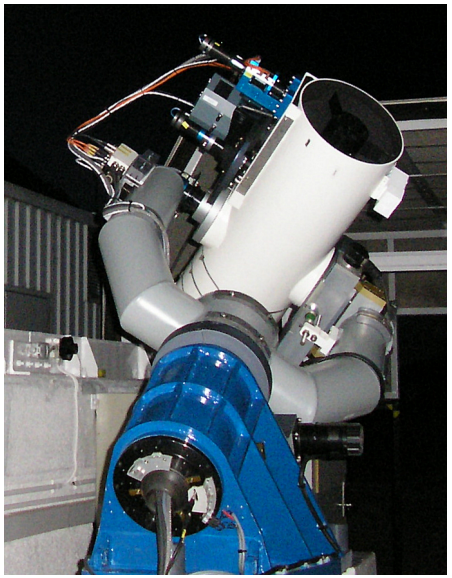
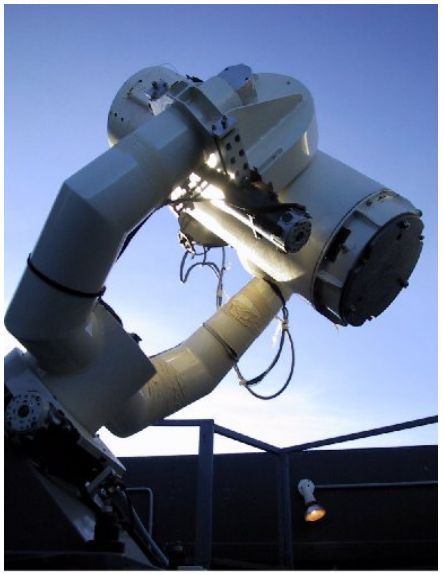


Alerts of the network of the TAROT telescopes



Loïc EYMAR

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France

ARTEMIS

With contributions of

cnes
CENTRE NATIONAL D'ÉTUDES SPATIALES

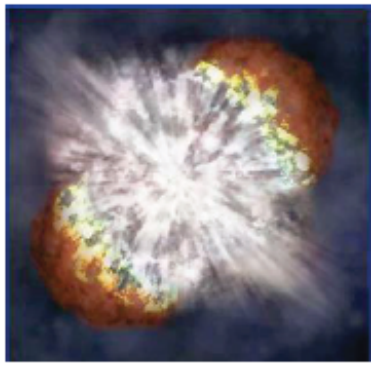
Institut Pythéas
Observatoire des Sciences de l'Univers
Aix*Marseille Université

TS2020-II

5 juin 2018

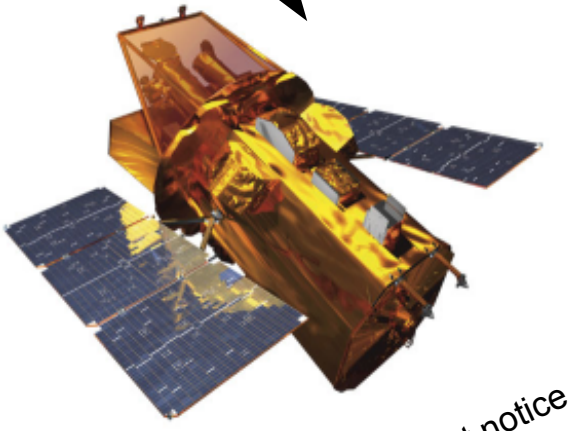
Principles of the observation gamma ray bursts

A star explodes



Other wavelengths

Gamma rays



Gamma rays are detected by spatial telescopes

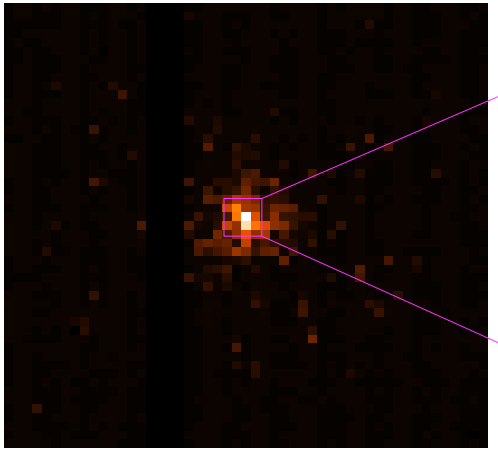
Find and perform a follow-up of the optical counterpart

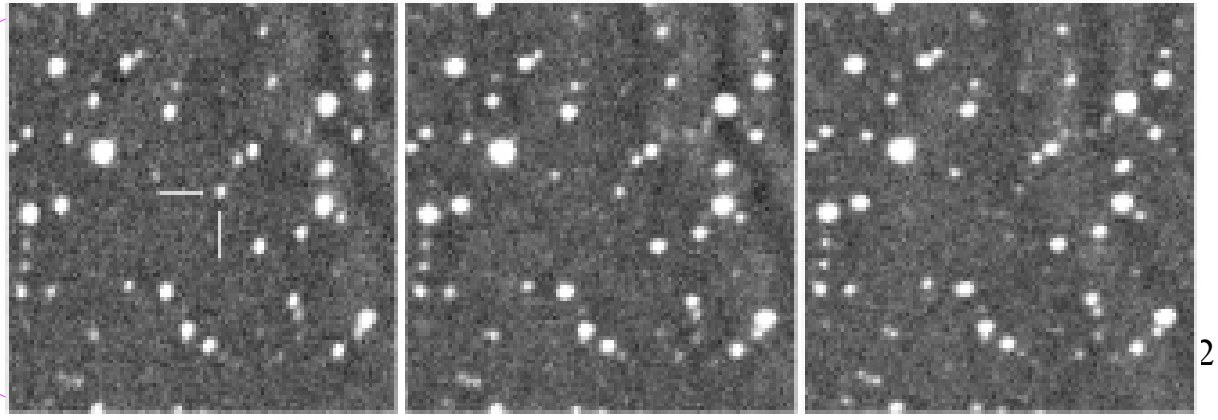
Alert notice

Find a star in an almost void field of view

Find a star in field of view amongst hundreds of stars

90 degrees





0.1 degree

+8 min

+40 min

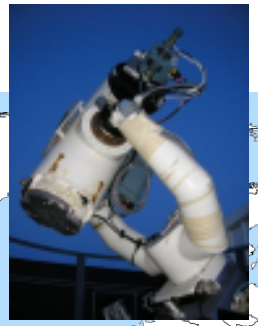
+1h30min

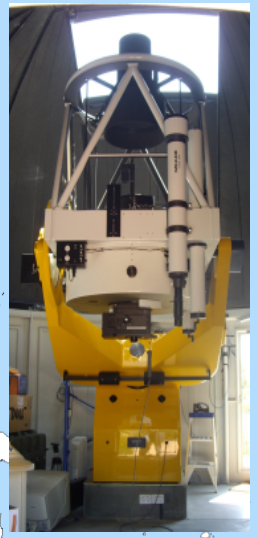
TAROT + Zadko – Heterogeneous network of telescopes

Alain KLOTZ | Michel BOER | David COWARD

CADOR computers at OHP (France)
Web acces and storage 30 To

TAROT Calern (France)
D = 25 cm
FoV = 2° x 2°
Slewing < 10 s
Since 1998





TAROT La Silla (Chile)
D = 25 cm
FoV = 2° x 2°
Pointing < 10 s
Since 2006

TAROT Reunion (France)
D = 18 cm
FoV = 4° x 4°
Pointing < 5 s
Since 2016

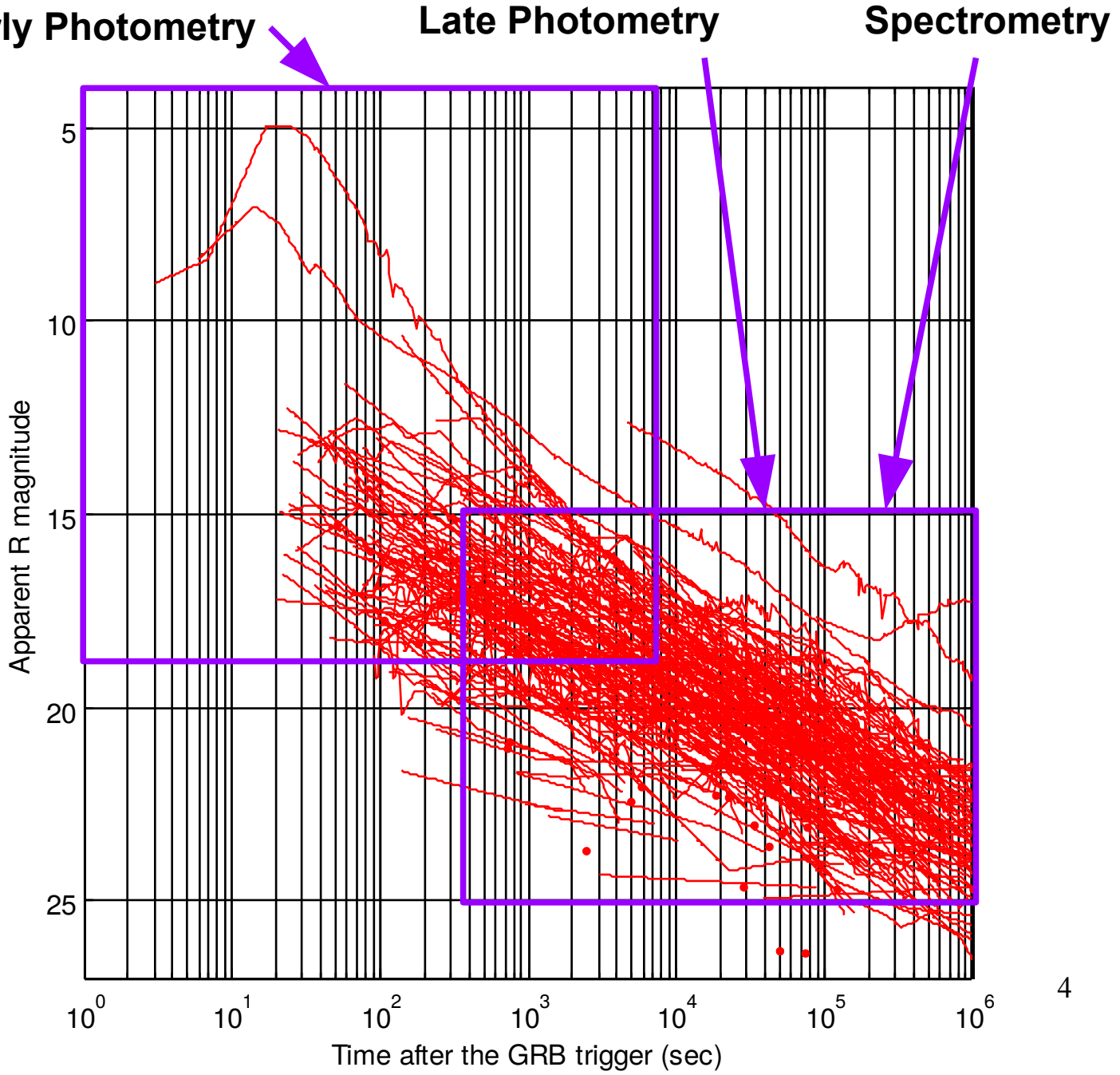
Zadko (Australia)
D = 1 m
FoV = 23 x 23 arcmin
Pointing ~ 60 s
Since 2010

Optical telescopes for GRBs

Photometric follow-up (light curves)

Gamma trigger
t0 : t0+300s

Swift
INTEGRAL
FERMI



Optical telescopes for GRBs

Classification of telescopes

Gamma trigger
t0 : t0+300s

Swift
INTEGRAL
FERMI

Early Photometry
t0+30s : t0+2h

MASTER
MITSuME
Rotse
TAROT
UVOT
TNT
PROMPT
REM
KAIT

Small diameters
20 cm to 1 meter
Rapid slewing
Autonomous

Late Photometry
t0+3min : t0+1 week

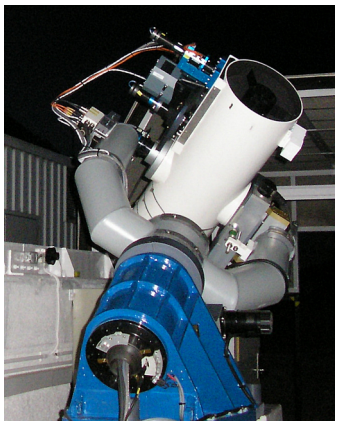
GROND
Shajn
NOT
RATIR
P60
Tautenburg
Faulkes
Liverpool
RTT150

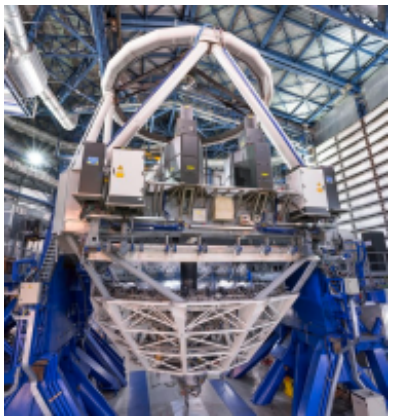
Intermédiate diameters
1 to 4 meters
Standard pointing
Human vérif.

Spectrometry
t0+1h : t0+1day

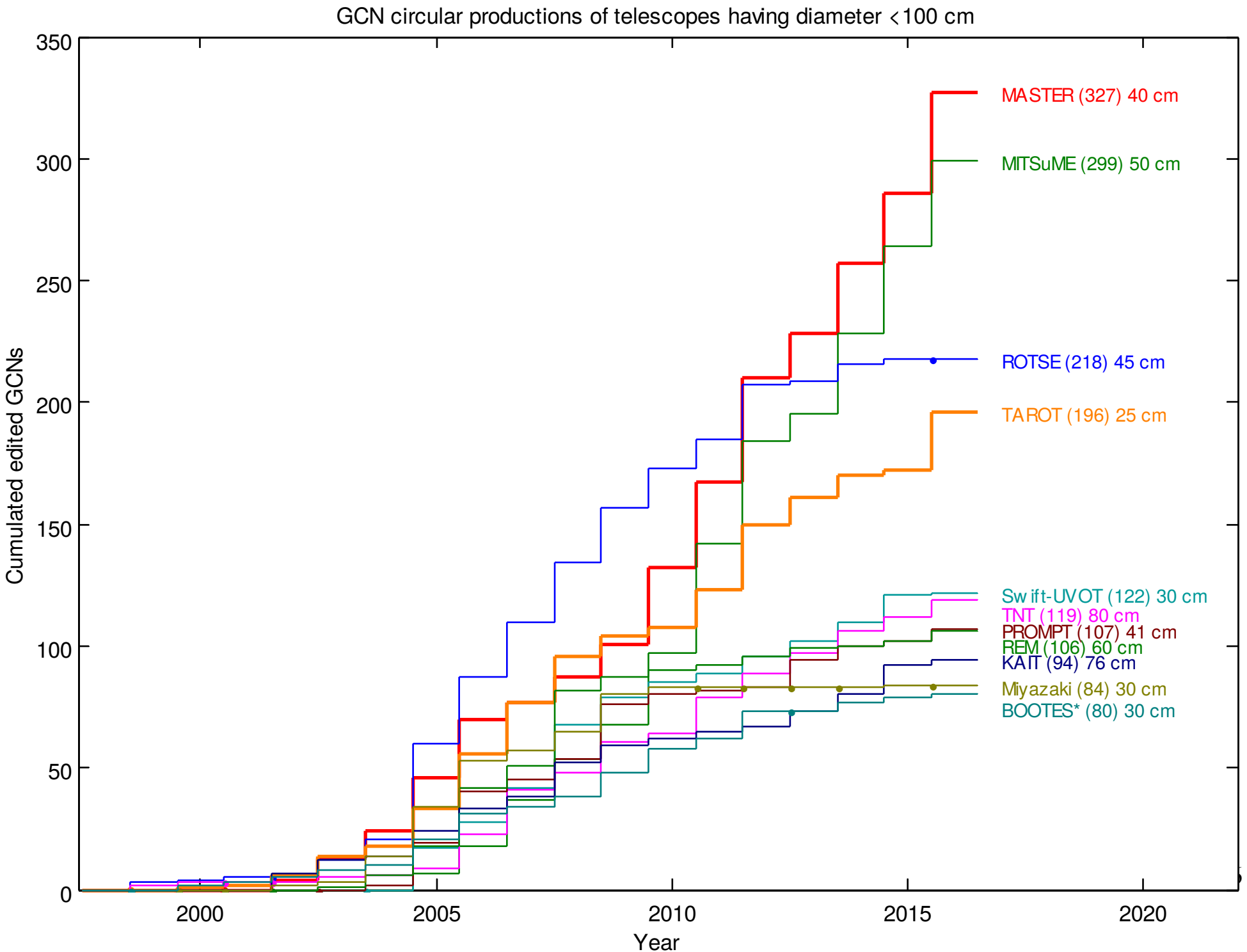
VLT
Gemini
Keck
Magelan
GTC

Large diameters
4 to 11 meters
Slow reactivity
Human manual



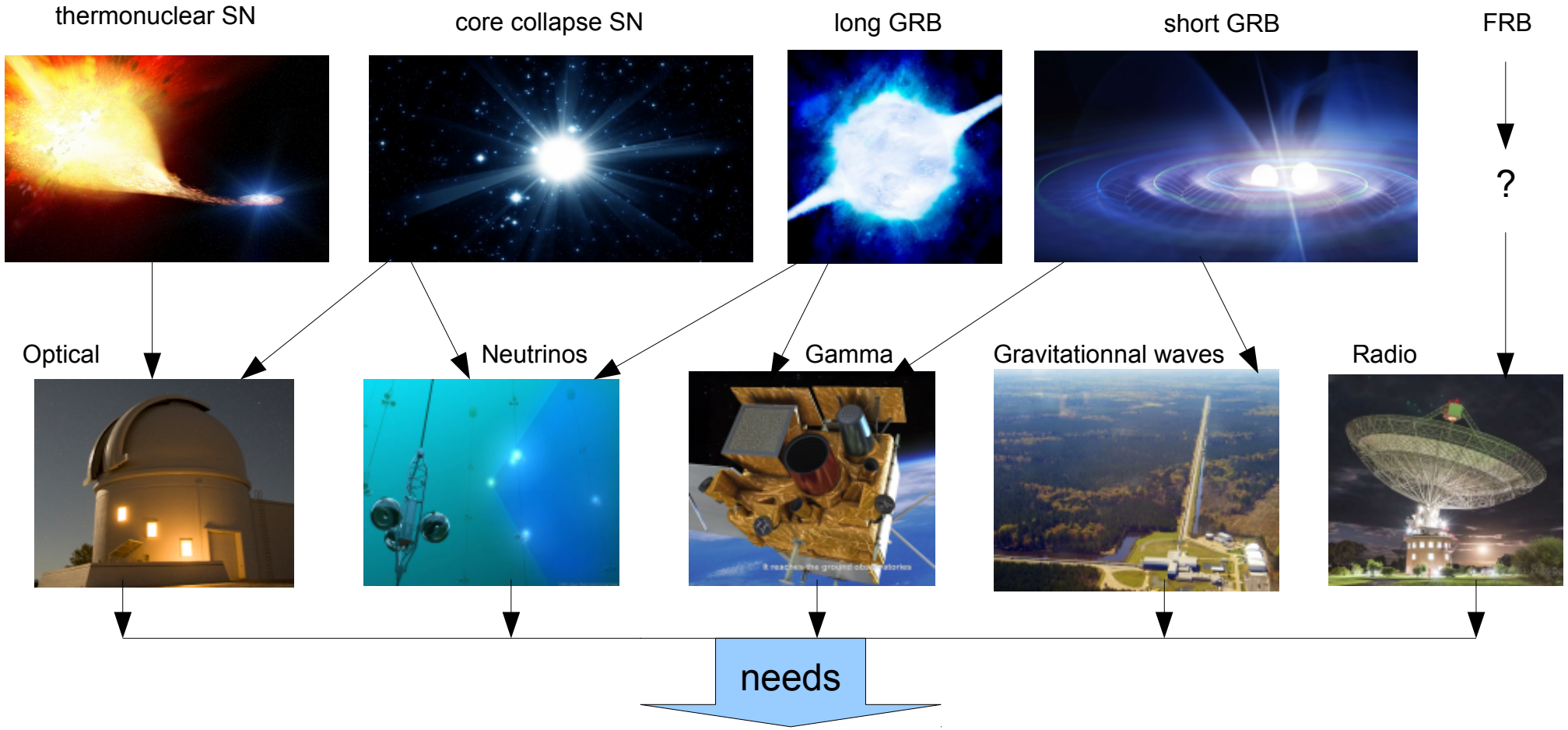


Telescopes for GRBs : Early photometry



Prepare the optical observations after 2020

Context of cosmic explosions



Prompt observation of cataclysmic events => Rapid slewing mounts

Large field of view => Short focal length optics
Network of telescopes

Deep detectivity => Large diameter

Different kinds of ALERTS

Trigger instrument	Delay	Error box	TAROT+Zadko
GRB Swift BAT	15s	6 arcmin	15 /year
GRB Integral Ibis	15s	3 arcmin	1 /year
GRB FERMI LAT	few hours	1 deg	1/year
GRB FERMI GBM	few minutes	5 deg	1/year
Neutrinos ANTARES	10s	1 deg (muons)	10/year
Neutrinos KM3Net	10s	1 deg (electrons)	10/year (>2020)
GW Ligo	few minutes	40 deg	2/year
GW Ligo + Virgo	few hours	10 deg	1/year

TAROT – Summary of scientific publications about GRBs

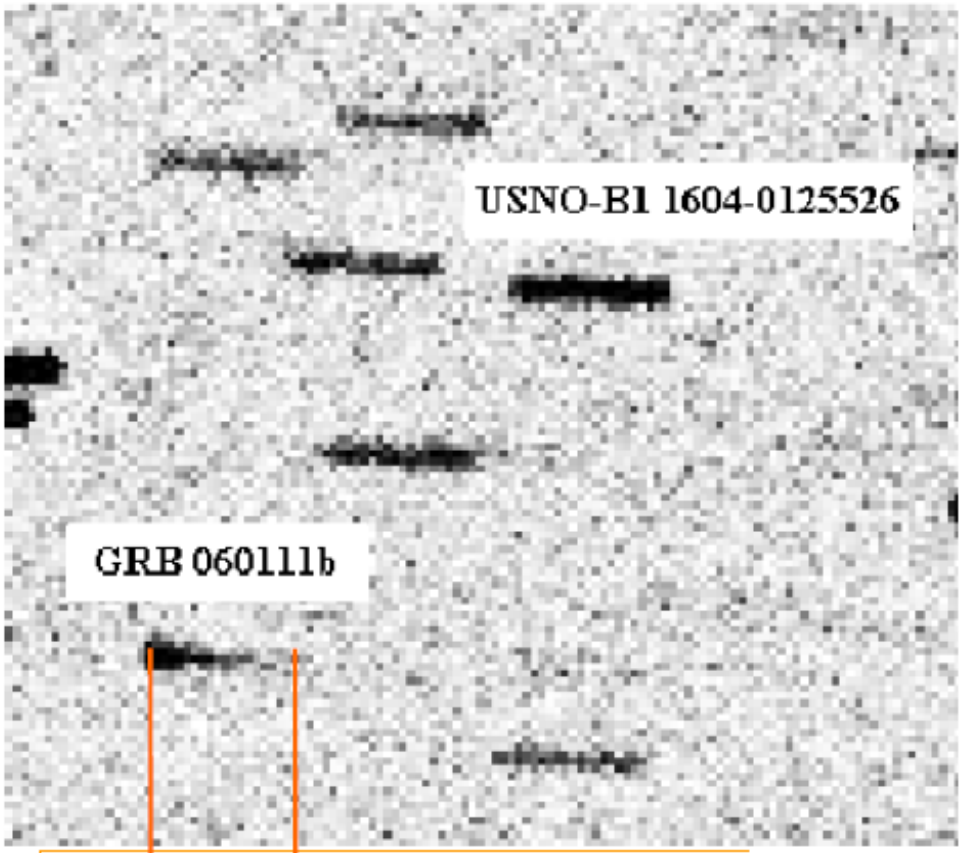
205 GRBs observed

- 5% observed during gamma emission + optical counterpart detected
- 13% observed during gamma emission without counterpart detected
- 10% observed after gamma emision + optical counterpart detected

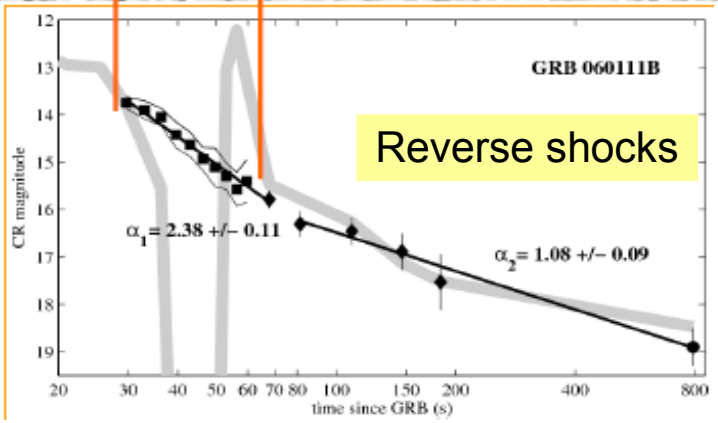
26 papers on GRBs in referred journals
196 GCN circulars

GRBs with TAROT – Early observations

The "drift" technique: Good temporal resolution during the first minute



(Klotz et al. 2006 A&A 451, L39)



GRB 081126
Lag Optic-Gamma = +8s

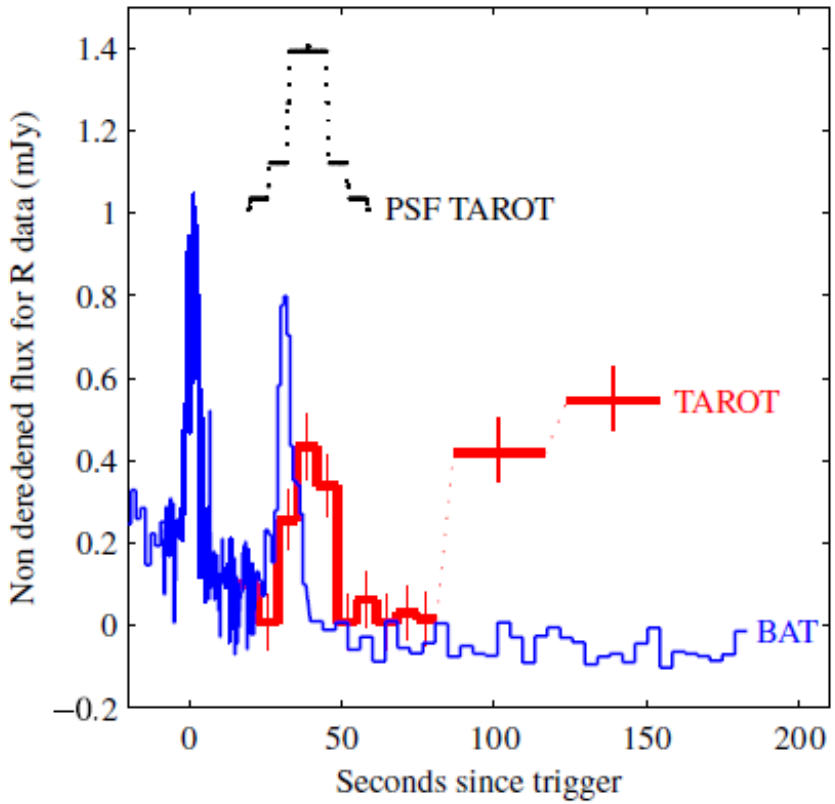


Figure 3. Light curves of GRB 081126 measured by BAT and TAROT. The dotted line labeled "PSF-TAROT" stands for the spread of a star equivalent to an instantaneous flash of 0 s duration.

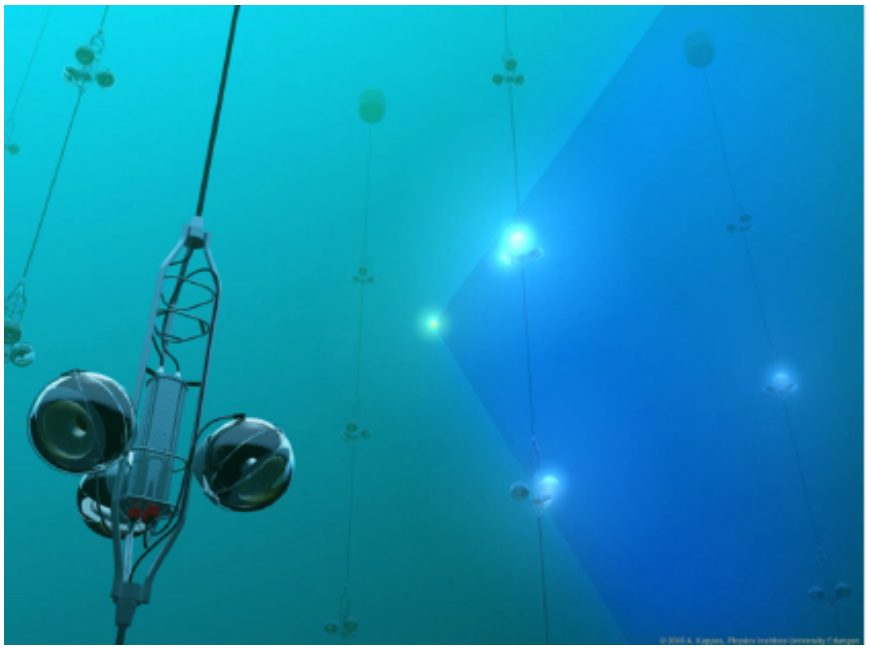
Klotz et al. (2009)

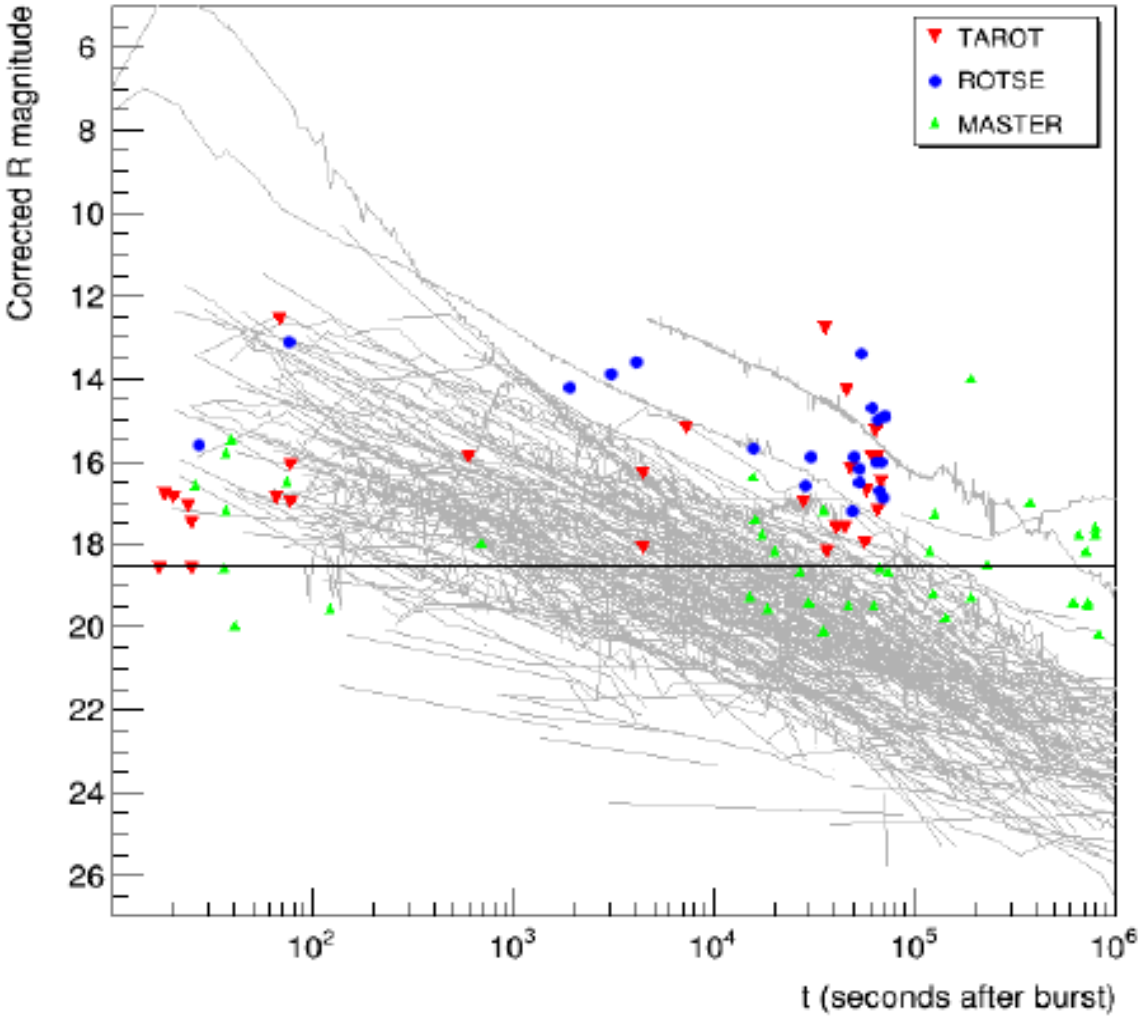
No reverse shock during gamma emission. Lags

Neutrinos

TAROT follow-up of neutrino events from ANTARES / KM3Net

An example of joined research between MASTER, TAROT and ROTSE



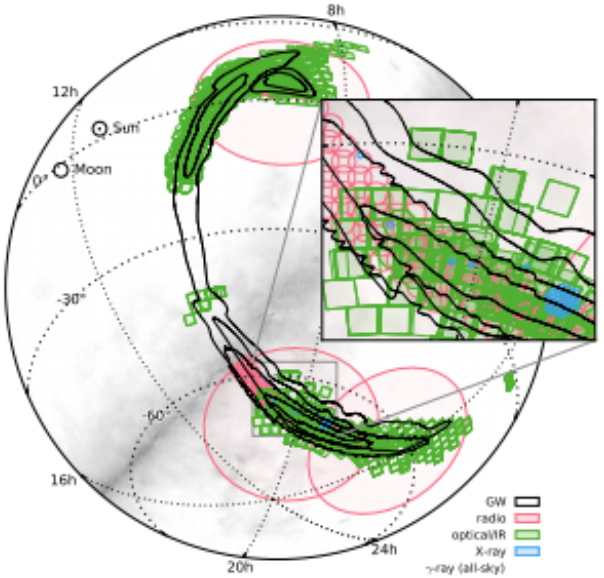


Adrian-Martinez, S. et al. (2016)

Gravitational waves

TAROT follow-up of gravitational wave events from LIGO/Virgo

GW150914 : Abbott, B.P. et al. (2016)



Very arge area in the sky

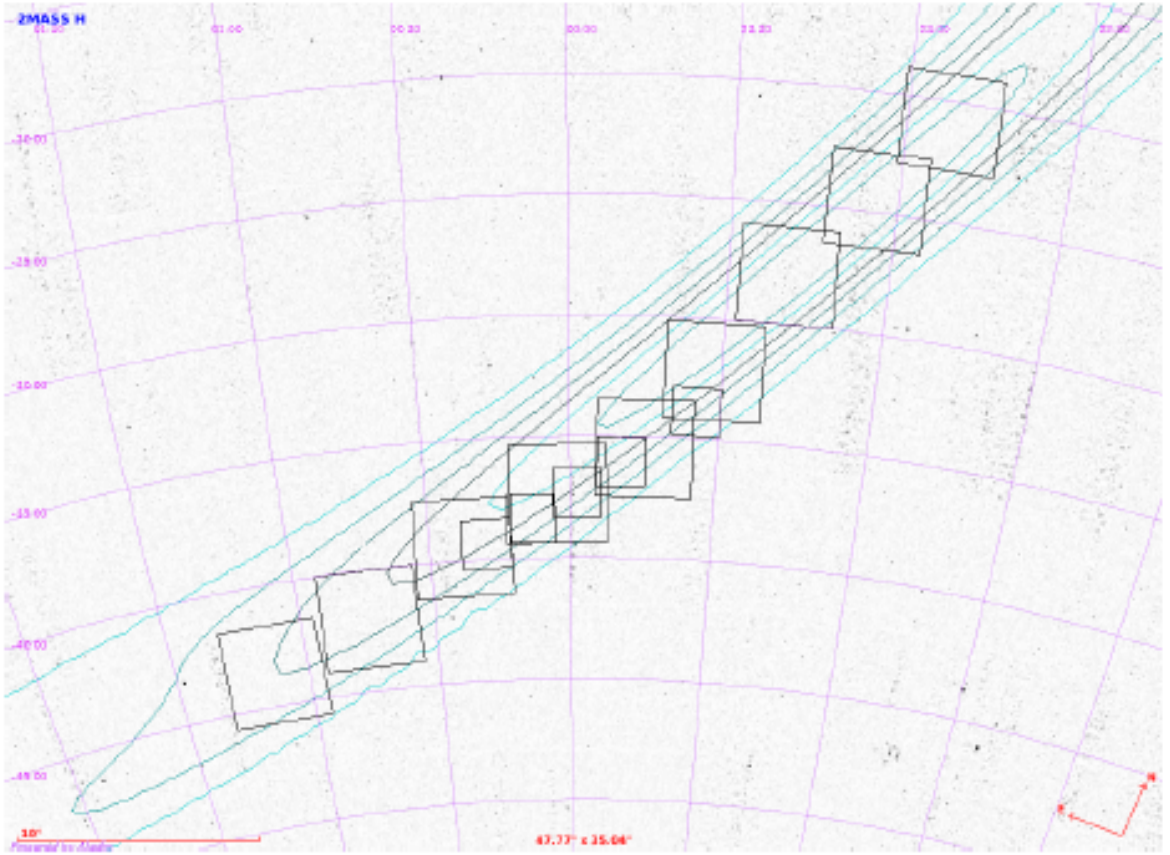
Merging of black holes
Merging of neutron stars
New type to come...

				Optical[e]					
DECam	i, z	$i < 22.5, z < 21.5$	3.9, 5, 22	100	38	14	14	11	18344, 18350
iPTF	R	$R < 20.4$	3.1, 3, 1	130	2.8	2.5	0.0	0.2	18337
KWFC	i	$i < 18.8$	3.4, 1, 1	24	0.0	1.2	0.0	0.1	18361
MASTER	C	< 19.9	-1.1, 7, 7	710	50	36	55	50	18333, 18390, 18903, 19021
Pan-STARRS1	i	$i < 19.2 - 20.8$	3.2, 21, 42	430	28	29	2.0	4.2	18335, 18343, 18362, 18394
La Silla–QUEST	g, r	$r < 21$	3.8, 5, 0.1	80	23	16	6.2	5.7	18347
SkyMapper	i, v	$i < 19.1, v < 17.1$	2.4, 2, 3	30	9.1	7.9	1.5	1.9	18349
Swift UVOT	u	$u < 19.8$ (gal.)	2.3, 1, 1	3	0.7	1.0	0.1	0.1	18331
	u	$u < 18.8$ (LMC)	3.4, 1, 1						18346
TAROT	C	$R < 18$	2.8, 5, 14	30	15	3.5	1.6	1.9	18332, 18348
TOROS	C	$r < 21$	2.5, 7, 90	0.6	0.03	0.0	0.0	0.0	18338
VST@ESO	r	$r < 22.4$	2.9, 6, 50	90	29	10	14	10	18336, 18397

ALERTS GW Ligo

3 GW alerts observed with TAROTs

Kanthankorn NOYSENA in prep.



Two different types of TAROT's footprint, 3.24 deg^2 and 17.98 deg^2 over the contours of the initial distributed BAYERSTAR localization of GW170104. Nine large tiles almost enclose one-thirth of credible region of southern himisphere

ALERTS GW170817 Ligo + Virgo (NS / NS)

Zadko Follow-up

Andreoni et al. (2017)

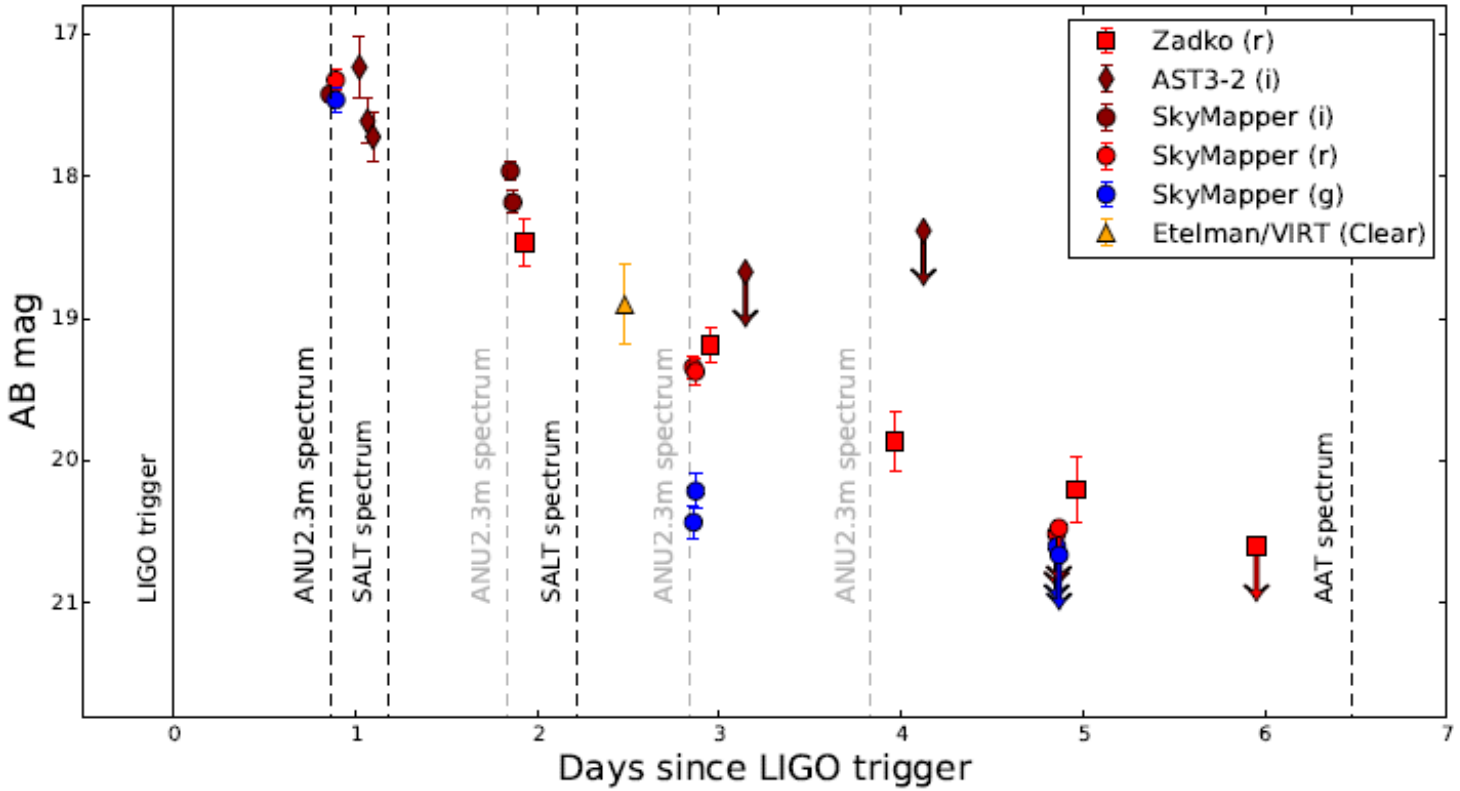


Figure 4.: Optical light curve of AT2017gfo for the first week after the GW detection obtained with the AST3-2, SkyMapper (SM), Zadko, and Etelman/VIRT telescopes. Down-arrows indicate upper limits. Note that the evolution at bluer bands is faster than the evolution at redder bands. Dashed vertical lines indicate epochs when spectroscopy was acquired. Spectra analysed in this work and presented in Figure 7 and Figure 8 are indicated in black, whereas spectra marked in grey are to be analysed at a later time.

TAROT – Alert techniques

Small fields of view = 1 pointing + series of images

Large fields of view = (1 pointing + series of images) * N

FERMI = 6 pointings

LIGO = 10 pointings (not enough !)

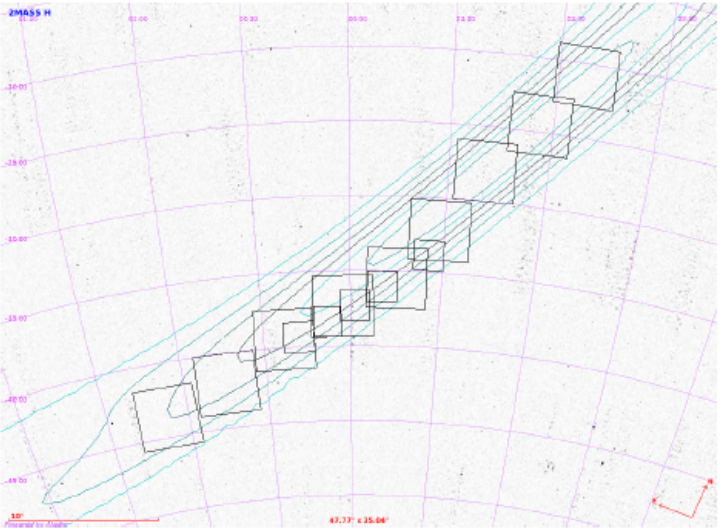
LIGO + Virgo = 9 pointings

.

TAROT – Alert techniques : planing

Planing for alert :

- Best priority for the first minute after the alert
- Decrease of the priority with the time
- Increase the time between tow picture with the time



Two different types of TAROT's footprint, 3.24 deg^2 and 17.98 deg^2 over the contours of the initial distributed BAYERSTAR localization of GW170104. Nine large tiles almost enclose one-thirth of credible region of southern himisphere

Program for GW observation on O2 :

- Generate mosaic of pointing for minimise the number of pointing inside of the area with the best probability
- Choose a maximum number of pointing by night
- Choose a minimum number of observation of each selected pointing
- For each pointing calculate visibility by each telescope

TAROT – Alert techniques : Objectif for O3

Improve the program for GW observation :

- Progressive calculation -> fast generation of the first pointing
- Use the quality value of GW alert
- Use the distance range of GW alert and check the number of galaxy inside

Question ?