



# Multi messenger astronomy: latest results from the Fink broker

Julien Peloton, on behalf of the Fink team  
17/10/2023



# Rubin data challenge

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The Rubin Observatory (2024+) will send about **10 million alerts per night over 10 years**

- ~1TB / night: x100-x1000 above current streams
- Current tools do not scale

Rubin brokers were selected to analyse this monster stream.

Fink: <https://fink-broker.org>



Currently testing on the Zwicky Transient Facility (~200,000 alerts/night)



# Turning information into science

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Alert information solely is not enough – we need experts to extract the science!

- More than 60 scientists worldwide contribute to the project.

Our ambition is to **study the transient sky as a whole**, from solar system objects to galactic and extragalactic science.

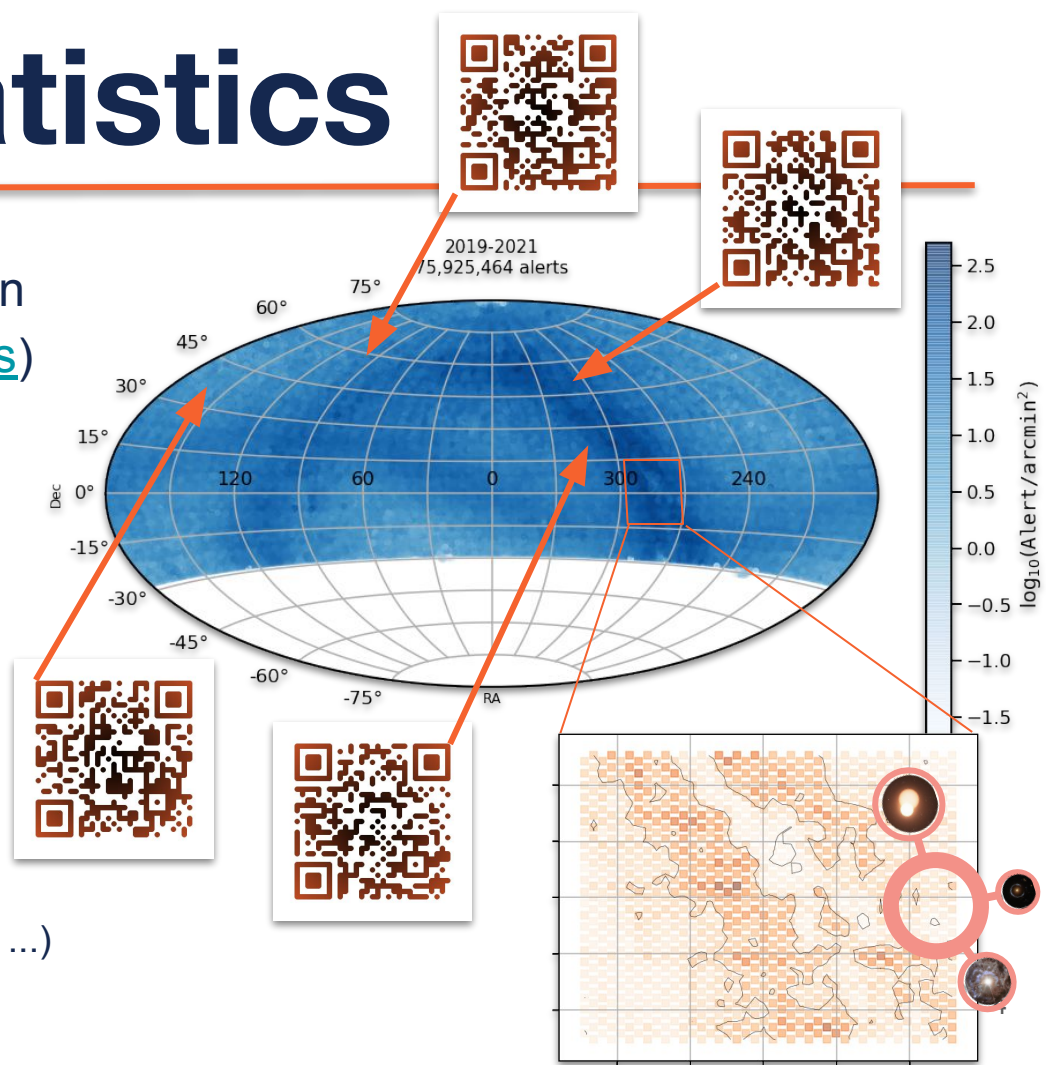


# ZTF/Fink statistics

210 million alerts received, 140 million processed (<https://fink-portal.org/stats>)

Typical nightly rates (200,000 alerts):

- ~75,000 known variable stars
- ~25,000 known SSO
- ~100 new SSO candidates
- ~100 new supernovae & core-collapse candidates
- ~50 (known+new) AGN
- ~10 (un)identified satellite glints
- ~5 new SN Ia candidates
- ~1 fast transient candidate (KN, GRB, CV ...)
- ~1 new microlensing candidate
- ~1 anomaly



# Crossmatch with GW sky maps

Goal: provide any ZTF/Rubin alerts emitted within  $[-1, +6]$  days of a GW trigger <https://fink-portal.org/gw>

- Search among 160+ million ZTF alerts!
- O3 & O4 sky maps available
- API: </api/v1/bayestar> endpoint.

Customisable to any existing source

- Contact us if you want to add your sky maps!



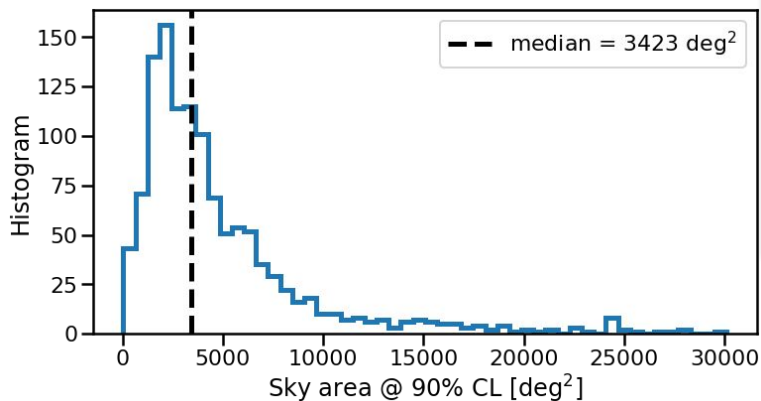
This service is still experimental. Open an issue on [GitHub](#) if you experience problems or if you have suggestions.

Supernovae  
Enter an event ID from the O3 or O4 runs.  
S20029ay

Credible level  
From 0 (most likely) to 1 (least likely)  
0.10

[Search for alerts matching](#)

objectId	Classification	Number of measurements
<a href="#">ZTF23aambhkh</a>	Unknown	1
<a href="#">ZTF23aambhwnk</a>	Solar System candidate	1
<a href="#">ZTF23aambhwjk</a>	Solar System candidate	1
<a href="#">ZTF23aambhwjl</a>	Unknown	1



Gravitational Waves

Supernovae  
Enter an event ID from the O3 or O4 runs.  
S200219ac

Credible level  
From 0 (most likely) to 1 (least likely)  
0.35

[Search for alerts matching](#)

# Real-time MMA



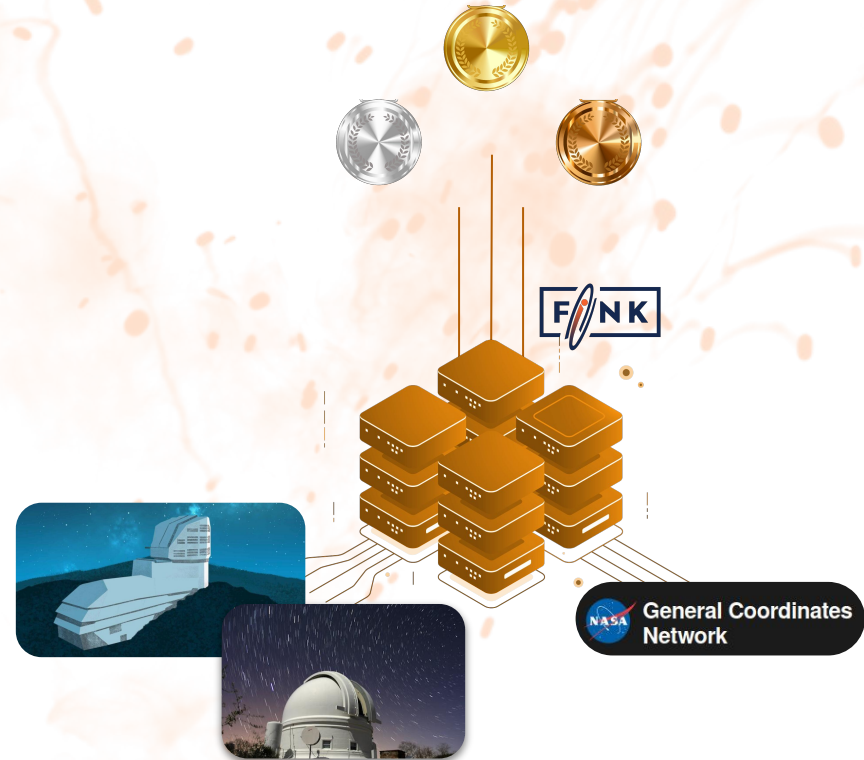
Roman Le Montagner  
(IJCLab)

Fink-MM: open source framework  
interfaced with Fink

**Real time** crossmatch between optical  
survey streams (ZTF/Rubin) and  
circulars from the GCN (Fermi, Swift,  
INTEGRAL, LVK, Icecube,...)

Series of **custom filters** implementing  
user-driven logic (physics!)

Scalable to **million of alerts** per night



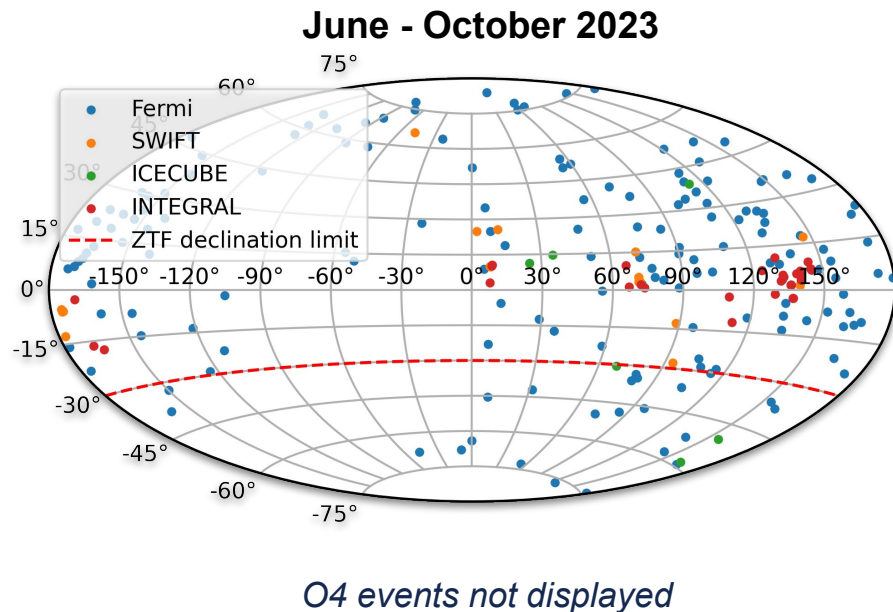
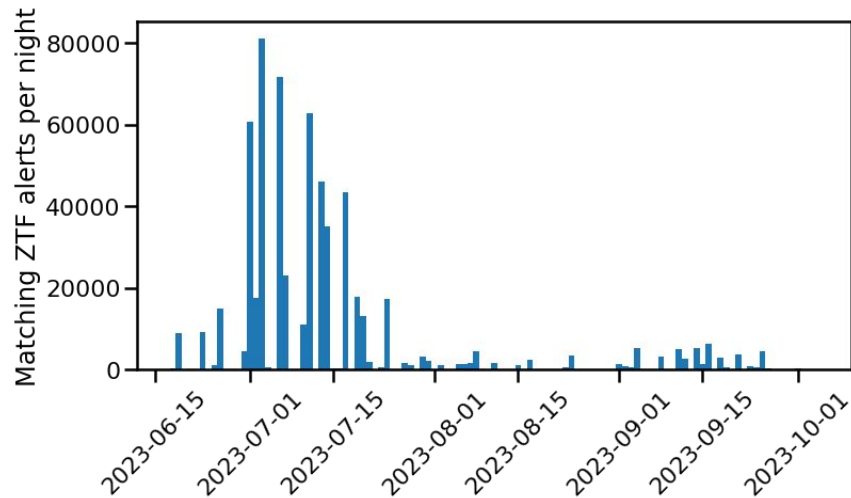
# Who are the GCN?



Roman Le Montagner  
(IJCLab)

GCN mainly from Fermi GBM...

... but error boxes can be huge!

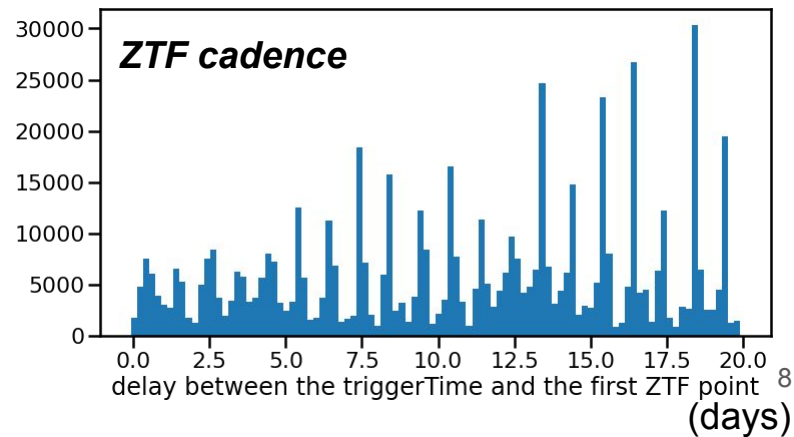
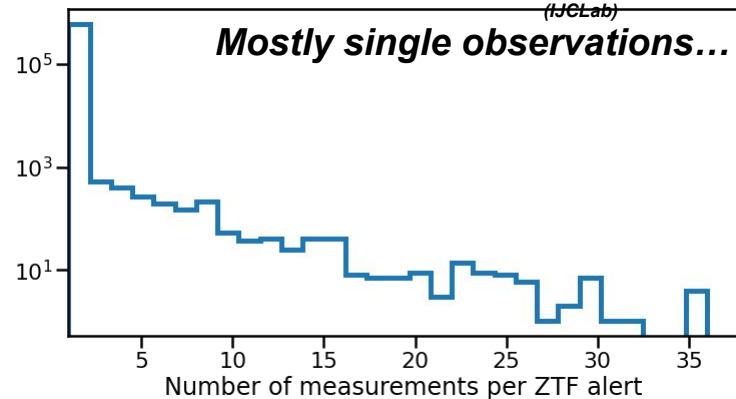
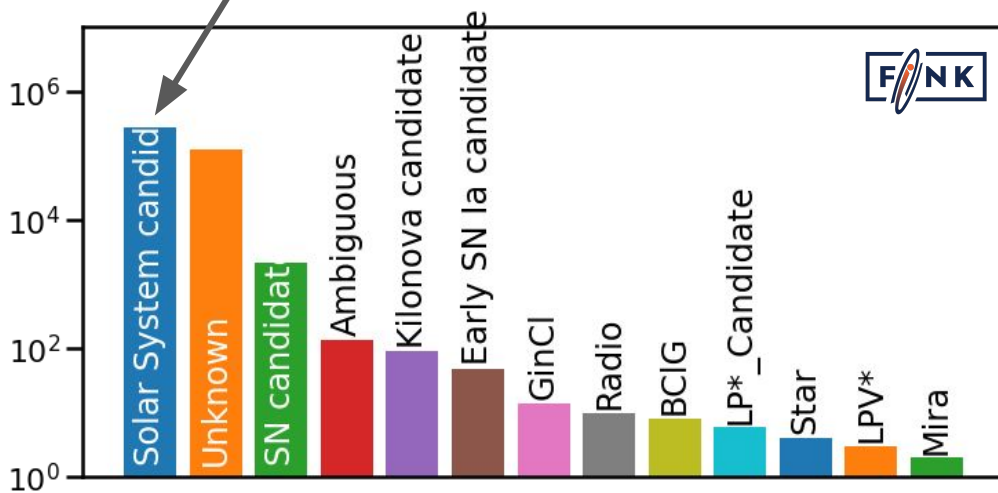


# Who are the ZTF match?



Roman Le Montagner  
(JCLab)

[Le Montagner et al 2023, A&A, in press](#)

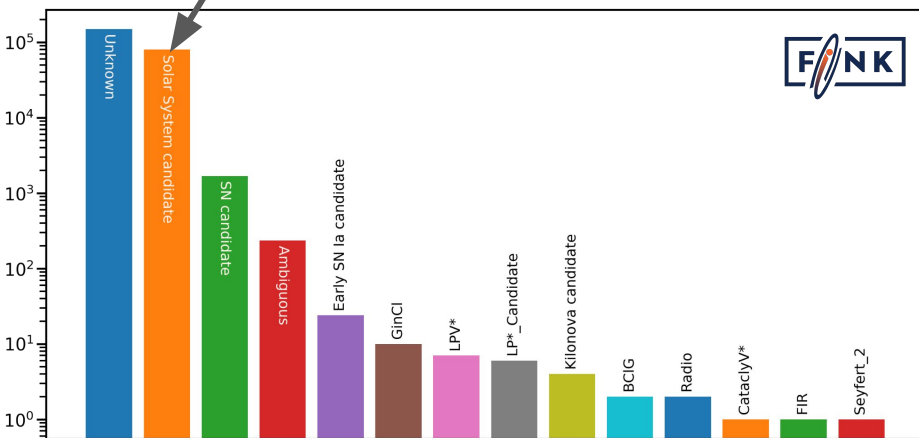




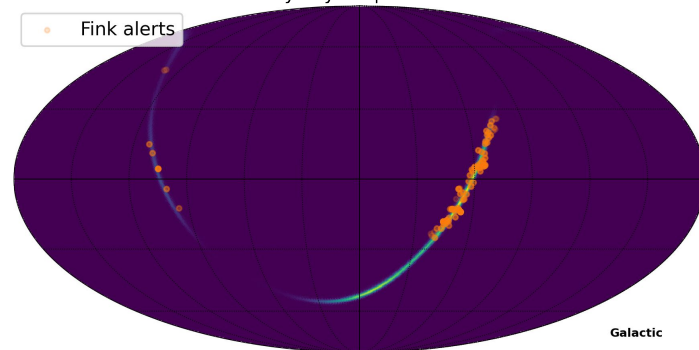
# Who are the ZTF match?



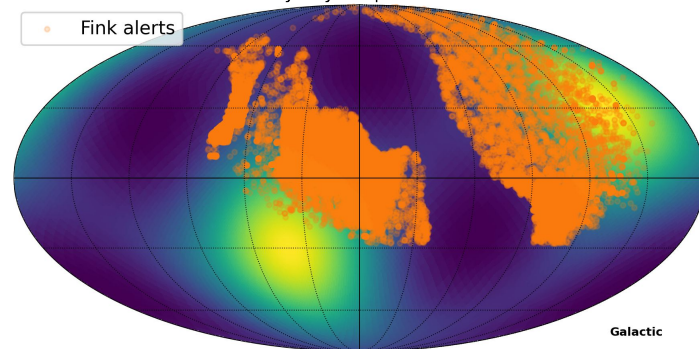
[Le Montagner et al 2023, A&A, in press](#)



Probability sky maps for G441185



Probability sky maps for G419671



7.12045e-09

6.93508e-05

# GRB230827B



Roman Le Montagner  
(IJCLab)

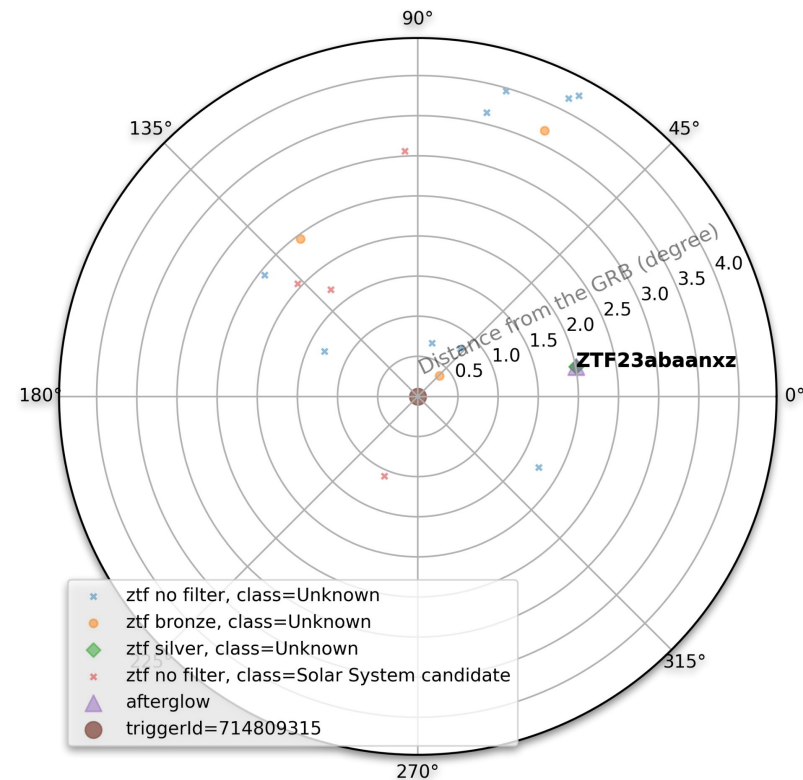
ZTF alert distribution  
for the GRB triggerId=714809315

GCN N° 714809315 / GRB230827B

- Fermi GBM
- Long GRB : T90 ~ 11 s (50-300 keV)

2 **silver** match in ZTF alerts:

- [ZTF23abaanxz](#)
- Two measurements in r band, fast fading.
- Afterglow reported by the ZTF team

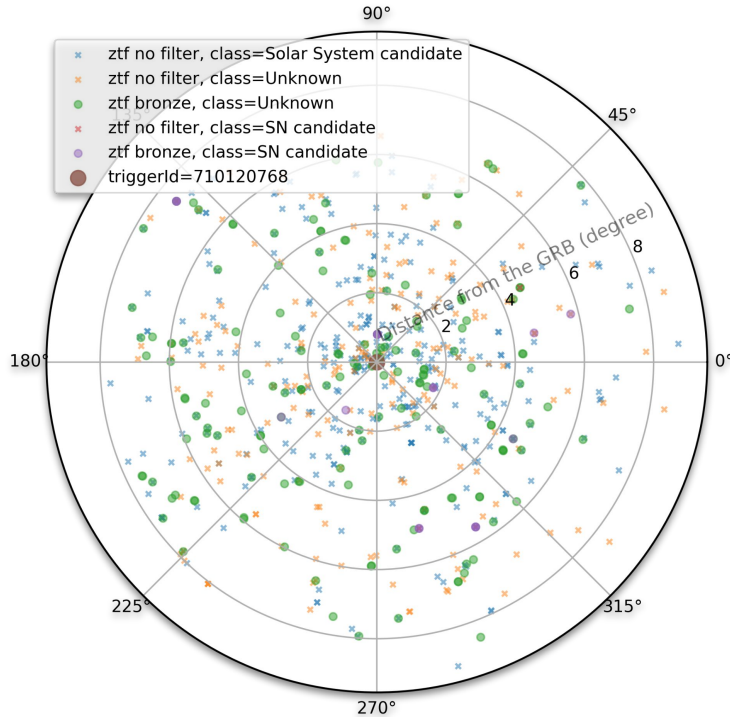


# Not always easy...

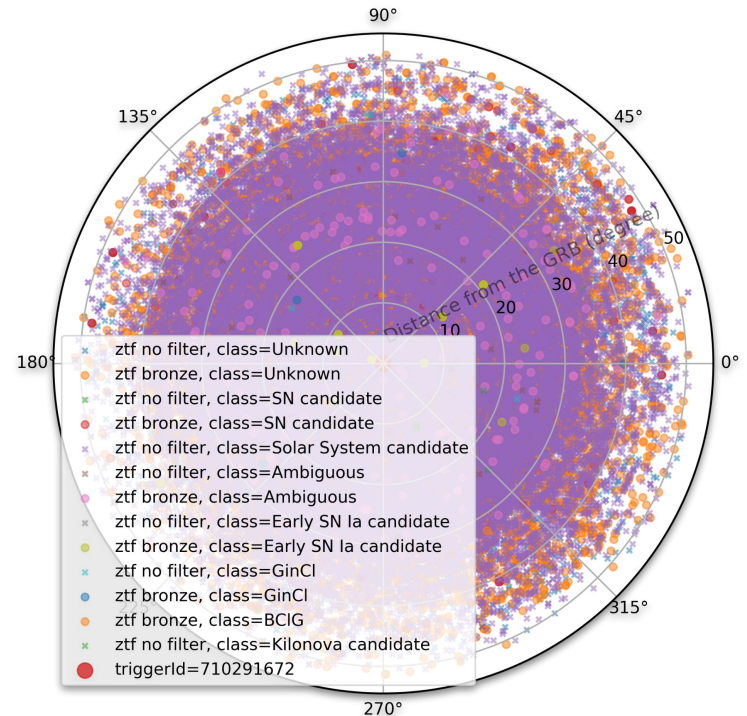


Roman Le Montagner  
(IJCLab)

ZTF alert distribution  
for the GRB triggerId=710120768



ZTF alert distribution  
for the GRB triggerId=710291672



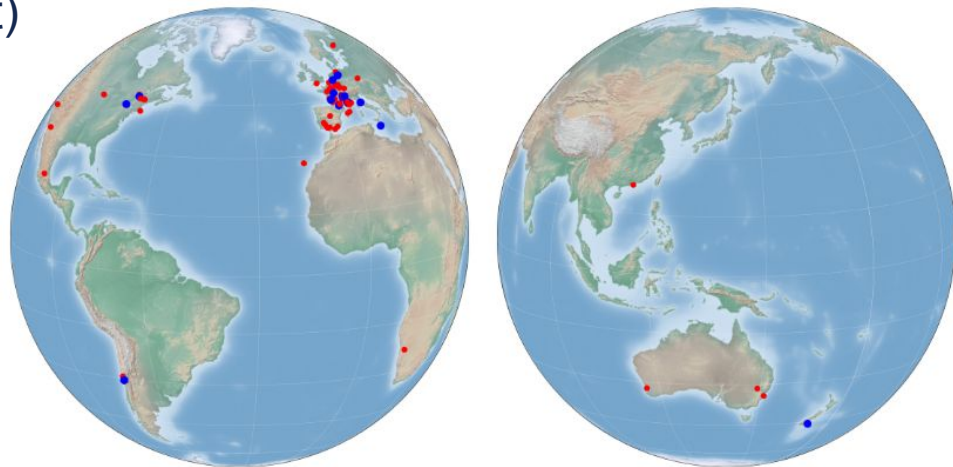
# GRANDMA network for fast transients follow-up

Fink classifies in real-time ZTF alerts from transient phenomena ( $\sim 200\text{k}/\text{night}$ )

Selected fast transients ( $\sim 1/\text{night}$ ) are sent to the GRANDMA network in real-time for potential follow-up

- ML techniques
- Rate-based consideration
- Contextual consideration

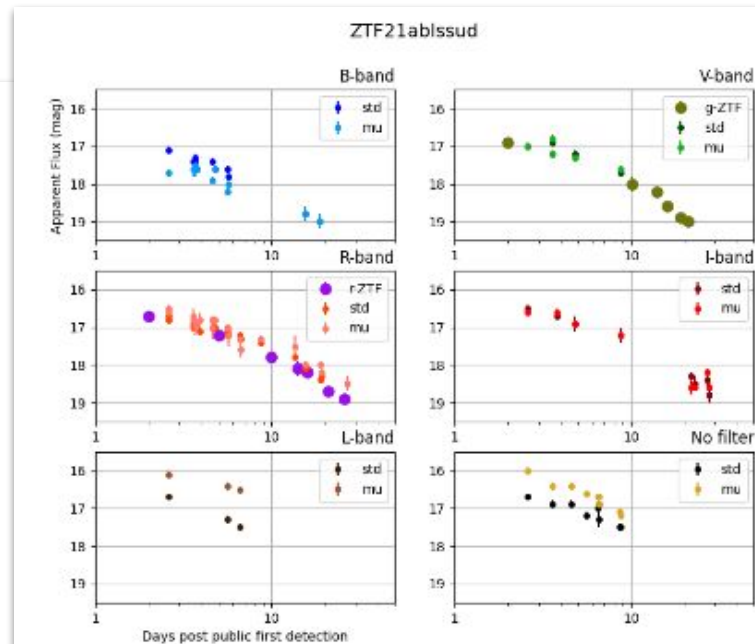
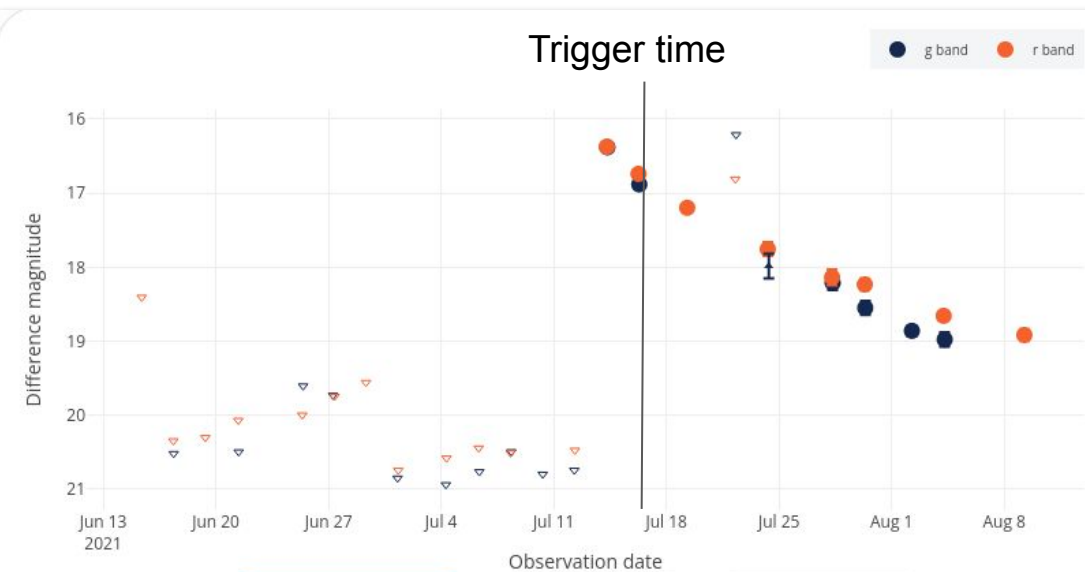
Citizen science program in parallel



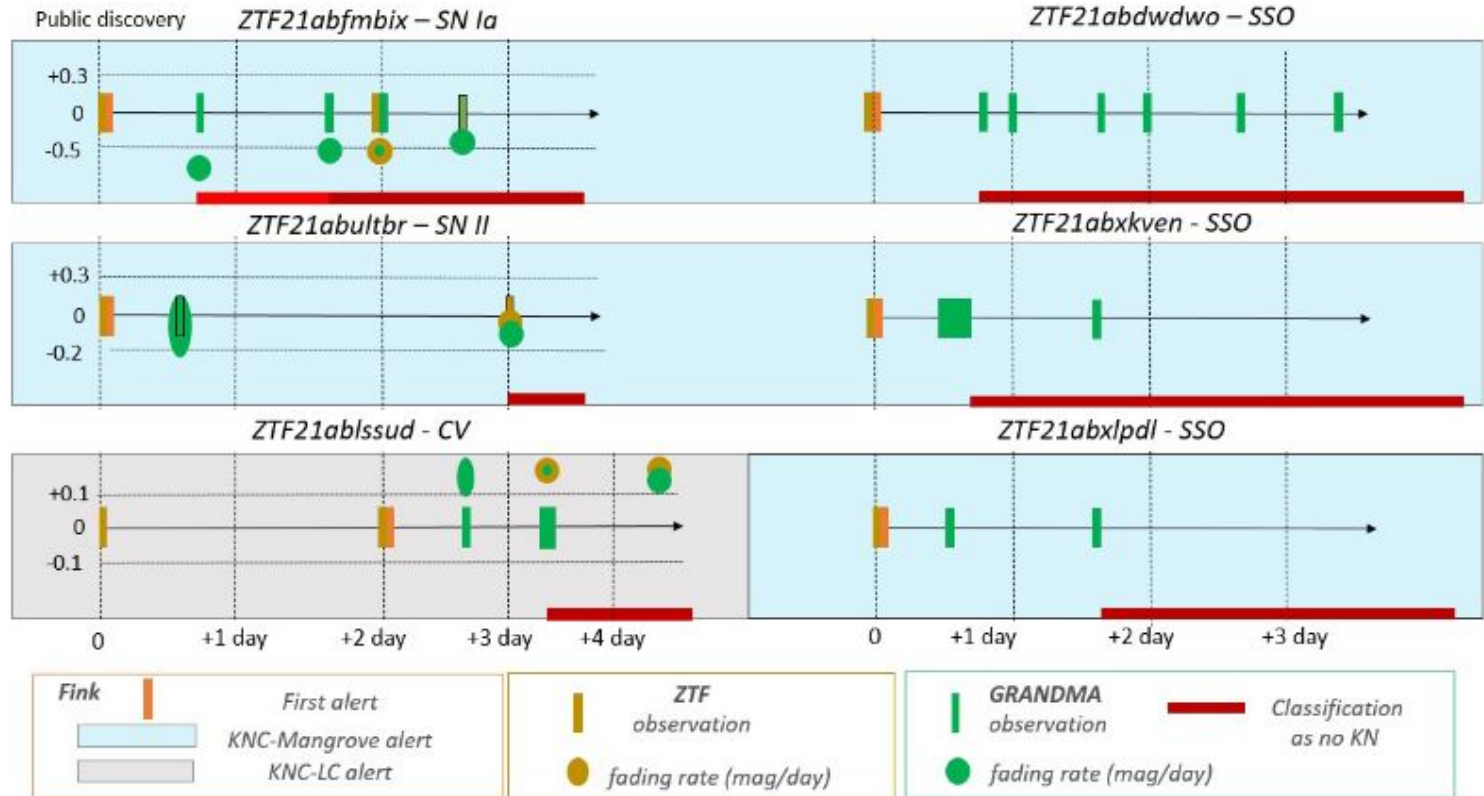
GRANDMA Collaboration 2022 MNRAS 515 4, 6007-6022  
B. Biswas et al 2023 A&A 677, A77  
M. W. Coughlin et al 2023 ApJS 267 31



# Follow-up (pre-O4)



# No KN found though...

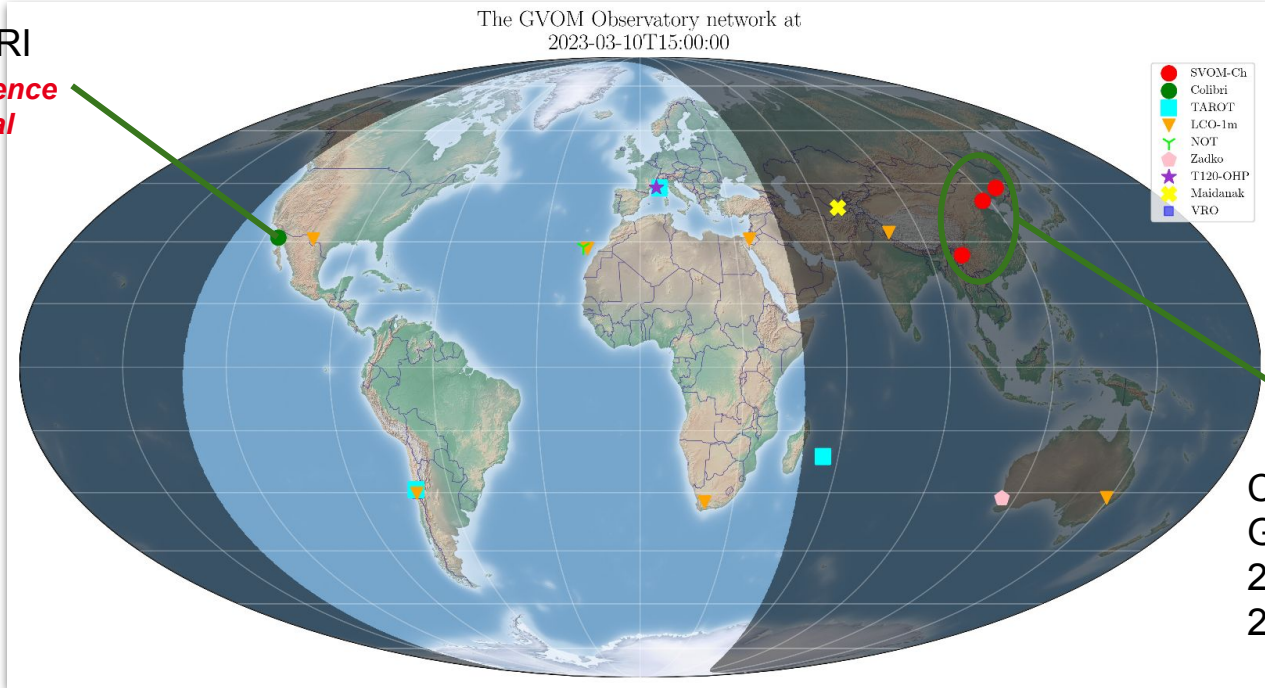


# A network in construction

COLIBRI

Colibri Science Proposal

The GVOM Observatory network at  
2023-03-10T15:00:00



C-GFT  
GWAC-F60  
2.12m Xinglong  
2.4m Lijiang



Credits: D. Turpin, CEA



<https://fink-broker.org>

<https://fink-portal.org>

[contact@fink-broker.org](mailto:contact@fink-broker.org)



# Fink under the hood

Operating in real time on large cloud computing infrastructures. Deployed at VirtualData since 2019, and now migrating at CC-IN2P3 (IN2P3 LSST Master Project).

