Multi messenger astronomy: latest results from the fink broker

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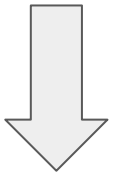
07/05/2024

Wide Field Optical Surveys

High Energy Universe

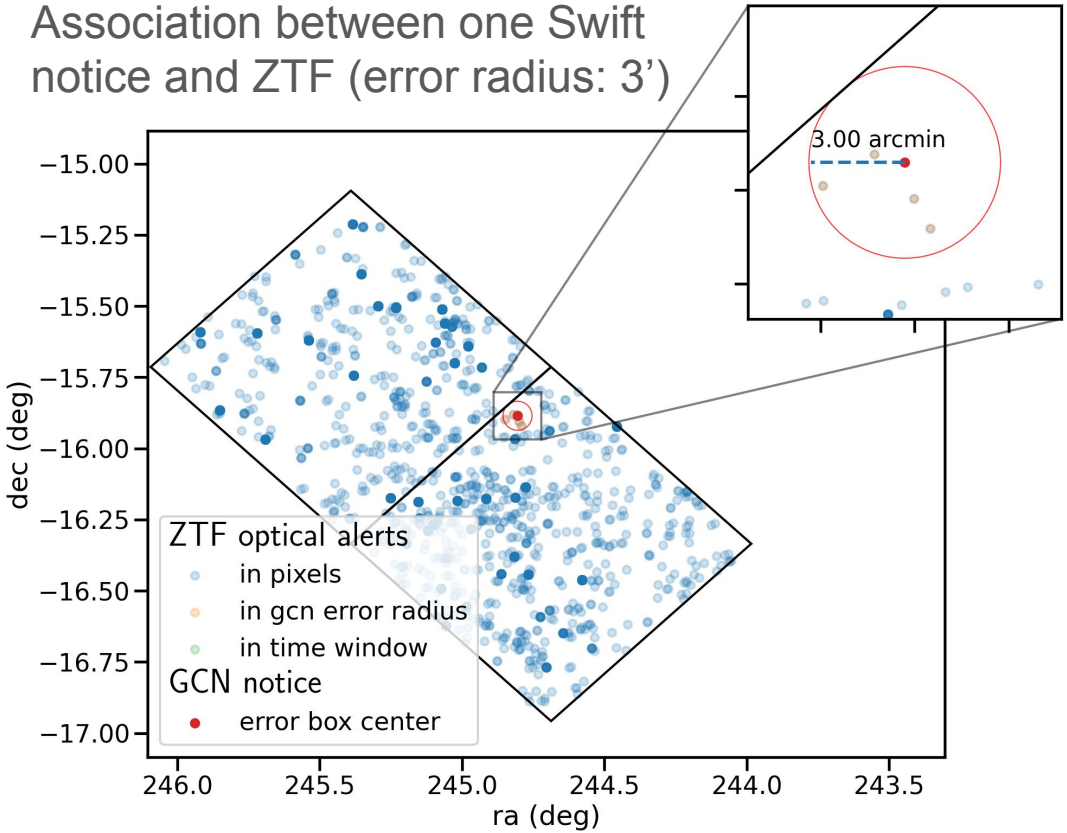


Real-time

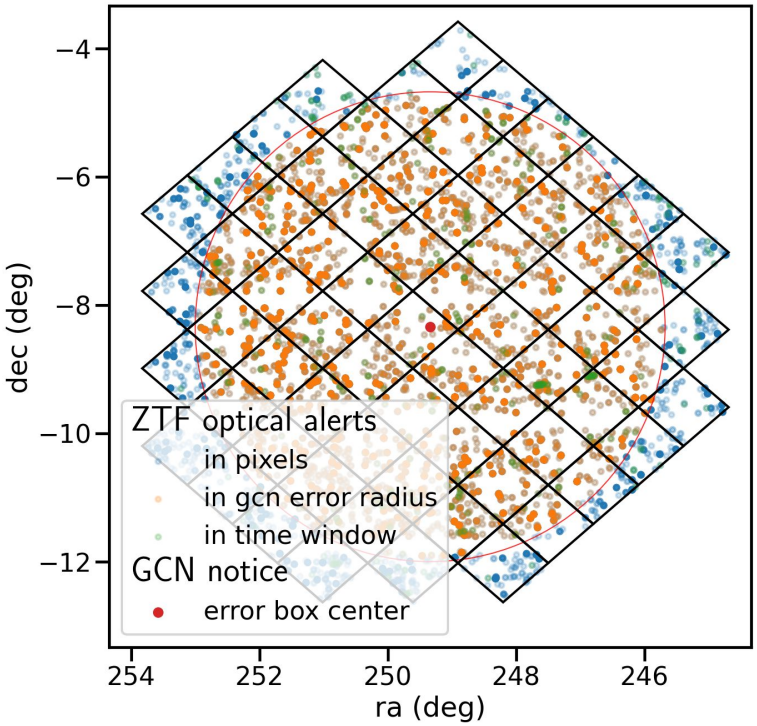
Public

Fink-MM examples

Association between one Swift notice and ZTF (error radius: 3')

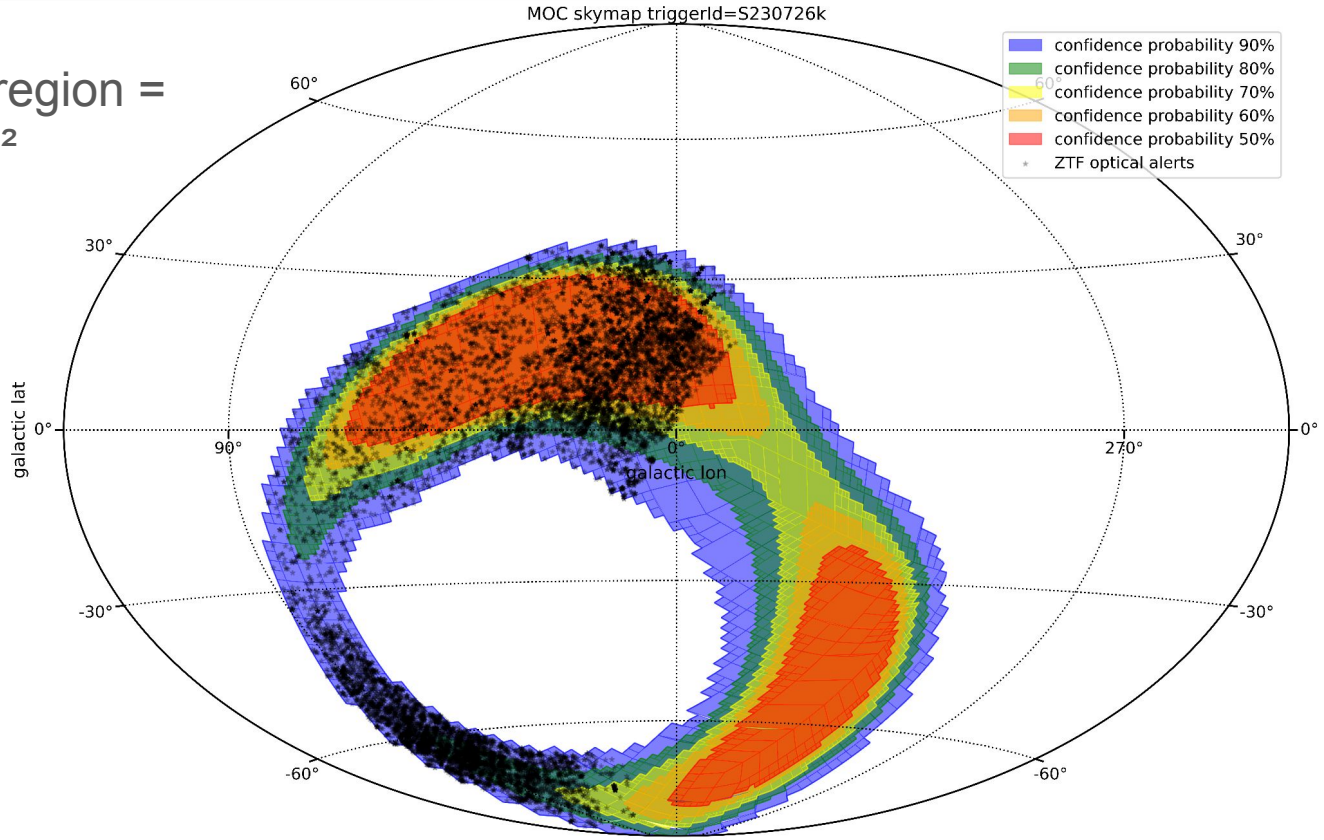


Association between one Fermi notice and ZTF (error radius: ~3.6°)



Fink-MM examples (o4a)

90% area region =
~8000 deg²



Dataset and configuration

Period: from 2023-05-29 to 2024-01-16

ZTF number of alerts: 24,852,814 (154,365 alerts / night)

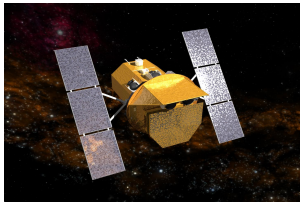
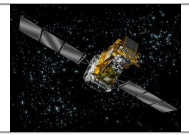
GCN number of notices: 3,383 (~16 notices / day)

Fink-MM configuration

- Healpix Map Resolution = Nside = 64 (~55 arcminutes per pixels)
- PAN-STARRS and GAIA filter threshold: 2 arcseconds
- MPC filter threshold: 5 arcseconds
- Time window: 20 days (cut at 10 days for GW)

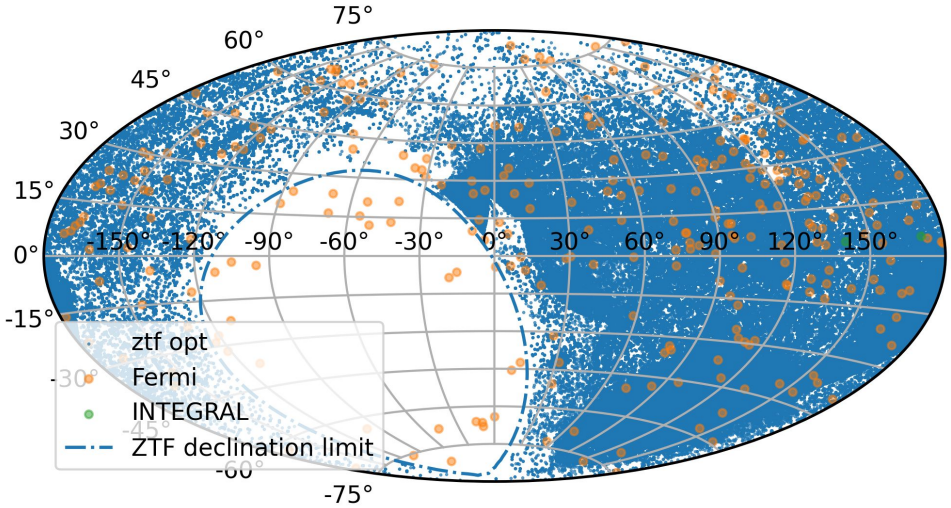
Results - GRB

- 690 unique events from the GRB observatories

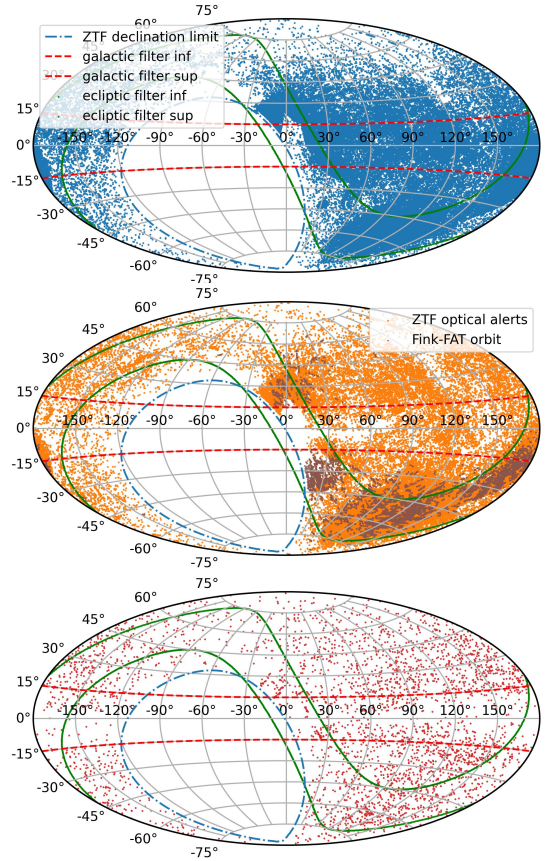
Observatory	number of unique events	Notices per instruments
Fermi	**63.48%**	GBM: 99.5%
		LAT: 0.5%
Swift 	**13.91%**	BAT: 86.95%
		XRT: 12.27%
		UVOT: 0.78%
Integral 	**22.61%**	IBIS:100% (weak: 89.2%, wakeup: 6.6%, refined: 4.2%)

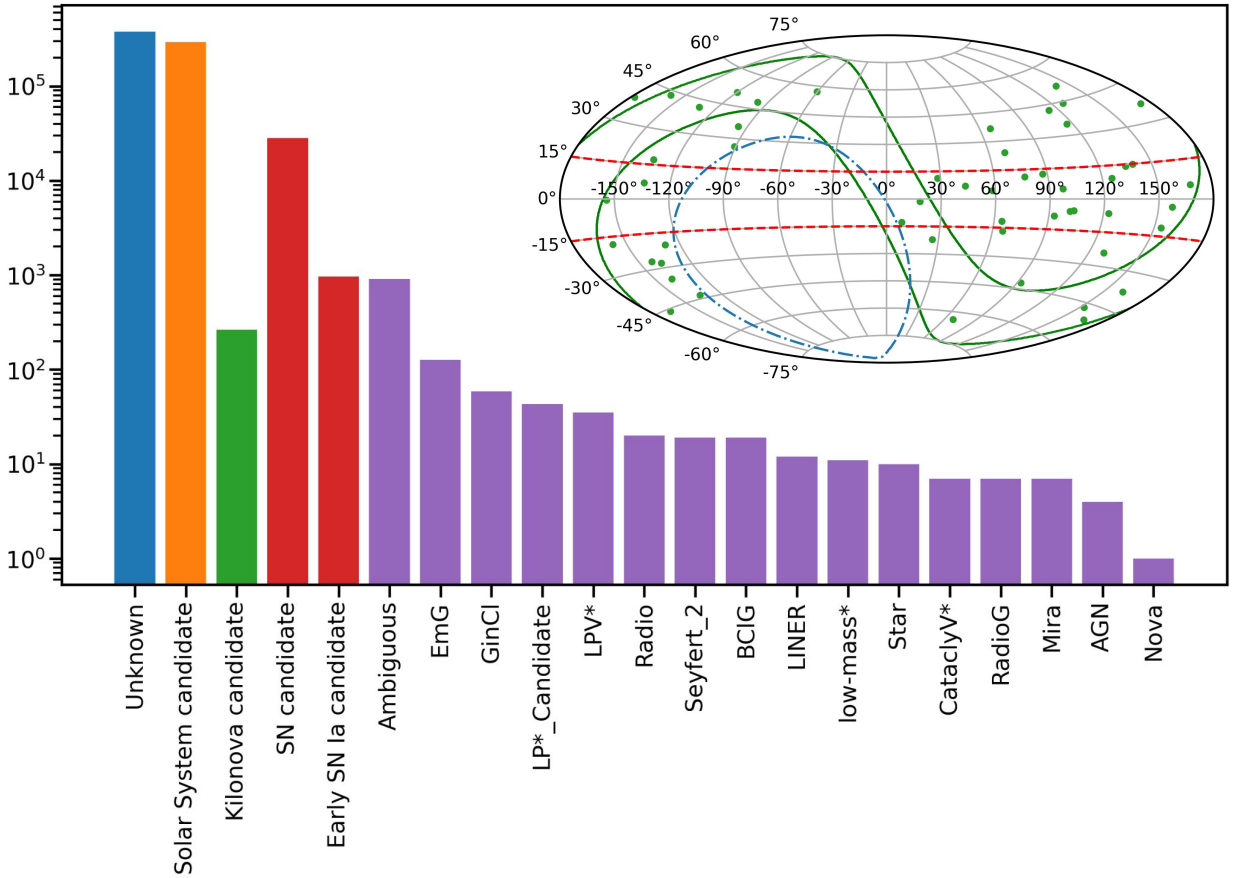
Results - GRB

- **42% of unique GCN events** with positive match in ZTF based on the spatial and temporal condition
  - Fermi: 702,613 (2.8%) ZTF matches with notices (~ 3,123 match / night)
  - Integral: 2 matches from weak notices
  - Swift: 0 match with any of the BAT, XRT or UVOT notices



Results - GRB


ZTF declination limit
galactic filter inf
galactic filter sup
ecliptic filter inf
ecliptic filter sup
ZTF optical alerts
Fink-FAT orbit


Unknown
Solar System candidate
Kilonova candidate
SN candidate
Early SN Ia candidate
Ambiguous
EmG
GinCl
LP*_Candidate
LPV*
Radio
Seyfert_2
BClG
LINER
low-mass*
Star
CataclyV*
RadioG
Mira
AGN
Nova

Results - GRB

Stringent quality cuts + selection based on Fink classifiers

→ 36.15 % (401.61 alert / night)

Bronze + *serendipitous probability* above 5 sigma

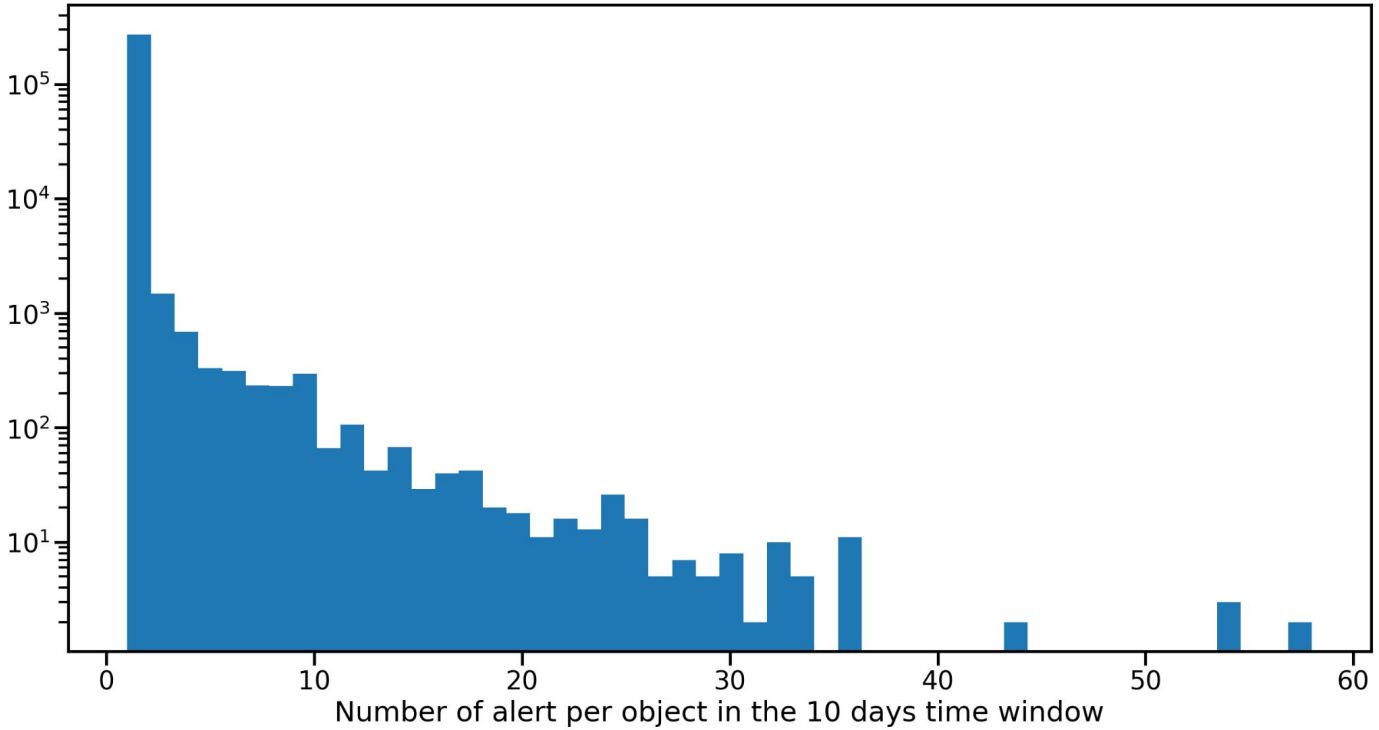
→ Only 9 alerts

Silver + fast transient behaviour

→ 0 alerts

Results - GRB

- **Bronze alerts**



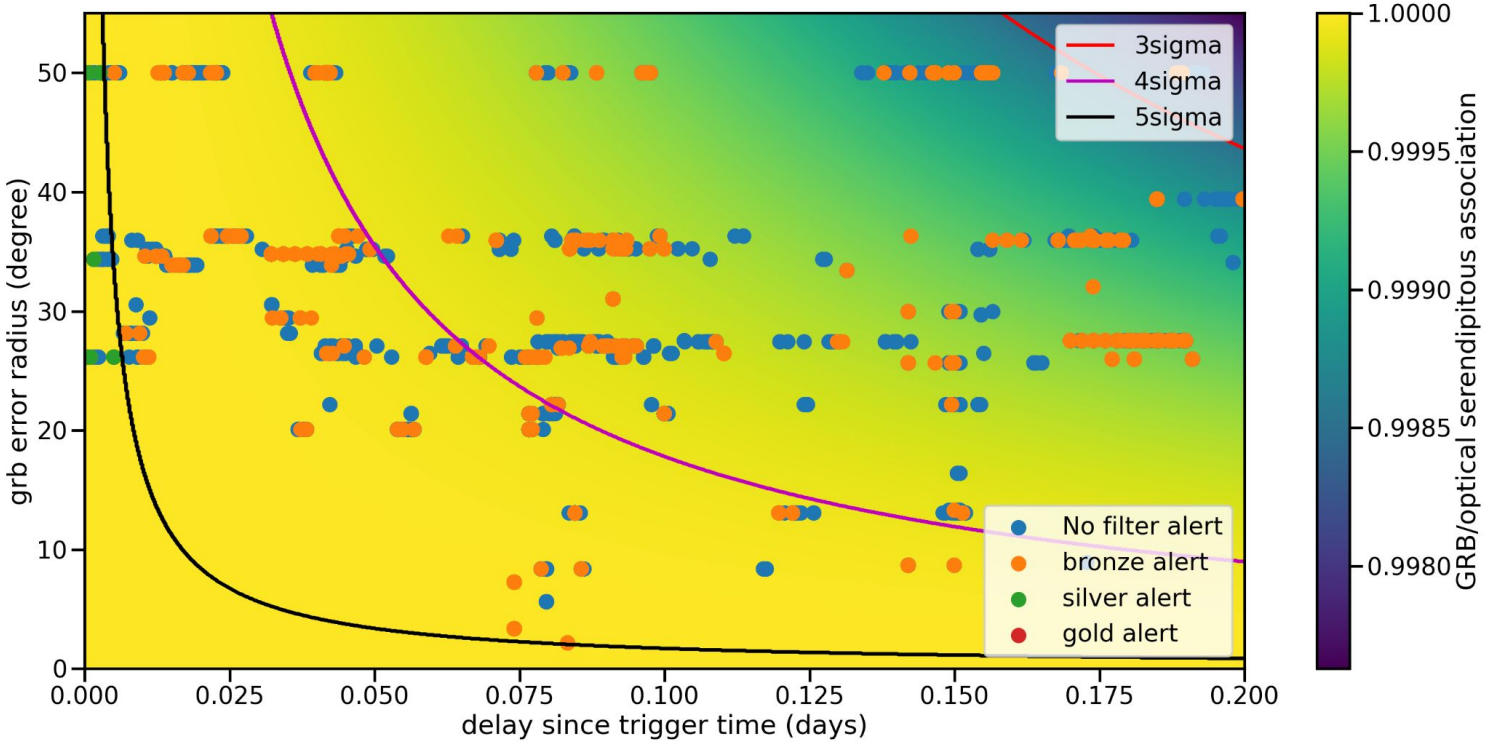
Results - GRB

- **Bronze alerts**
  - Increase knowledge with more catalogues in other wavelength
  - catalog condition: astrometry as precise as ZTF (around the arcsecond)
    - Galex UV catalog (82,992,086 sources)
      - 0.80 %
    - AllWISE mid-infrared catalog (747,000,000 sources)
      - 2.03 %
    - Very Large Array Sky Survey VLASS radio catalog (3,400,000 sources)
      - 0.01 %
    - Artificial Satellites Fink offline science module
      - 6.10 %

Karpov, S.; Peloton, J. 2023

Results - GRB

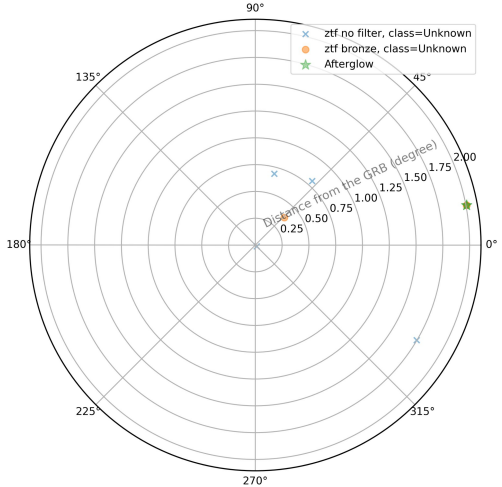
- **Silver alerts**

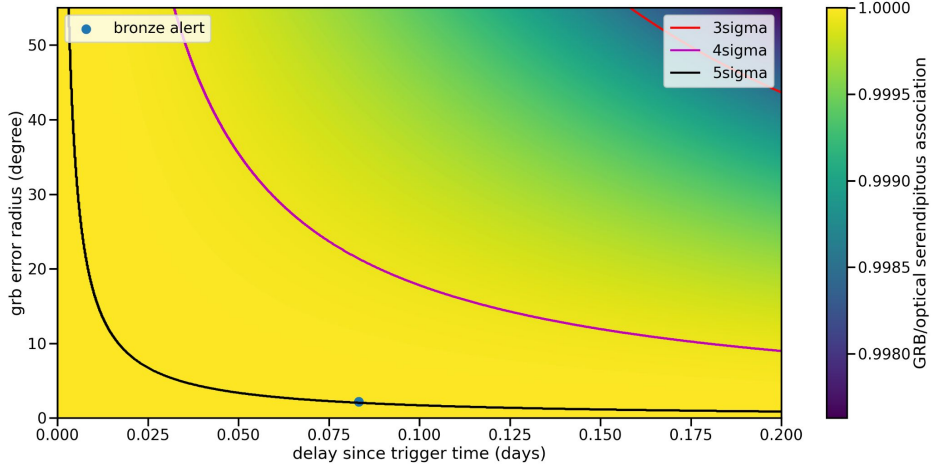


Results - GRB

- One confirmed GRB optical afterglow identify so far in the Fink-MM data
  - GRB 230827B
  - https://fink-portal.org/ZTF23abaanxz
  - ZTF delay: ~ 2 hours after GRB trigger Time for the first point
  - AstroNote 2023TNSAN.238....1L and 2023GCN.34789....1S

P. Reichherzer *et al* 2021 *ApJS* **256** 5





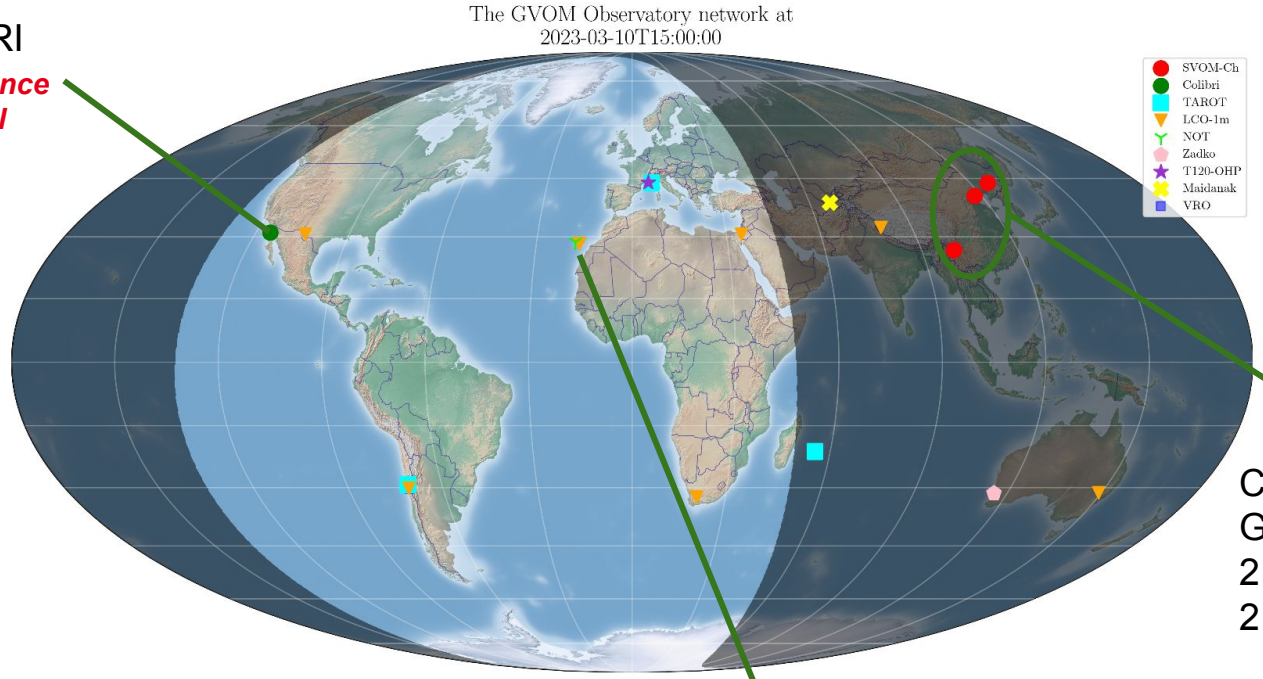
TOM-TOOLKIT

- 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

GVOM : A telescope network to build



COLIBRI

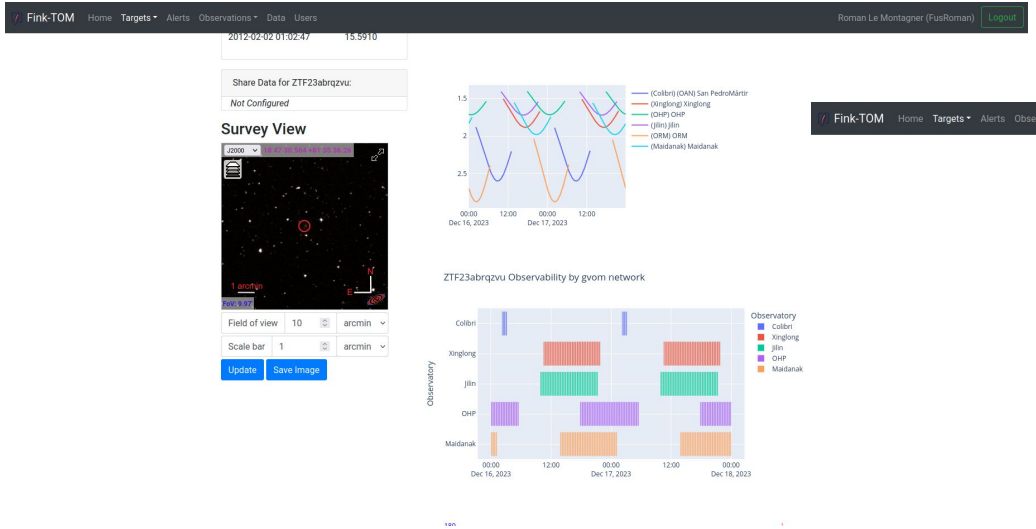
Colibri Science Proposal

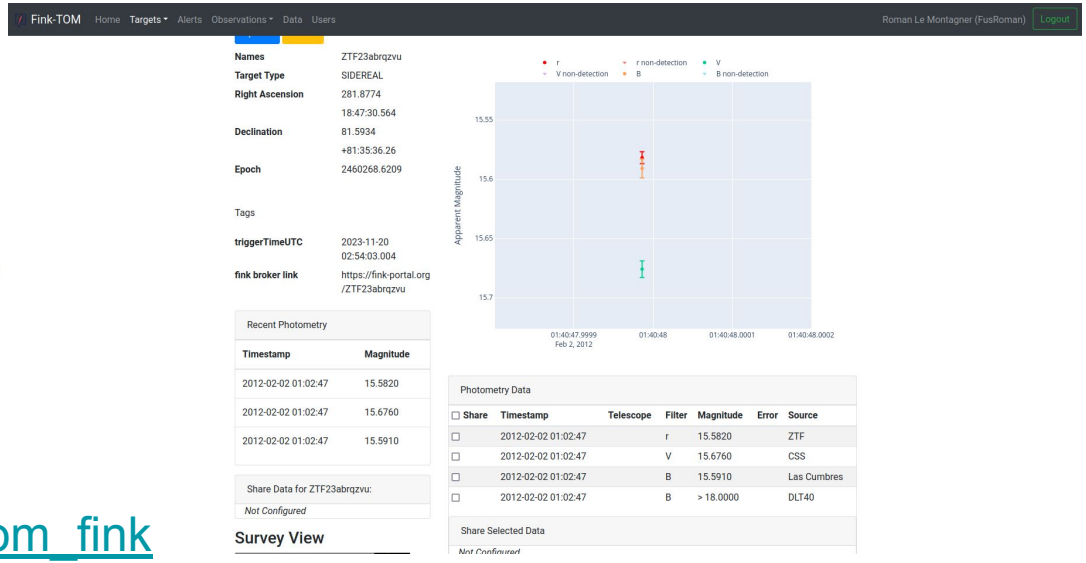
C-GFT
GWAC-F60
2.12m Xinglong
2.4m Lijiang

NOT

Credits: D. Turpin, CEA

GVOM-TOM





- Plugin: https://github.com/TOMToolkit/tom_fink
- Dedicated application: https://github.com/FusRoman/fink-tom

Conclusion/Discussion

- Real-Time crossmatch between optical survey and high energy observatories
  - Implemented through the Fink-MM framework
  - Fully customisable and scalable to millions of alerts per night
- Tested over 9 months of ZTF observation with simple filters
  - Bronze (94,809 matches), Silver (9 matches), Gold (0 match)
  - One confirmed GRB optical afterglow
  - Unknown with one point: What are they? (cosmic rays, asteroids, star flares, other, …)
  - Further catalogue cross-match did not reveal more information
- Lessons learned from this first cross-matching campaign
  - MMA pipeline in place in Fink, but it requires further optimization for Rubin
    - Refining of the selection criteria for candidate
  - Access to the full stream is absolutely necessary

Backup

Results - GRB

Fink-MM filters:

- Bronze: real bogus score > 0.7 and class belonging to Unknown, Ambiguous and extra galactic (SN, KN, …)
  - 36.15 % returned as bronze (401.61 alert / night)
- Silver: bronze condition and serendipitous probability above 5 sigma
  - only 9 alerts from the 702,615 alerts returned by Fink-MM
- Gold: silver condition and magnitude rate above 0.3 magnitude per day (rising or fading)
  - 0 alert

ZTF silver list

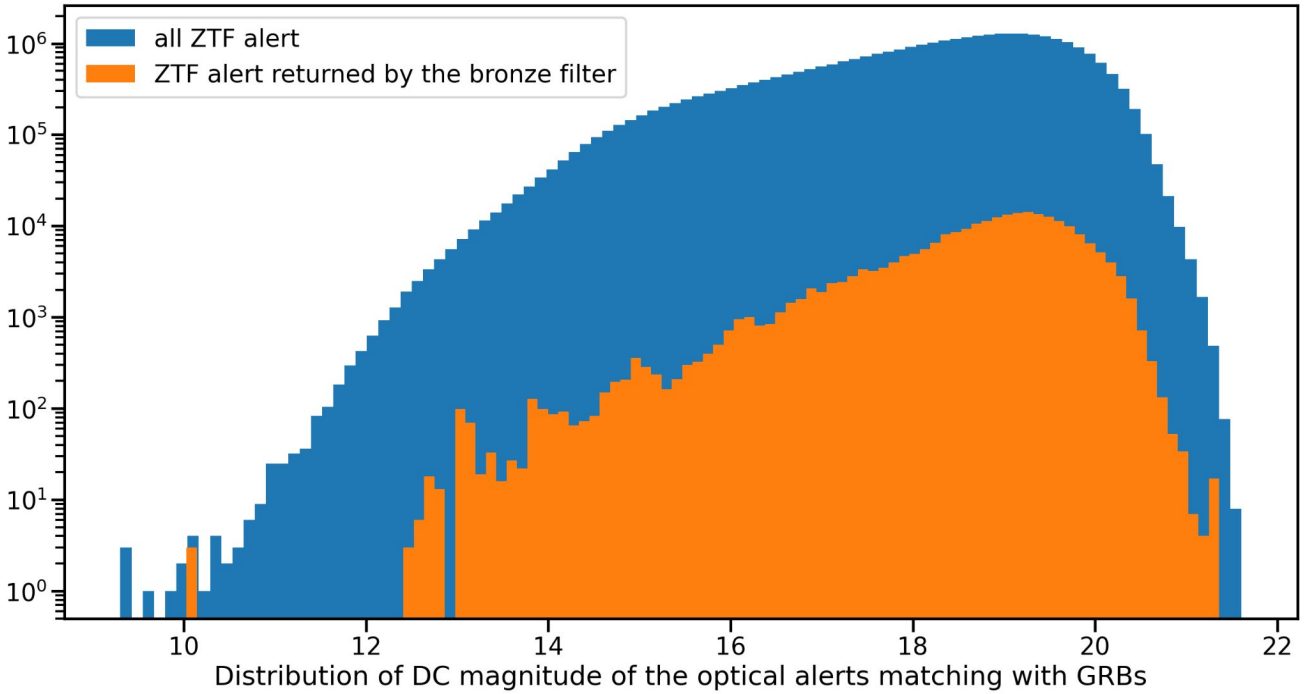
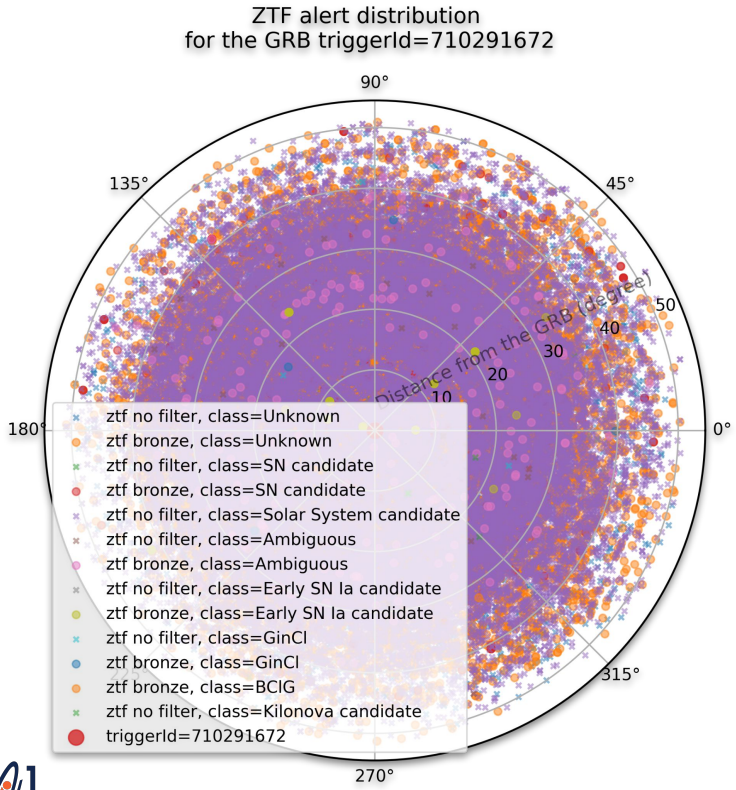
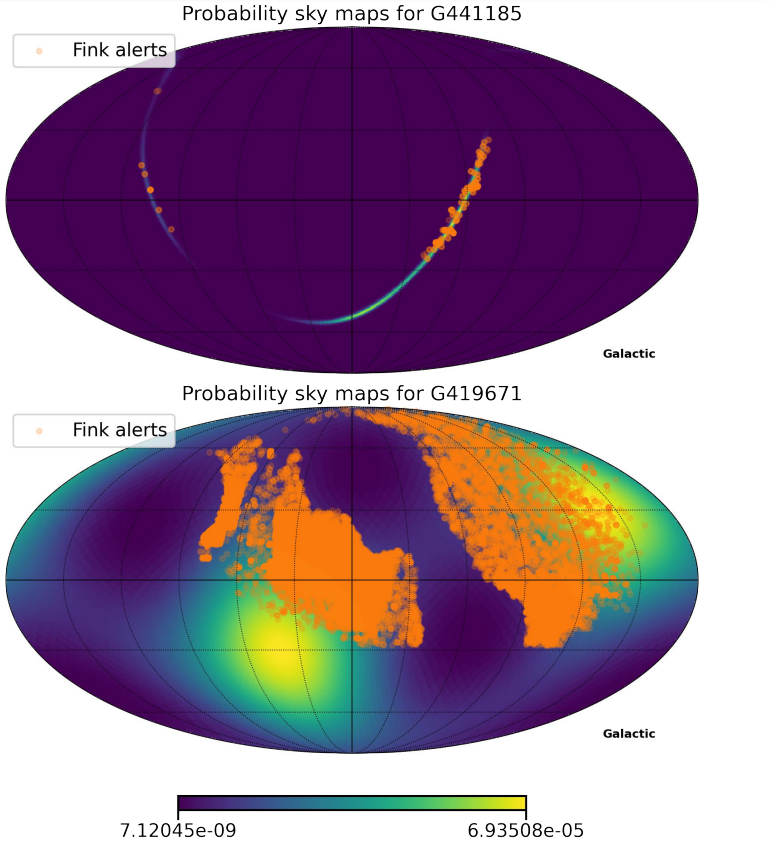
ZTF science portal link : Fermi trigger id

- https://fink-portal.org/ZTF23aaqjybs : 710063283
- https://fink-portal.org/ZTF23abryskp : 723525390
- https://fink-portal.org/ZTF23aaqdzeb : 709806846
- https://fink-portal.org/ZTF23aaqebau : 709806846
- https://fink-portal.org/ZTF23abrypyv : 723525390
- https://fink-portal.org/ZTF23aaqdzyt : 709806846
- https://fink-portal.org/ZTF23aaqebvb : 709806846
- https://fink-portal.org/ZTF23aaqdywx : 709806846
- https://fink-portal.org/ZTF23aaqeako : 709806846

look the fermi trigger: https://gcn.gsfc.nasa.gov/fermi_grbs.html

Results - GRB

- **Bronze alerts**



Fink-MM: Challenges