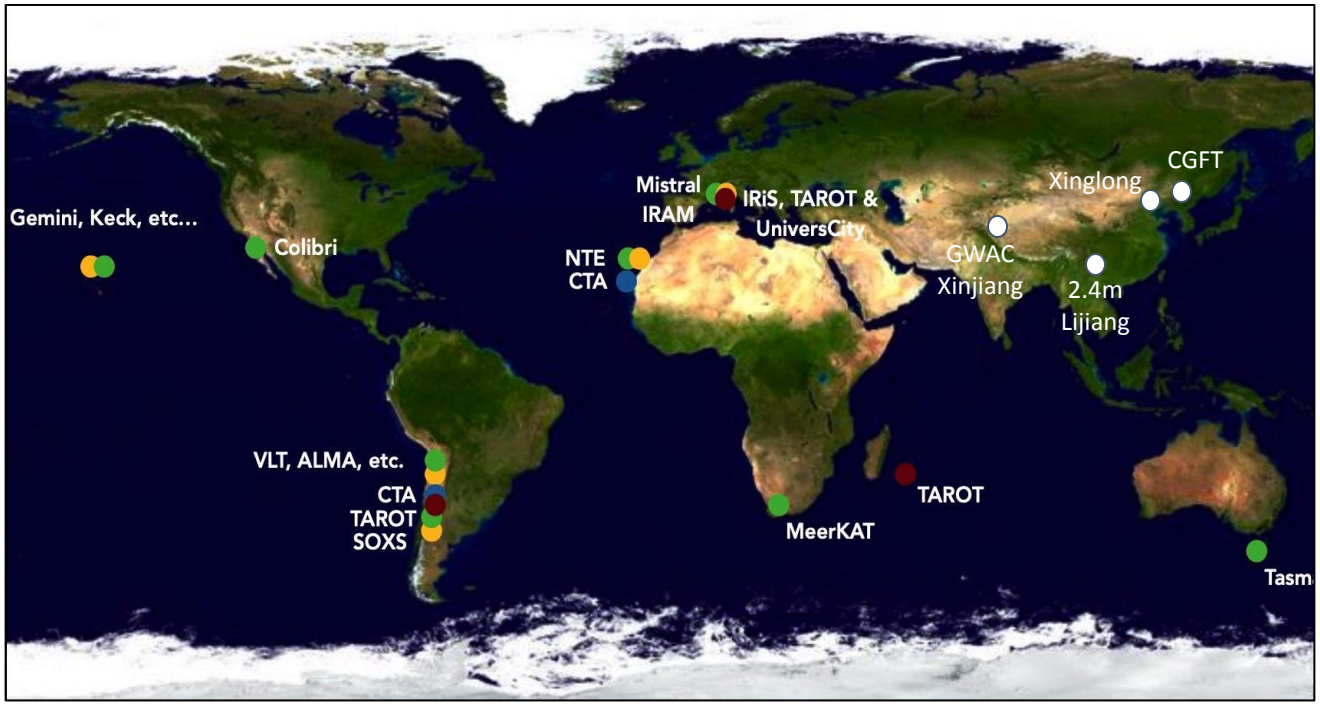
MISTRAL : a new spectrograph at Observatoire de Haute-Provence (France), permanently mounted on the T193cm telescope

- **Imaging: G', r', I', z', Y , Ha, [OIII], SII, Hb**
- **FOV : 5.1 arcmin (full), ~9 arcmin (total)**
- **Wavelength range : ~4200 – 10000 Ang.**
- **Spect. : blue (4200 – 8200 Ang.)**
  red (5800– 9950 Ang.)
- **Resolution : ~750 at 6000 Ang.**
- **Slit : 1.9"**
- **Sampling : 0.48 arcsec/px**

GRB follow-up on-going since 2022, led by the SVOM team

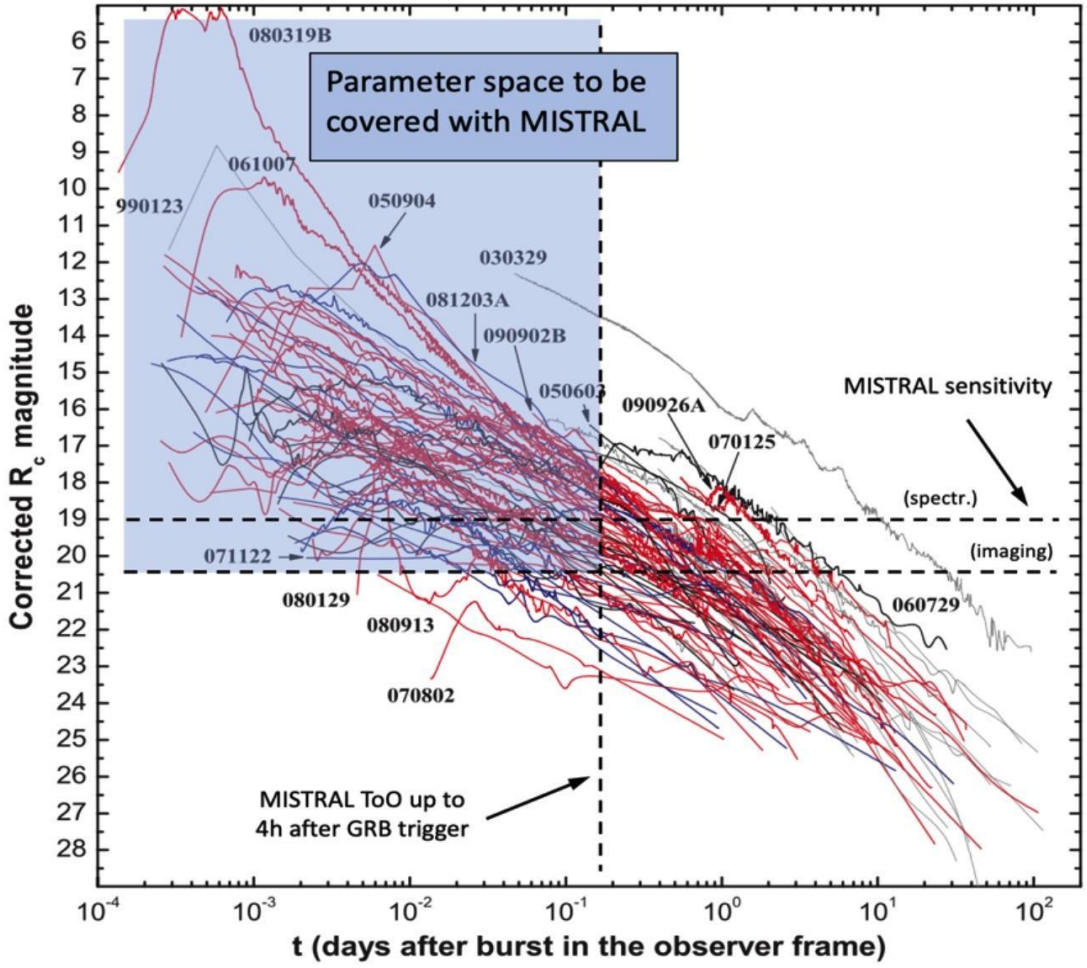
Spectro-imaging follow-up of GRB afterglows with MISTRAL

Two main goals : (i) Science (photometric monitoring, redshift determination, …)
(ii) Improving the French expertise for GRB follow-up in the SVOM era



OHP: strategic position between China (C-GFTs) and San Pedro Martir (Colibri)

Spectro-imaging follow-up of GRB afterglows with MISTRAL



Triggering criteria

- **<u>As proposed</u>:**
  - GRBs with well-localized X-ray afterglows (i.e., Swift XRT)
  - GRBs outside the Galactic plane (□ Av_Gal < 0.5mag)
  - $T_{MISTRAL} - T_0 < 4h$
  - R < 19mag for spectroscopy
- **<u>In practice</u>:**
  - Swift triggers often occur in European day time □ $T_{MISTRAL} - T_0 >> 4h$ and spectroscopy still rare ☹
  - Av_Gal sometimes relaxed

Spectro-imaging follow-up of GRB afterglows with MISTRAL

A typical GRB observation with MISTRAL

Decision (phase 1)

- Following a given alert (received through GCNs, Telegram, Astro-Colibri, …), we get together on a dedicated Slack Workspace to discuss and decide if a follow-up with MISTRAL is relevant (depending on observability, weather conditions and flux constraints already obtained by other groups)
- In case of a day-time trigger, we need a special approval from the head of OHP

Observation (phase 2)

- Observations are not automized at the OHP T193cm : real-time interactions are needed with the telescope operator. This is done again with Slack
- Data are automatically pushed to a cloud : we get them and adjust the observing strategy in real time (i.e., switch to spectroscopy if the afterglow is bright enough, or switch to other filters for the imaging mode)
- We are allowed for 2h max for a given ToO

Spectro-imaging follow-up of GRB afterglows with MISTRAL

A typical GRB observation with MISTRAL

Processing (phase 3)

- Data can be processed in real-time using Python codes dedicated to MISTRAL data reduction
- Photometric calibration still has to be done by hand, either during the night or (most often) the following day.
- GCNs are quickly drafted in most cases

Spectro-imaging follow-up of GRB afterglows with MISTRAL

We finally maintain a wiki page reporting all Swift GRBs and those observed with MISTRAL. GCNs are almost systematically issued following our MISTRAL observations

GRB	RA (J2000)	Dec (J2000)	Loc. error (")	XRT AG	Gal. Av (mag)	OHP ?	Comment
240529A	22:21:17	+51:33:19	3.5	Y	0.9	Yes	r'=19.8 +/- 0.3 https://gcn.nasa.gov/circulars/36575
240523A	02:14:16.31	-22:02:00.1	2.1	Y	0.04		Dec. too low
240516A	14:11:13.704	-63:29:16.08	6.12	Y	7.53		Dec. too low
240511	22:26:42.168	+08:30:46.44	1.8	Y	0.3		No visibility
240421	19:58:48.144	-14:51:34.92	1.8	Y	0.57		No visibility
EP240420a	228.713 deg	14.796 deg	180.0	N			ToO not allowed
240419B	21:43:35.289	+04:14:05.30	2.5	Y	0.25		ToO not allowed
240419A	06:18:08.016	-45:00:00.36	1.8	Y	0.2		Dec. too low
240418A	15:57:29.616	+23:35:45.6	1.8	Y	0.18	Yes	
240415A	08:36:45.32	+73:08:46.8	2.8	Y		Yes	r' = 21.67 mag https://gcn.nasa.gov/circulars/36124
240414A	12:19:08.52	+56:44:17.2	4.9	Y	0.06	Yes	z=1.833 https://gcn.nasa.gov/circulars/36084 https://gcn.nasa.gov/circulars/36085 https://gcn.nasa.gov/circulars/36101
240411B	15:26:10.11	-02:08:47.0	2.6	Y		Yes	r' = 23.1 mag https://gcn.nasa.gov/circulars/36067
240222A	09:32:53.976	-68:01:50.52	3.24	Y	0.51		Dec. too low
240218	10:47:11.352	+01:16:45.48	3.6	Y	0.14	Yes	r' > 23

Spectro-imaging follow-up of GRB afterglows with MISTRAL

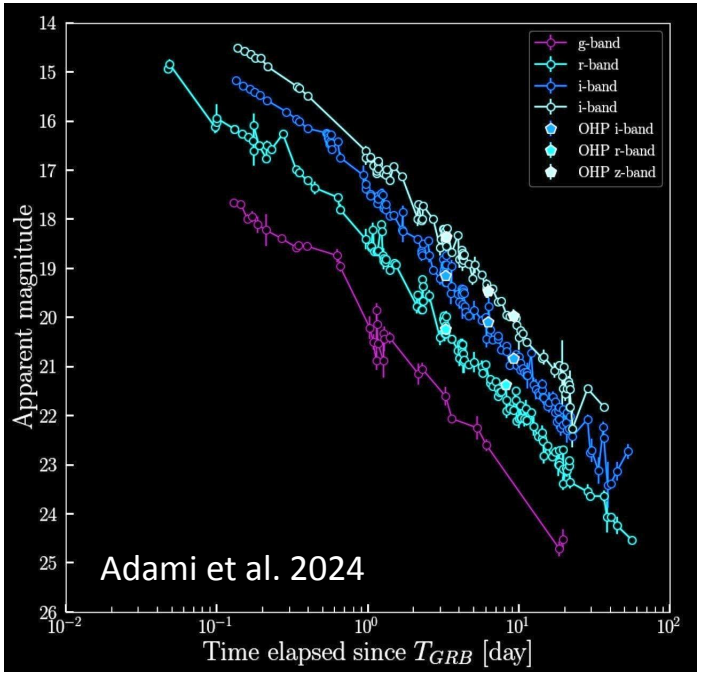
A few results

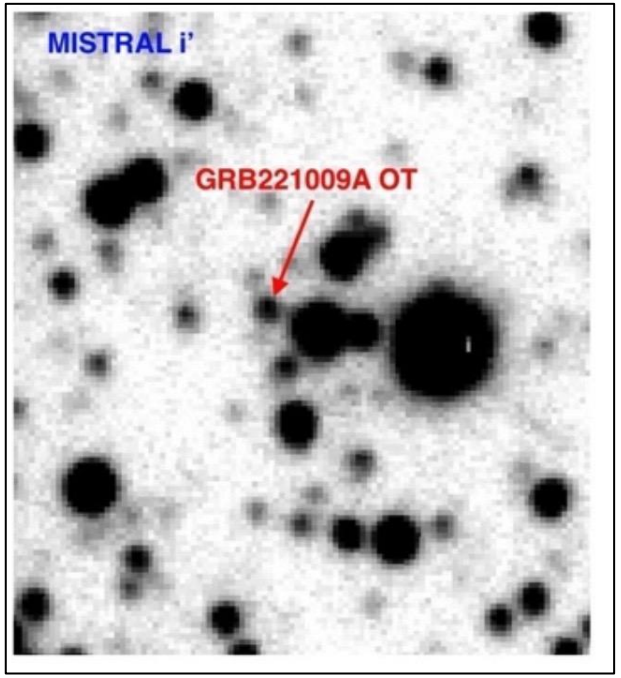
GRB 221009A (z=0.15), the brightest GRB ever observed over 50 years

Contribution to the late-time monitoring

Consistent with other follow-up reported in the literature

No deviation from power-law time decay (no evidence for an underlying SN despite its brightness and short distance)





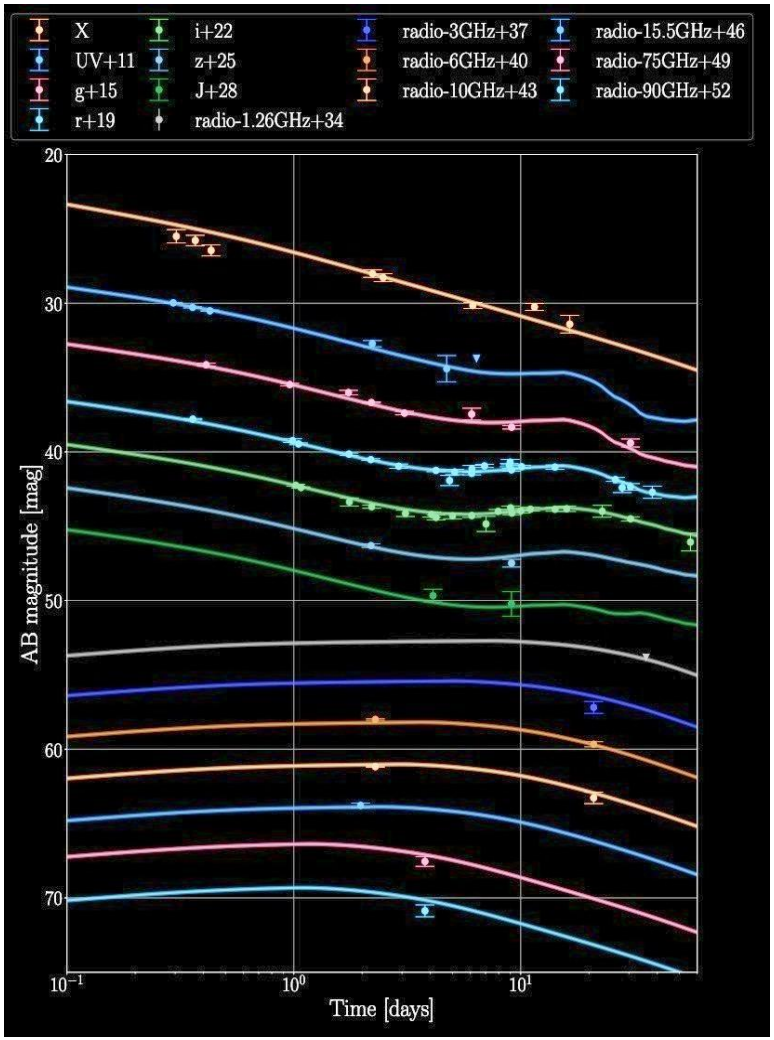
Spectro-imaging follow-up of GRB afterglows with MISTRAL

A few results

GRB 230812B and the associated SN2023pel

Hussenot-Desenonges et al. 2024 (led by the GRANDMA consortium, with a contribution from MISTRAL photometry)

- “Nearby” GRB : z=0.36
- One of the clearest case of association between a long GRB and a supernova
- 80 multi-wavelength observations combined !!
- Illustrates the need for a multi-observatory approach to enable detailed follow-up

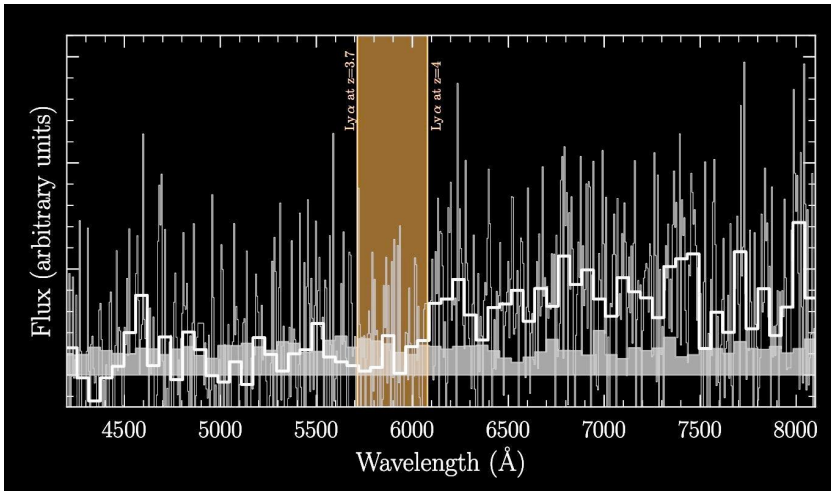


Spectro-imaging follow-up of GRB afterglows with MISTRAL

A few results

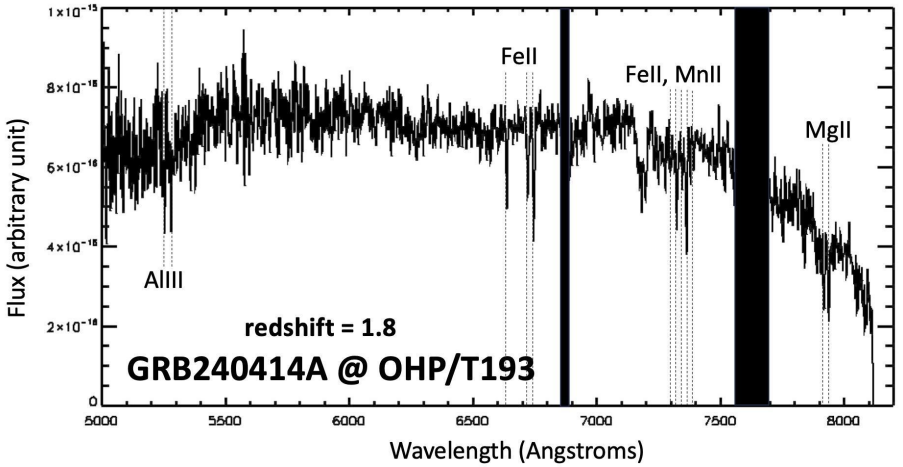
GRB 230506C

Constraint on the position of the Lyman break, leading to z~4 (Adami et al. 2024)



GRB 240414A

z=1.8 (also confirmed by GTC)
Current follow-up with JWST by another group (Levan +) to constrain the presence (or not) of an SN signature

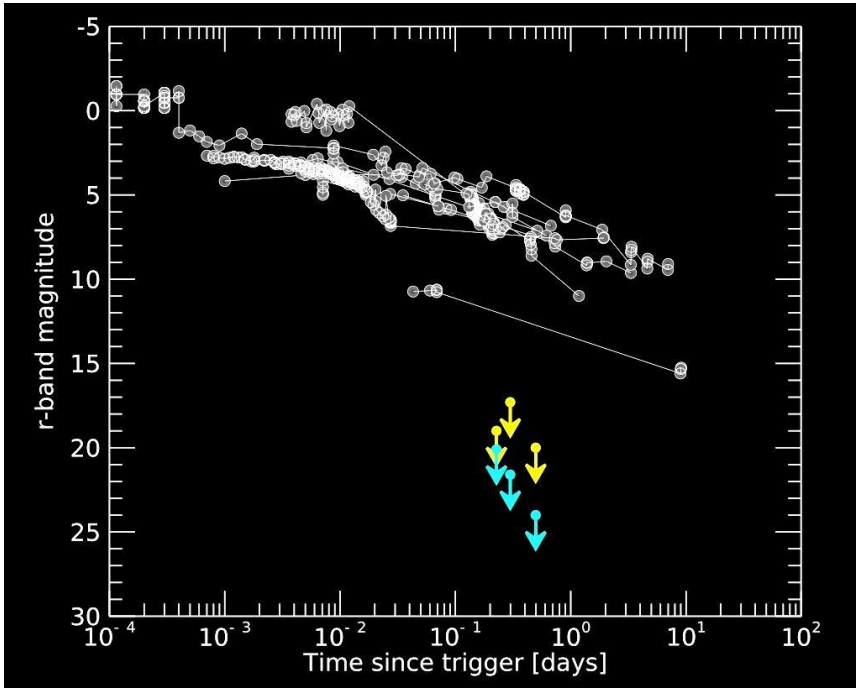


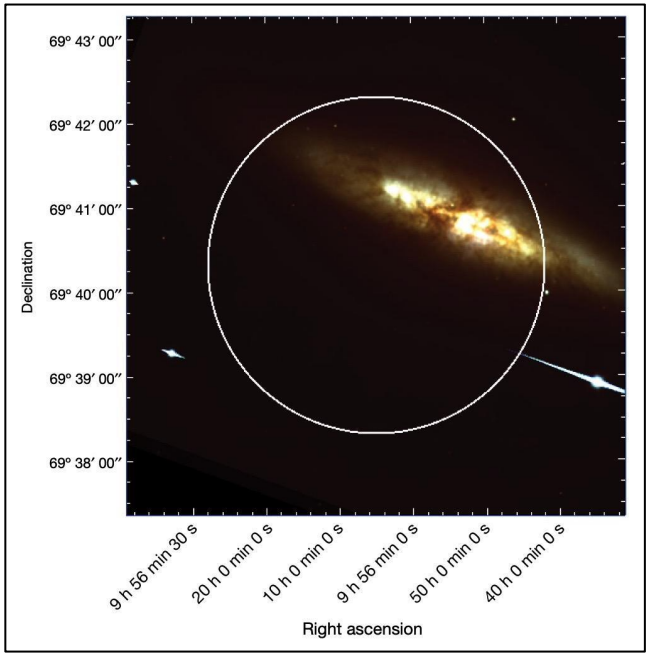
Spectro-imaging follow-up of GRB afterglows with MISTRAL

A few results

A giant flare from a magnetar in the M82 starburst galaxy

Mereghetti et al. 2024, Nature





- GRB 231115A, coincident with the location of M82
- Spectral and temporal properties along with the limits on the X-ray and optical counterparts (from MISTRAL and other facilities) qualify this burst as a giant flare within M82