

Enabling multi-messenger science with Fink : current status and future development

Roman Le Montagner
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FINK : An Astronomical Alert Broker

Alert : Information packet of an optical transient event

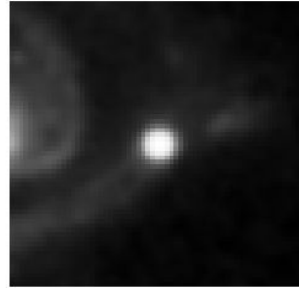
Content:

- Sky position and emission time
- Calibration output
- Photometry
- Cross-match source identification
- Image cutout
- Object history

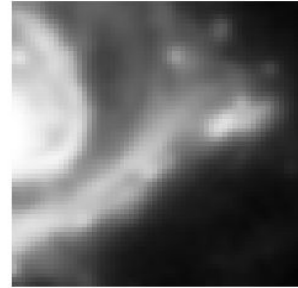
Size : ~ 100 KiloBytes

ZTF21abfaohe

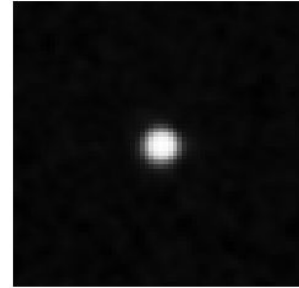
Science



Template



Difference



FINK : An Astronomical Alert Broker

Fink Science Portal

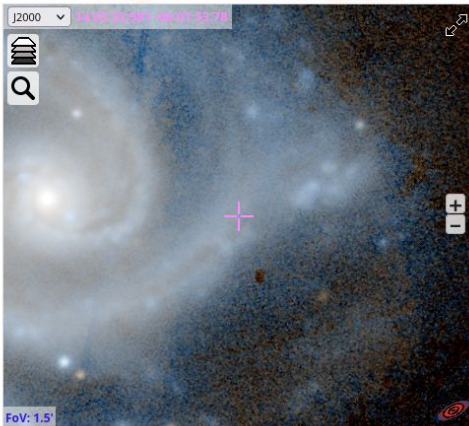


Summary Supernovae Variable stars Microlensing Solar System Tracklets GRB

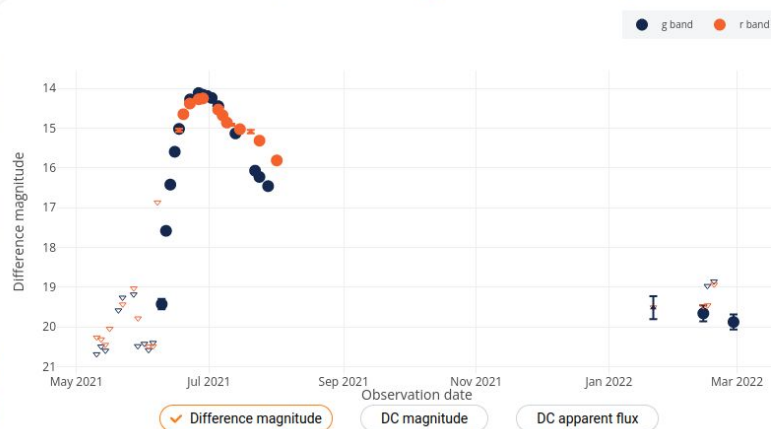
ZTF21abfaohe

SN CANDIDATE UNKNOWN

Discovery date: 2021-06-09 05:14:26.002
Last detection: 2022-02-27 09:06:04.003
Number of detections: 27
Number of low quality alerts: 4
Number of upper limits: 26



Individual alert classification SN candidate: 85% Unknown: 15%



Information

Circles (●) with error bars show valid alerts that pass the Fink quality cuts. In addition, the *Difference magnitude* view shows:

- upper triangles with errors (▲), representing alert measurements that do not satisfy Fink quality cuts, but are nevertheless contained in the history of valid alerts and used by classifiers.
- lower triangles (▽), representing 5-sigma mag limit in difference image based on PSF-fit photometry contained in the history of valid alerts.

Last alert cutouts



Coordinates

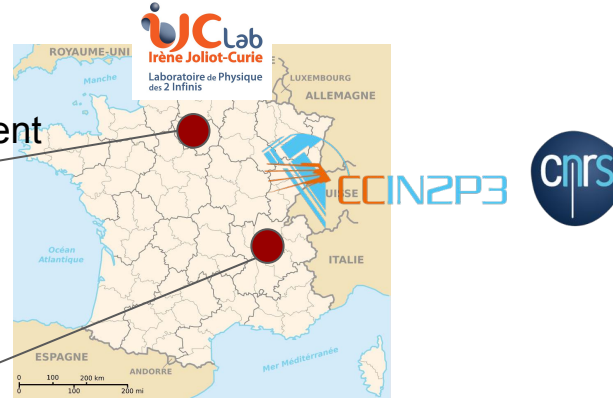
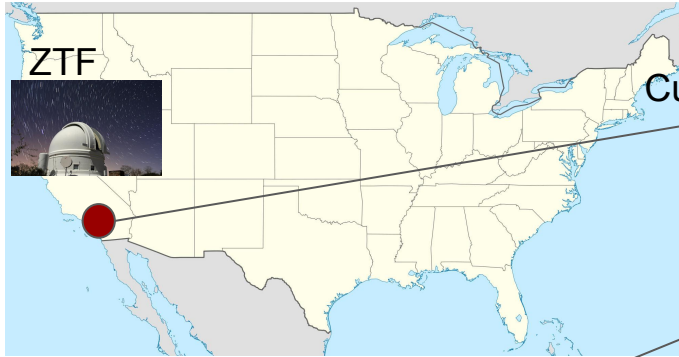
Last alert content

Download data

Neighbourhood

Share

FINK : An Astronomical Alert Broker



Fink's goals :

- Studying the transient sky as a whole, from solar system to galactic and extra-galactic science
- Enabling real-time science with the large volume of alerts from the Rubin Observatory
- Guaranteeing permanent access to archival data and data analysis tools (all Fink products are publicly available)

ZTF vs LSST

	ZTF	Vera C. Rubin (LSST)
Alerts / night	~ 300 000	~ 10 000 000
Delay	~ 30 minutes	~ 1 minute
Data / night (alerts only)	~ 10 GB	~ 1 TB (all survey = 3 PB / 10 years)
Depth	~ 20.4 magnitude	~ 25 magnitude
Photometrics bands	g, r	u, g, r, i, z, y
Field of view	47 deg ²	9.6 deg ²

GB, TB, PB : GigaBytes (10^9), TeraBytes(10^{12}), PetaBytes(10^{15})

Multi-wavelength / Multi-messenger Module in Fink

Listening and join multiple streams
in real time / offline

Currently:

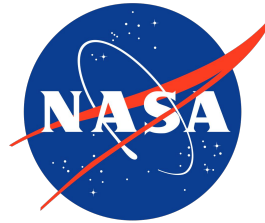
- Fermi
- Swift
- Integral
- Icecube

Planned:

- LVK (Ligo, Virgo, Kagra)
- SVOM

Delay expected performance:

- Real time :
 - LSST / GCN : < 1 minutes
- Offline :
 - < 1 day



Used by:

- ZTF
- LSST
- Now by the General Coordinates Network (GCN)

Multi-wavelength / Multi-messenger Module in Fink

Join experience ZTF x GCN:

- Period : 09/2022
- Time window : 10 days
- Number of ZTF alerts: 3,501,459

Filtering : Serendipitous probability (Damien Turpin, CEA)

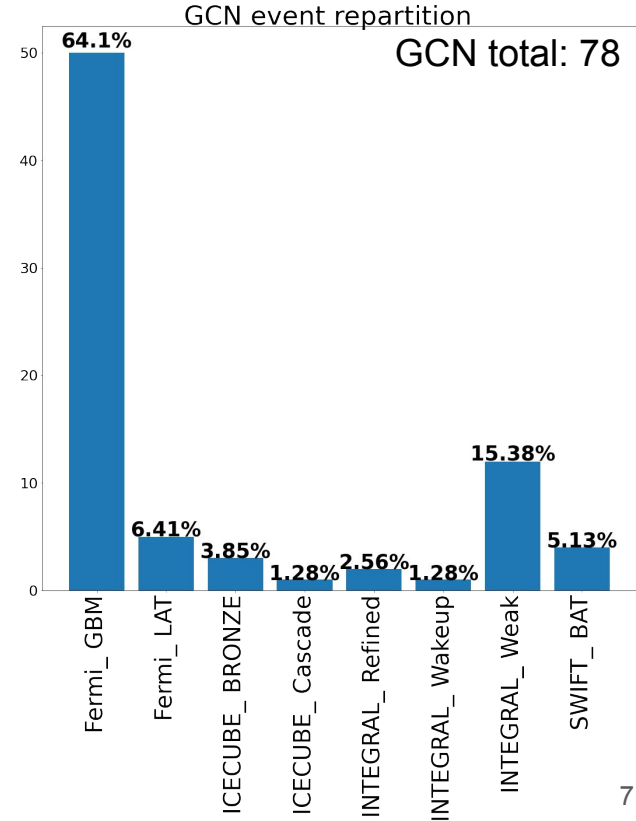
$\mu = \text{event_detection_rate} * \text{delay (between alerts and event)}$

$\Delta = \text{event error box}$

$$p_{\text{event}} = 1 - P(k = 1, \mu), P \sim \text{Pois}(\mu)$$

$$p_{\text{event_in_ZTF}} = \frac{\text{ZTF_sky_area}}{\text{all_sky_area}} * p_{\text{event}}$$

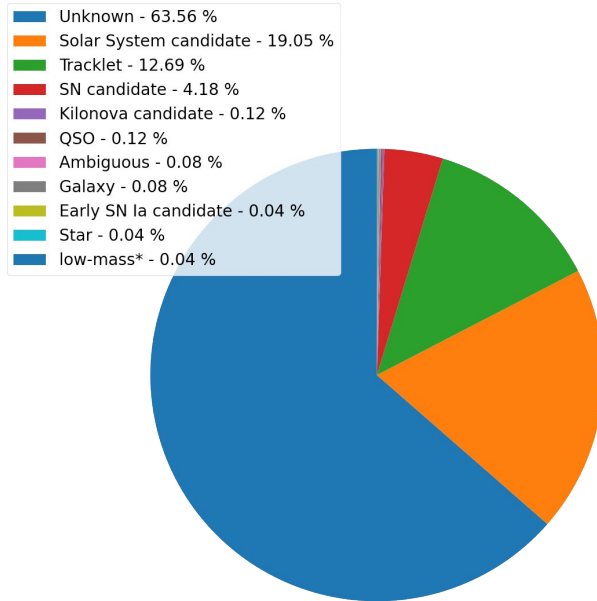
$$p_{\text{ser_event}} = p_{\text{event_in_ztf}} * \frac{\pi \Delta^2}{\text{ZTF_sky_area}}$$



Multi-wavelength / Multi-messenger Module in Fink

Results ZTF

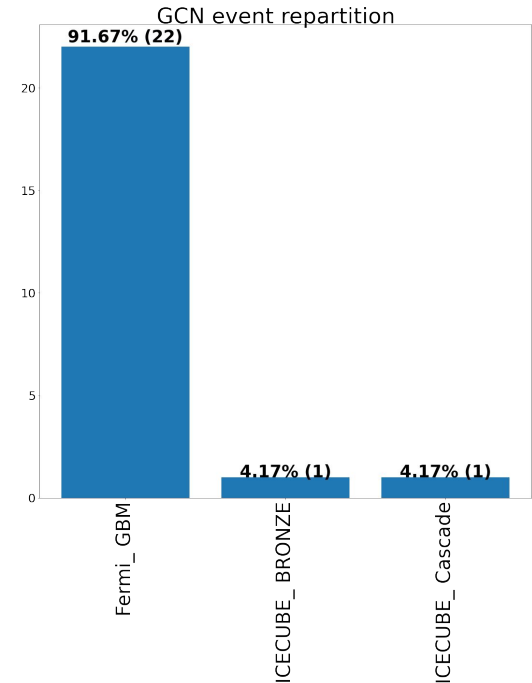
2,467 alerts (2361 objects)



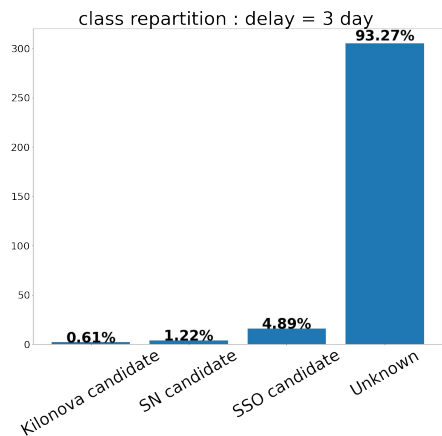
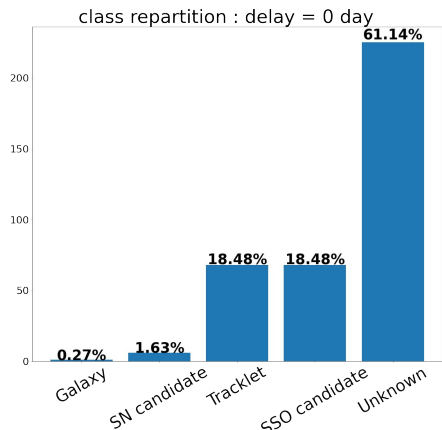
14 alerts with proba $> 5\sigma$
(neutrino event)

Results GCN

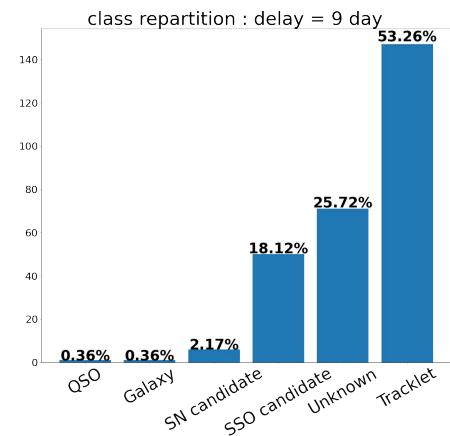
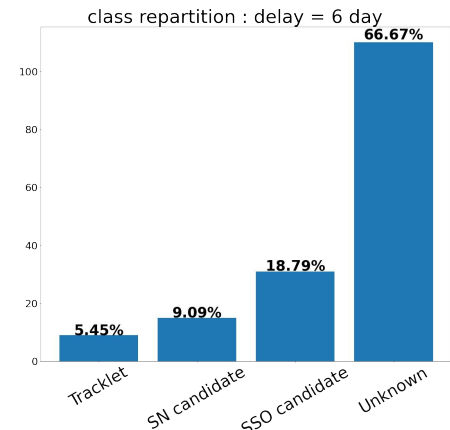
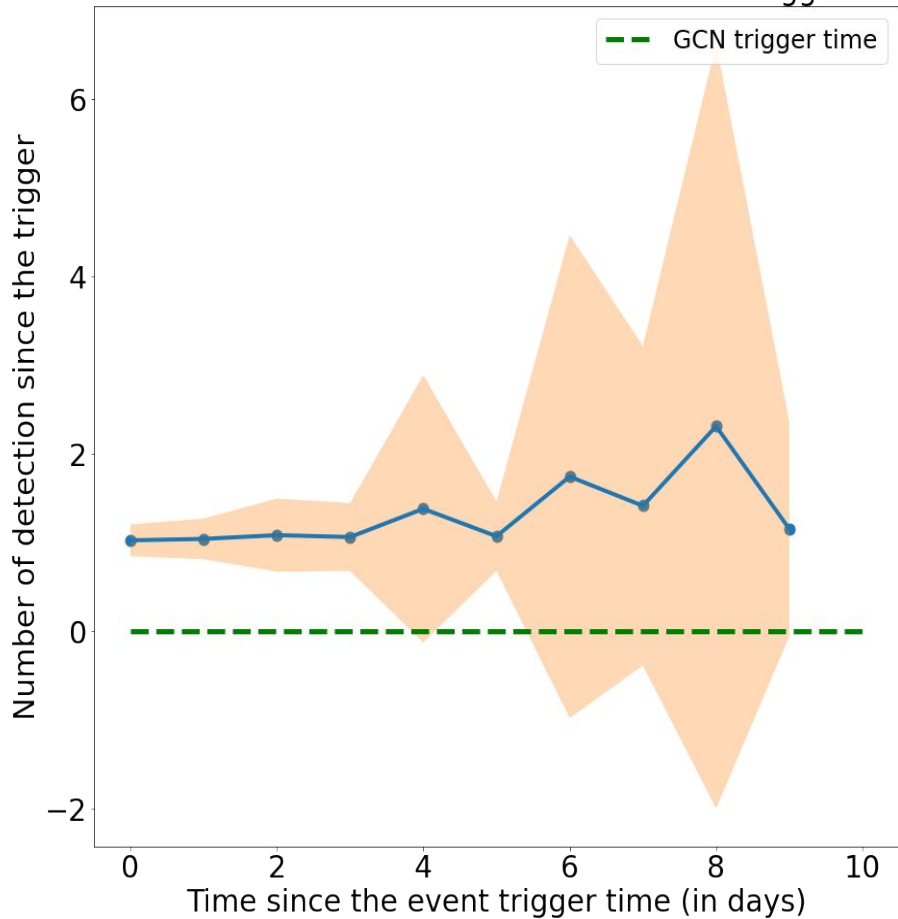
24 GCN



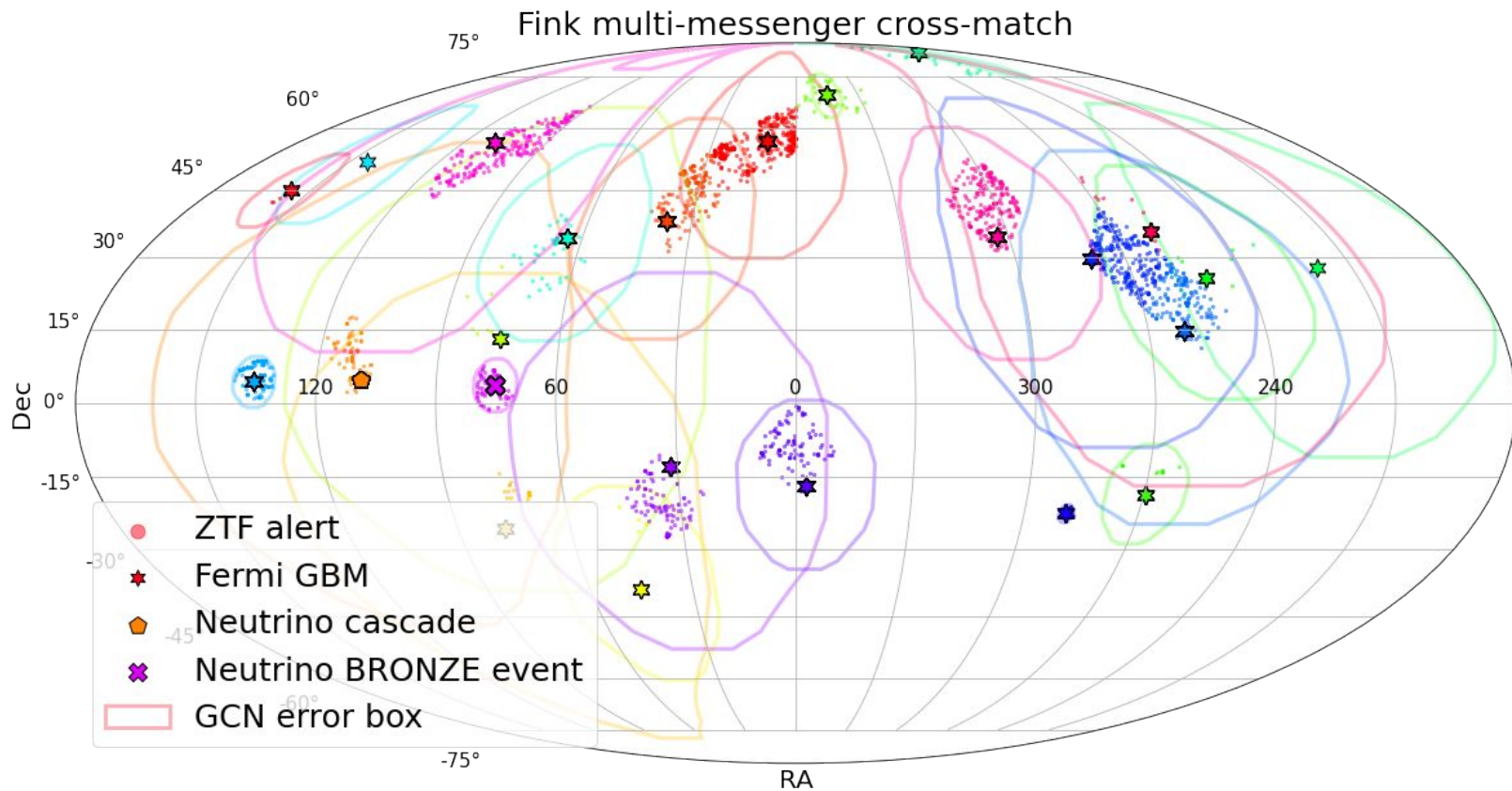
Multi-wavelength / Multi-messenger Module in Fink



Evolution of the number of detection after the trigger time



Multi-wavelength / Multi-messenger Module in Fink



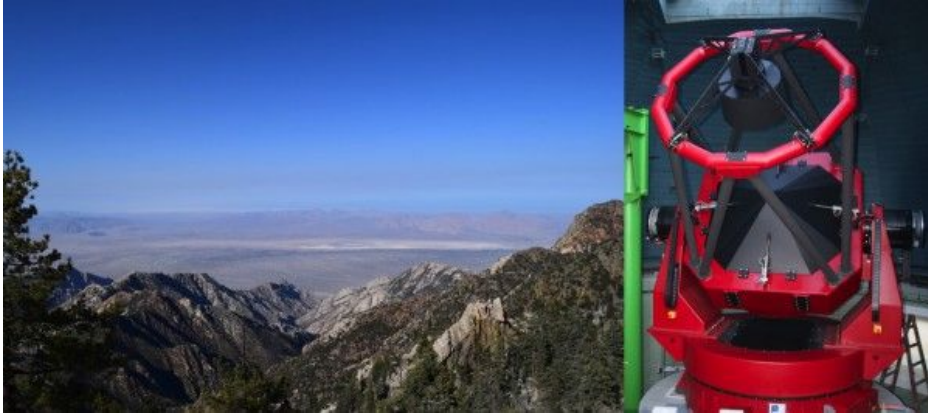


TOM TOOLKIT Las Cumbres Observatory LCO 

- Target and Observation Manager (TOM) Toolkit
- *'facilitate astronomical observing projects and collaborations'*
- *'particularly important for programs with a **large** number of potential targets and/or observations'*
 - Web development framework (Django)
 - easy as possible

<https://tom-toolkit.readthedocs.io/en/stable/introduction/about.html>

Telescope Partnerships - SVOM



French - GFT (Colibri) @ San Pedro Martir (Mexico)

Chinese - GFT @ Jilin (China)



Conclusion

- For fast transients, ZTF and LSST alone will not be sufficient to fully characterize events
 - the cadence has a huge impact on the characterization
 - Coverage lack in filters and messengers
- Follow-up will be crucial

- Alerts must be process and filter fastly and efficiently
 - - Fink is designed to work with multiple incoming streams, extract in real-time scientific values, and quickly redistribute this information to the community.

Thank you for listening

Appendix

Neutrino event with proba $> 5\sigma$

- TriggerId = 13706522012496 (Bronze event)
- Trigger time = 2022-09-18 14:46:05.320
- Error box = 3.57 deg
- Coordinates = (ra:75.15, dec:3.58)
- ZTF alerts:
 - SN = ZTF22abjbibn
 - SSO cand = ZTF22abgokpi
 - Tracklets (satellites) = ZTF22abgokiv, ZTF22abgokix, ZTF22abgokiy, ZTF22abgokiz, ZTF22abgokja, ZTF22abgokjb, ZTF22abgokjc, ZTF22abgokje
 - Unknown = ZTF22abgnhyz, ZTF22abgnjrn, ZTF22abgokae, ZTF22abgosvp

<https://fink-portal.org/>

Appendix



The only optical afterglow confirmed alert in Fink's database

- ZTF21aagwbjr (Reporter/s : Erik Kool, Igor Andreoni, Anna Ho, Michael Coughlin, Tomas Ahumada, Daniel Perley, Yuhan Yao)
- Paper study : The long-active afterglow of GRB 210204A: Detection of the most delayed flares in a Gamma-Ray Burst, harsh kumar et al, 15 april 2022

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ZTF21abfaohe

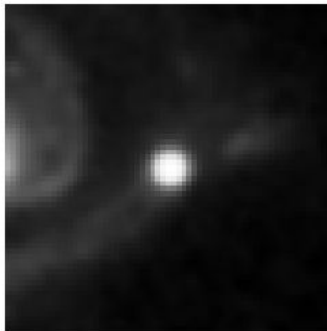
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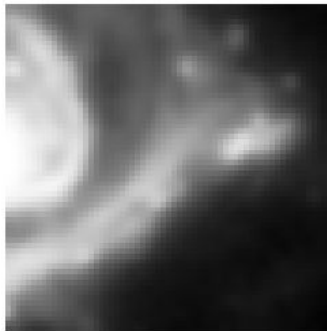
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