KILONOVA CATCHER

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KILONOVA CATCHER

Bring FINK/LSST transients to the amateur world

(FINK @ amateur world)

Damien Turpin (CEA/irfu Saclay)
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1
Kilonova-Catcher in a nutshell

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2018 : Everything started with GRANDMA....

GRANDMA: Global Rapid Advanced Network Devoted to the Multi-messenger Addicts

A network of telescopes connected across the world, equipped with photometry and spectrometry capabilities, dedicated to Time-domain Astronomy.

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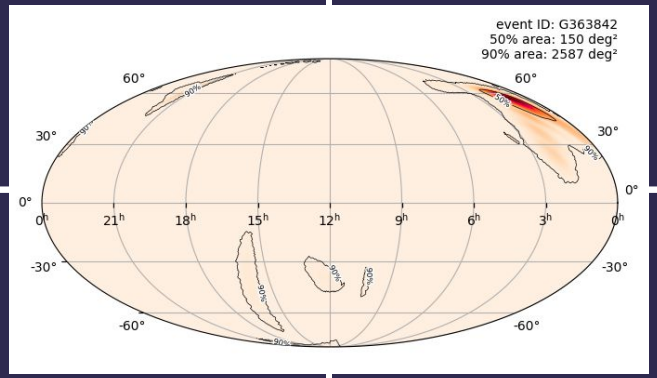
... and the challenges of the GW astronomy

Complex sky localisation region

Large localisation region (> 1000 sq.deg) & distributed in both North and South hemisphere

Astrophysical origin sometimes uncertain



All-sky alerts at any time

Significant updates of the GW localisation skymaps

Cosmological distance = large volume of Universe to cover

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The challenges of the GW astronomy

EM follow-up of GW sources
are

very greedy in telescope time,

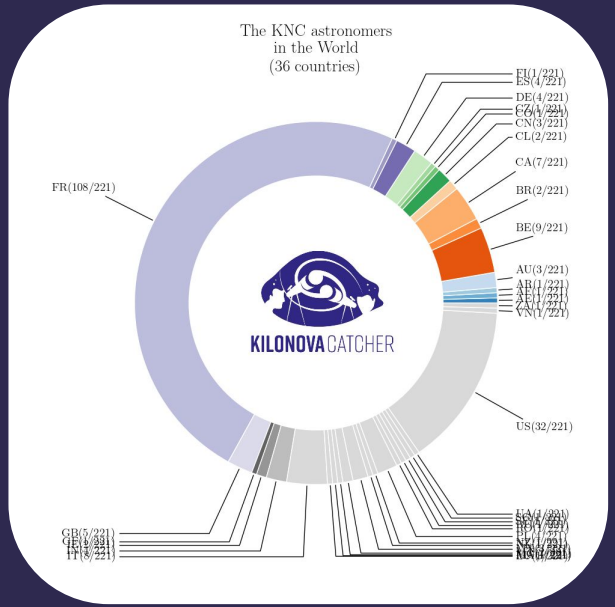
require

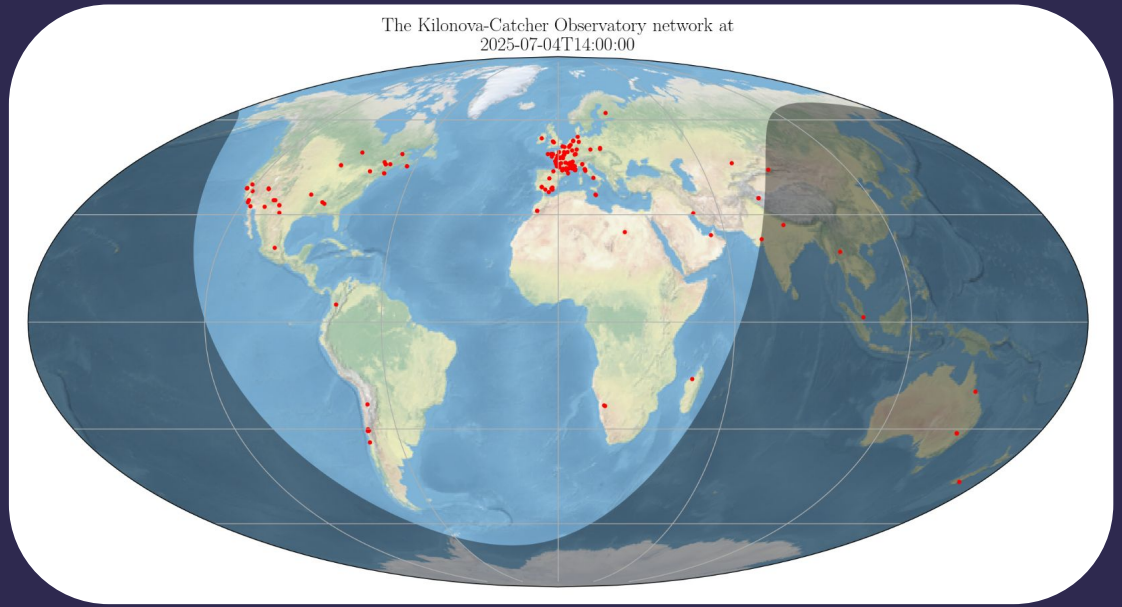
complex and smart observational techniques and strategies,

and can be

largely inefficient without a world wide network of coordinated telescopes

The Kilonova-Catcher network in a nutshell

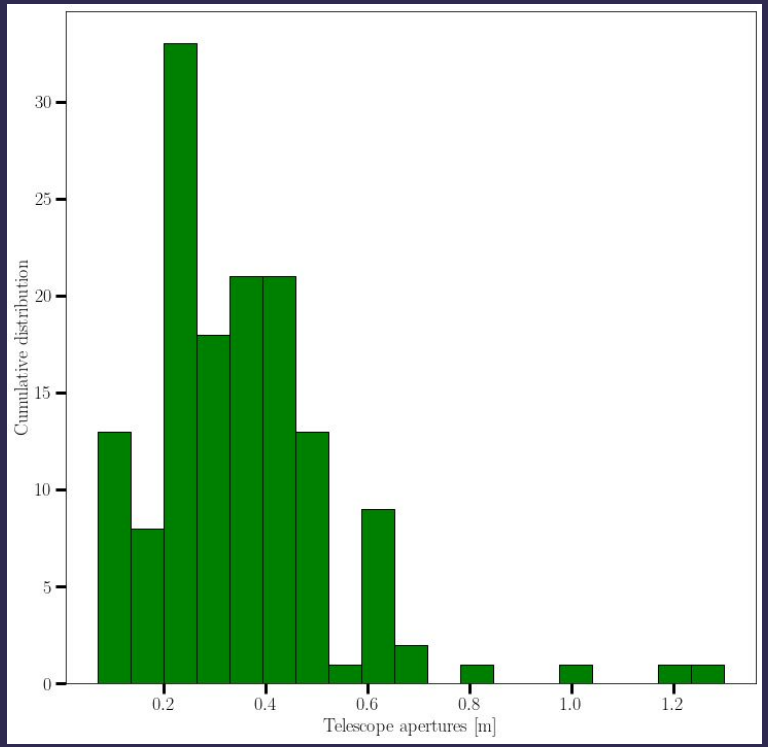




~240 registered astronomers, 36 countries, 160 télescopes (+14 in remote access)

~50% of French citizen astronomers

The Kilonova-Catcher network in a nutshell



typical telescope diameters = 0.32 m

Available filters

- Johnson BVRI
- Luminance / unfilter
- Gaia filters (RAPAS)
- sdss gri

Typical image depth

g~[18 - 21.5] (exp~30' - 2h)
r~[18 - 21] (exp~30' - 2h)
i~[16 - 19] (exp~30' - 2h)

The scientific team behind Kilonova-Catcher

KILONOVA CATCHER

KNC PI

Damien TURPIN
damien.turpin@cea.fr

GRANDMA PI

Sarah ANTIER
antier@ijclab.in2p3.fr

French pro-am coordination

Alain KLOTZ
alain.klotz@irap.omp.eu

Animation & communication

Cristina ANDRADE
Université Minnesota
USA

IT support

Gérard MARCHAL-DUVAL
IT dept. at IJCLab
(Paris, France)

Sébastien GREGOIRE
IT dept. at IJCLab
(Paris, France)

and with the contributions of

Antoine Cailleau
Pierre-Alexandre Duverne
Quentin André
Michael Coughlin
Jean-Grégoire Ducoin
Frédéric Carbain

The scientific programs of Kilonova-Catcher

Core Program (Since 2018)

Optical counterpart associated to BNS / NSBH mergers (LIGO, Virgo, Kagra)

Opportunistic Programs (Since 2020)

- GRB optical afterglows (Swift, SVOM)
- Fast optical transients (ZTF)
- SNe (ZTF)
- TDE, LFBOT? Orphan GRB afterglows?, GRB-SNe., nearby KNe?

The scientific programs of Kilonova-Catcher

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Here will come FINK

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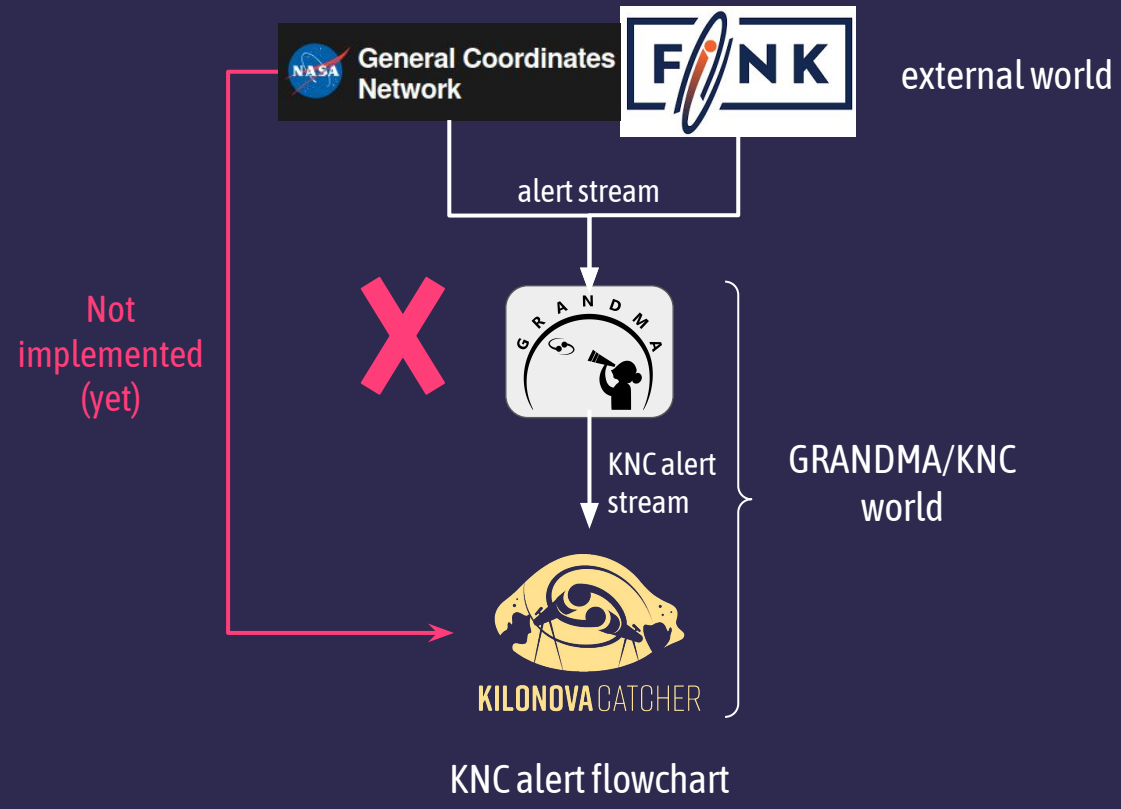
2

The KNC network, how it works?

The ICARE/Kilonova-Catcher system (simple view)



KNC alert flowchart

The KNC network

- is automatically trigger from the GRANDMA alert system
- can be manually trigger by contacting damien.turpin@cea.fr but needs a PI validation (the same guy ;))

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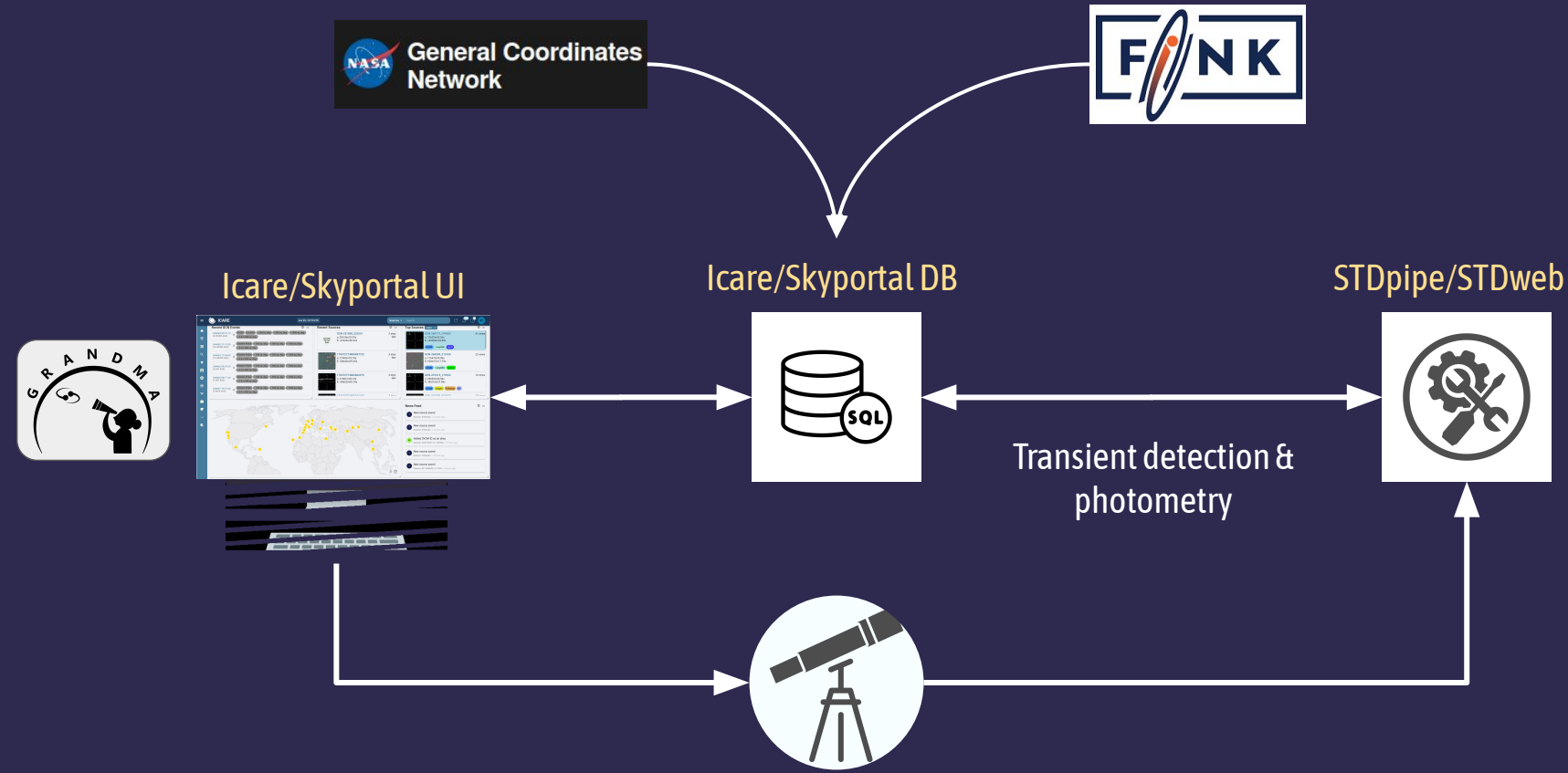
The ICARE/Skyportal alert system in a nutshell



The ICARE/Kilonova-Catcher system (less simple view)

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Icare/Skyportal UI

Icare/Skyportal DB

STDpipe/STDweb

GRANDMA

Transient detection & photometry

KNC alert stream
+ obs. plan for every telescopes

KNC web-UI

KNC user image push

image analysis

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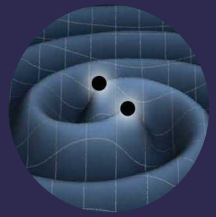
KNC DB

KNC image server

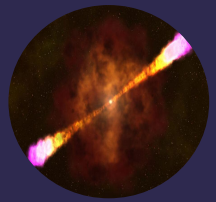
3
KNC scientific performances and past campaigns

Since 2020: scientific outputs

- **10 publications in refereed journals (+3 ongoing projects)**
- **~40 Circulaires GCN (rapport d'observations)**



1. GRANDMA observations of advanced LIGO's and advanced Virgo's third observational campaign
2. The first six months of the Advanced LIGO's and Advanced Virgo's third observing run with GRANDMA
3. Limits on the Ejecta Mass During the Search for Kilonovae Associated with Neutron Star-Black Hole Mergers: A case study of S230518h, GW230529, S230627c and the Low-Significance Candidate S240422ed



1. GRANDMA and HXMT Observations of GRB 221009A: The Standard Luminosity Afterglow of a Hyperluminous Gamma-Ray Burst
2. Multiband analyses of the bright GRB 230812B and the associated SN2023pel
3. Ready for O4 II: GRANDMA observations of *Swift* GRBs over eight weeks in spring 2022
4. GRB 241030A: a bright afterglow challenging forward shock emission
5. Multi-epoch afterglow rebrightenings in GRB 250129A: Evidence for successive shock interactions

1. GRANDMA observations of ZTF/*Fink* transients during summer 2021
2. Early-time Observations of SN 2023wrk: A Luminous Type Ia Supernova with Significant Unburned Carbon in the Outer Ejecta

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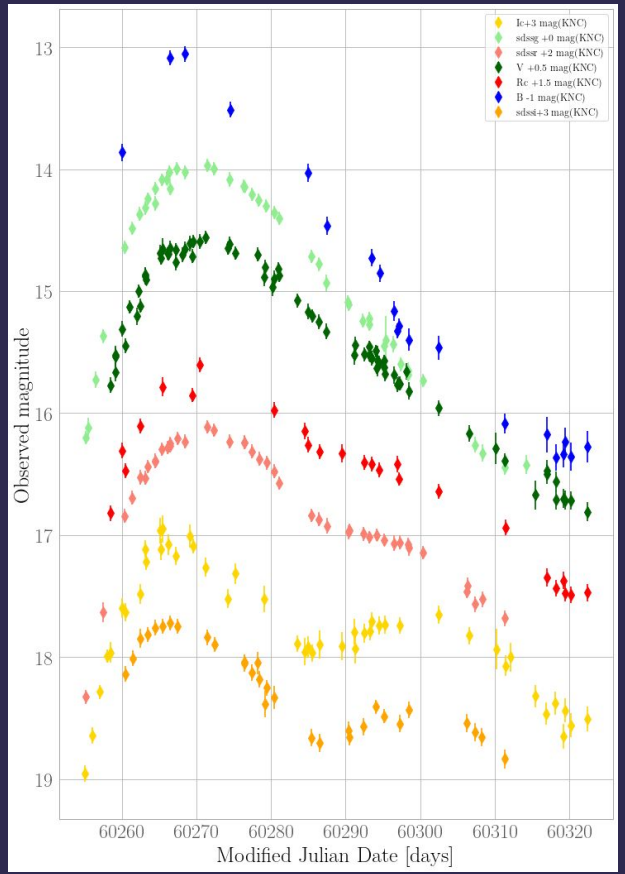
Nearby SNe monitoring: SN 2023wrk



- >450 images KNC (M. Freeberg, M. Serrau, E. Broens, D. Marchais, R. Ménard, F. Dubois, C. Galdies, D. ST-Gelais,E. Maris, R. Kneip, A. Popowicz, M. Odeh, G. Parent)
- >3 months of continuous observations in VRcIc & gri bands

Early-time Observations of SN 2023wrk: A Luminous Type Ia Supernova with Significant Unburned Carbon in the Outer Ejecta

Jialian Liu[1], Xiaofeng Wang[1], Cristina Andrade[2], Pierre-Alexandre Duverne[3], Jujia Zhang[4,5,6], Liping Li[4,5,6], Zhenyu Wang[4,5,6,7], Felipe Navarete[8], Andrea Reguitti[9,10], Stefan Schuldt[11,12], Yongzhi Cai[4,5,6], Alexei V. Filippenko[13], Yi Yang[1,13], Thomas G. Brink[13], WeiKang Zheng[13], Ali Esamdin[14], Abdusamatjan Iskandar[14,15], Chunhai Bai[14], Jinzhong Liu[14], Xin Li[16], Maokai Hu[1], Gaici Li[1], Wenxiong Li[17], Xiaoran Ma[1], Shengyu Yan[1], Jun Mo[1], Christophe Adami[18], Dalya Akl[19], Sarah Antier[20], Eric Broens[21], Jean-Grégoire Ducoin[22], Eslam Elhosseiny[23], Thomas M. Esposito[13], Michael Freeberg[24,25], Priyadarshini Gokuldass[26], Patrice Hello[27], Sergey Karpov[28], Isabel Márquez[29], Martin Mašek[30], Oleksandra Pyshna[31], Yodgor Rajabov[32], Denis Saint-Gelais[33], Marc Serrau[34], Oleksii Sokoliuk[35,36], Ali Takey[23], Manasanun Tanasan[37], and Damien Turpin[38]

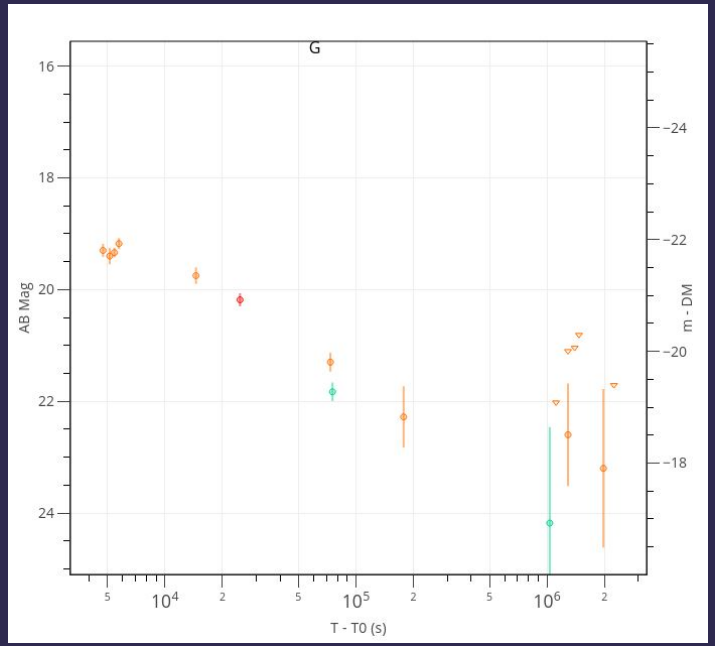
analyzing these data. D. Turpin, PI of the Kilonova-Catcher, acknowledges the observers of the Kilonova-Catcher program who actively participated in the follow-up campaign: E. Broens, F. Dubois, M. Freeberg, C. Galdies, R. Kneip, D. Marchais, E. Maris, R. Ménard, M. Odeh, G. Parent, A. Popowicz, D. ST-Gelais, and M. Serrau. We also thank Unistellar observers B. Guillet, B. Haremza, G. Di Tommaso, K. Borrot, M. Lorber, M. Shimizu, M. Mitchell, N. Meneghelli, N. Delaunoy, O. Clerget, P. Huth, P. Heafner, P. Kuossari, S. Saibi, S. Price, W. Ono, and Y. Arnaud.

GRB monitoring

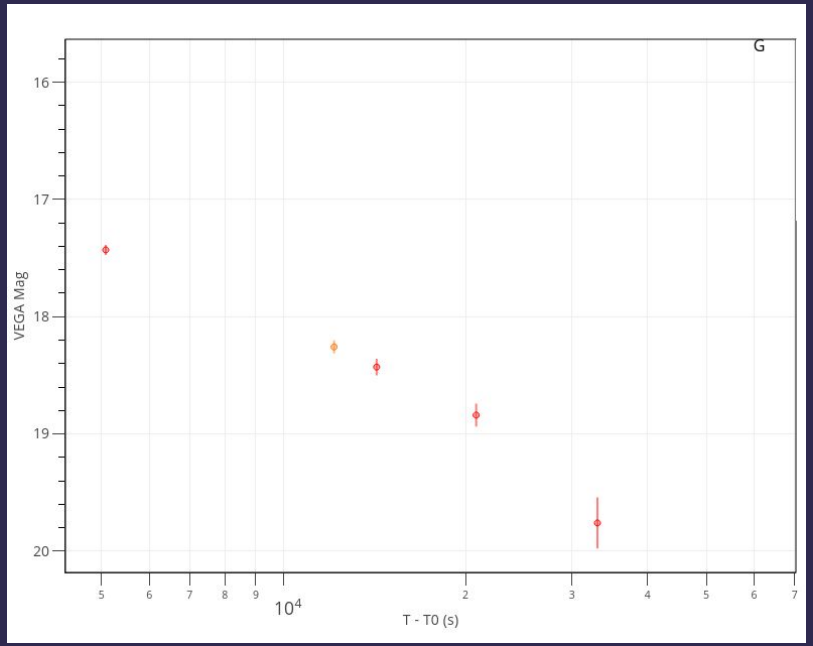
Since 2023: ~45 follow-up of GRBs with ~60% optical detection rate

GRB 250424A: A Case Study of Energy Injection with Multiwavelength Observations

Liang et al. submitted to ApJ



GRB 260604C: Follow-up campaign ongoing

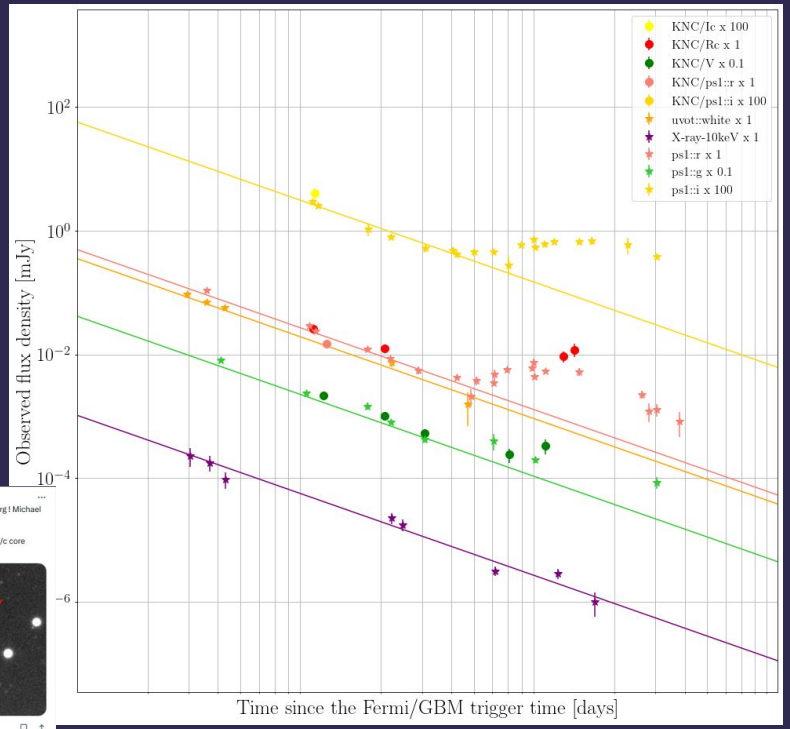


GRB/SNe connections

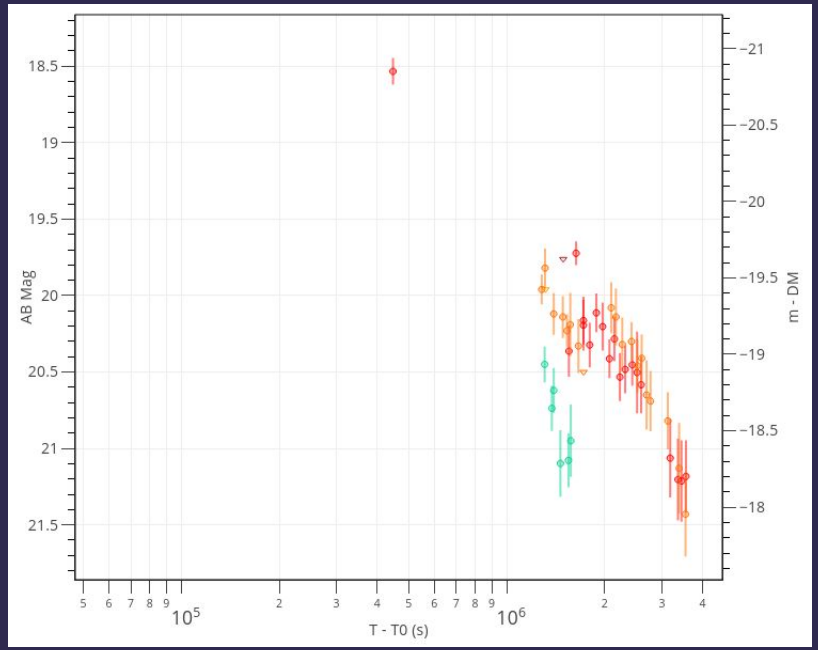
Since 2023: 2 well identified low-z GRB/SNe association

GRB 230812B / SN2023pel Ic-BL (z = 0.360)

Hussenot-Desenonges et al. 2024



GRB 260310A / SN2026fgk Ic-BL (z = 0.153)



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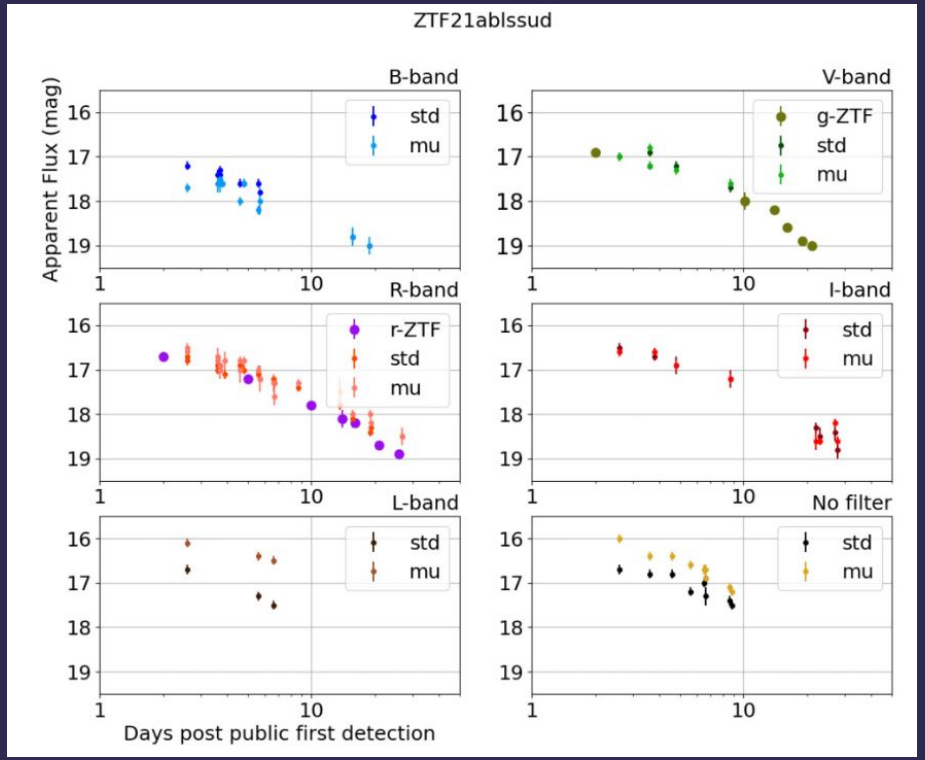
“Fast” ZTF transients (daily timescale)

GRANDMA observations of ZTF/Fink transients during summer 2021

Aivazyan et al. 2022



ZTF/Fink alerts

+

Spectro-Photometric follow-up by GRANDMA & KNC

=

Transient classification

Table 3. Results of the simulations of transients with rapid evolution, in order to validate or reject the concordance of each transient using ZTF data with the four models: KNe (Ka2017), supernova (nugent-hyper), GRB afterglows (TrPi2018), and shock cooling (Piro2021). Note that the Bayes factors are evaluated logarithmically.

Transients	Ka2017	TrPi2018	nugent-hyper	Piro2021	light curve
ZTF21abfmbix	−12.38	−15.95	−9.18	−10.1	Supernova Ia
ZTF21absvlrr	−9.78	−16.73	−9.91	−11.07	Supernova Ia
ZTF21abultbr	−2.73	-9.14	−5.24	−4.76	Supernova II
ZTF21ablssud	−6.32	−11.58	−9.83	−9.41	Cataclysmic Variable
ZTF21abfaohe	−12.3	−10.98	−7.47	8.67	Supernova Ia
ZTF21abbzjeq	−8.22	−11.41	−7.49	−8.47	Supernova Ia
ZTF21acceboj	−16.52	−19.44	−14.52	−15.6	Supernova IIb
ZTF21abotose	−6.37	−10.62	−7.41	−7.49	Shock Cooling - Supernova IIp

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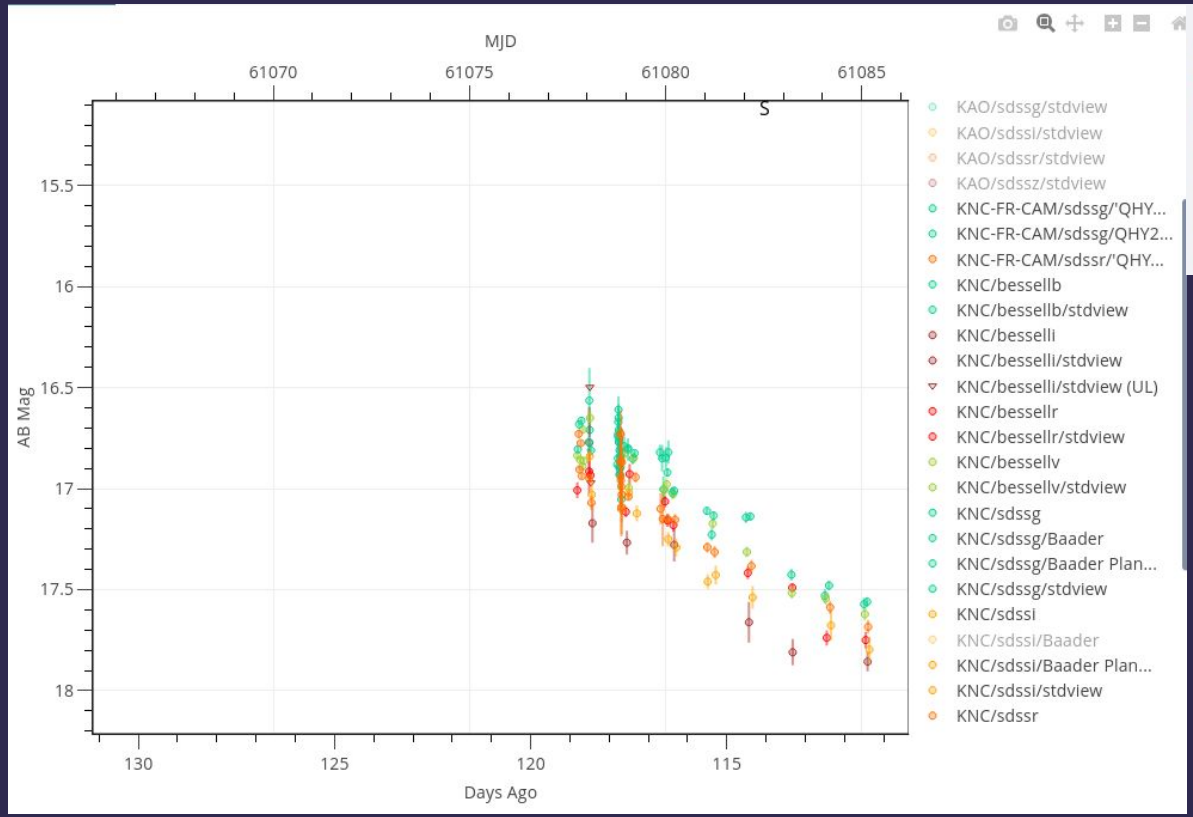
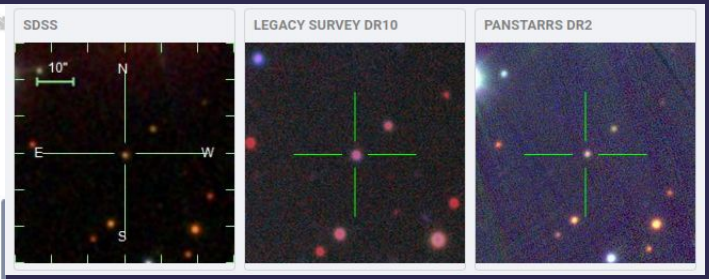
LFBOT candidates and CV-like transients





Cataclysmic variable AT 2026 cex

- 10 days of follow-up campaign
- hour timescale modulation signal detected likely due to the orbital motion of the binary system

Summary

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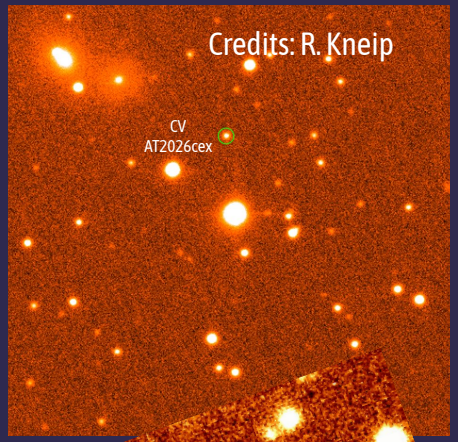

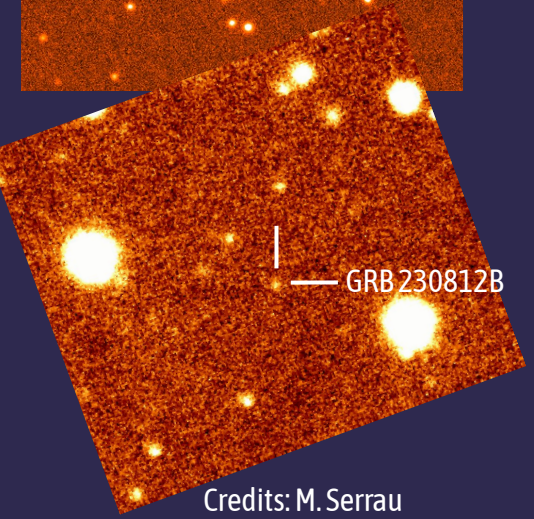

The KilonovaCatcher network

- ~240 amateur astronomers distributed in 36 countries
- Trained to answer to multi messenger alerts
- Response to alert in an hour or so
- R = 21-21.5 image depth capabilities for hours of exposure
- **Well suited for moderately fast transients: SNe, TDE, LFBOT, CV, nearby KNe**
- Very fast transients such as GRB afterglow are challenging but we already proved our follow-up capabilities in such cases
- **Willing to explore many types of explosive event. Follow-up rate of several campaigns per week is doable**
- **Willing to exploit LSST transients for the next decade**
- **Contact me: damien.turpin@cea.fr**