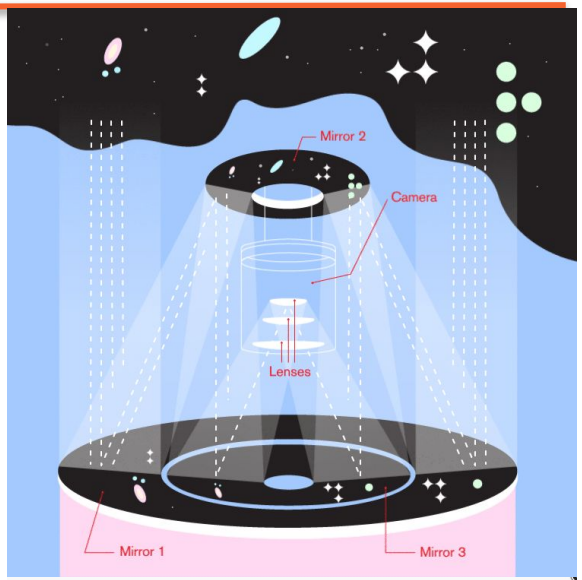
Multi-messenger astronomy at the LSST era

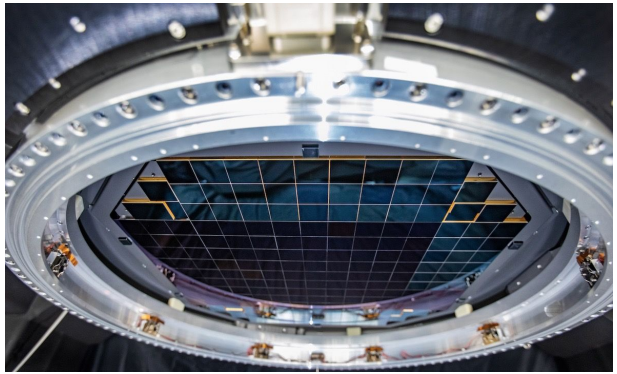
Roman Le Montagner

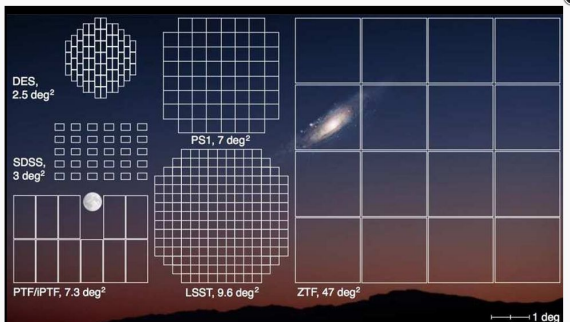
AG du département informatique

20/12/2023

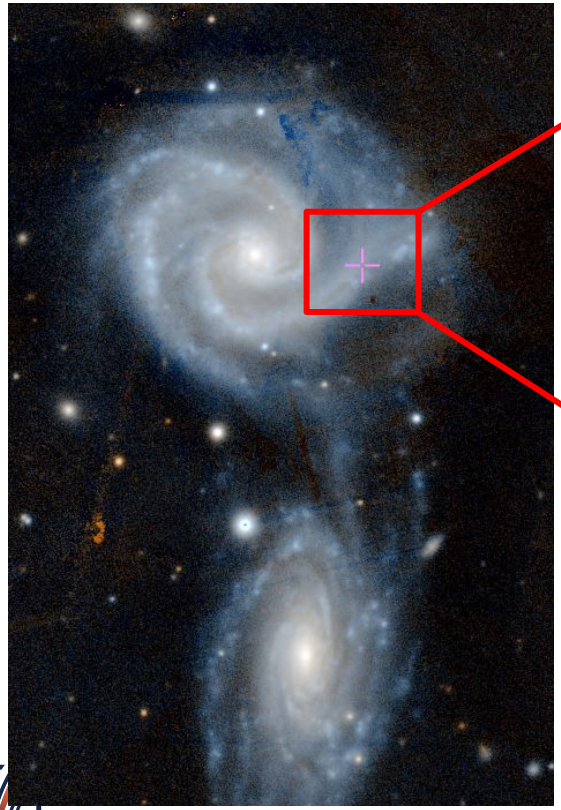
Vera C. Rubin observatory

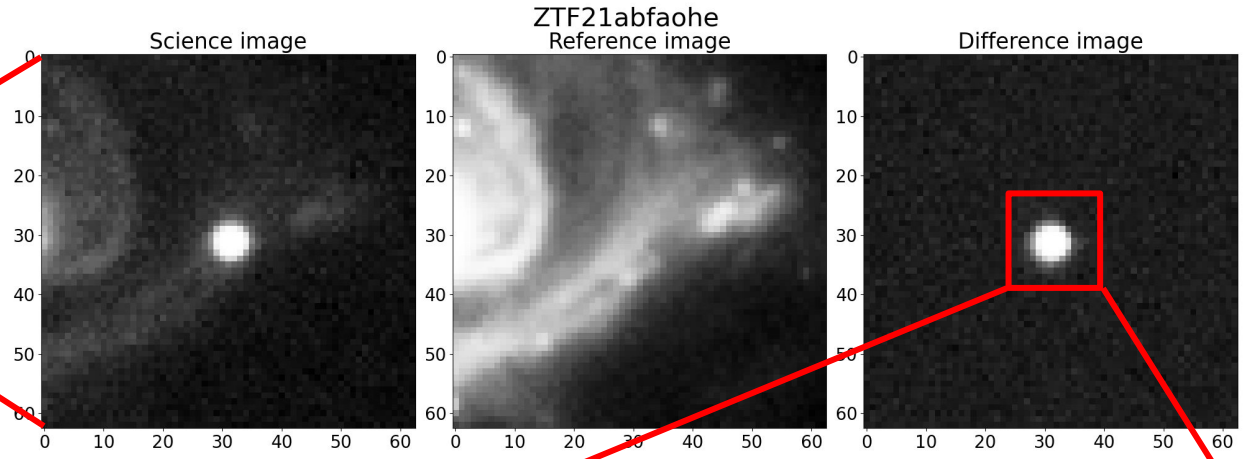






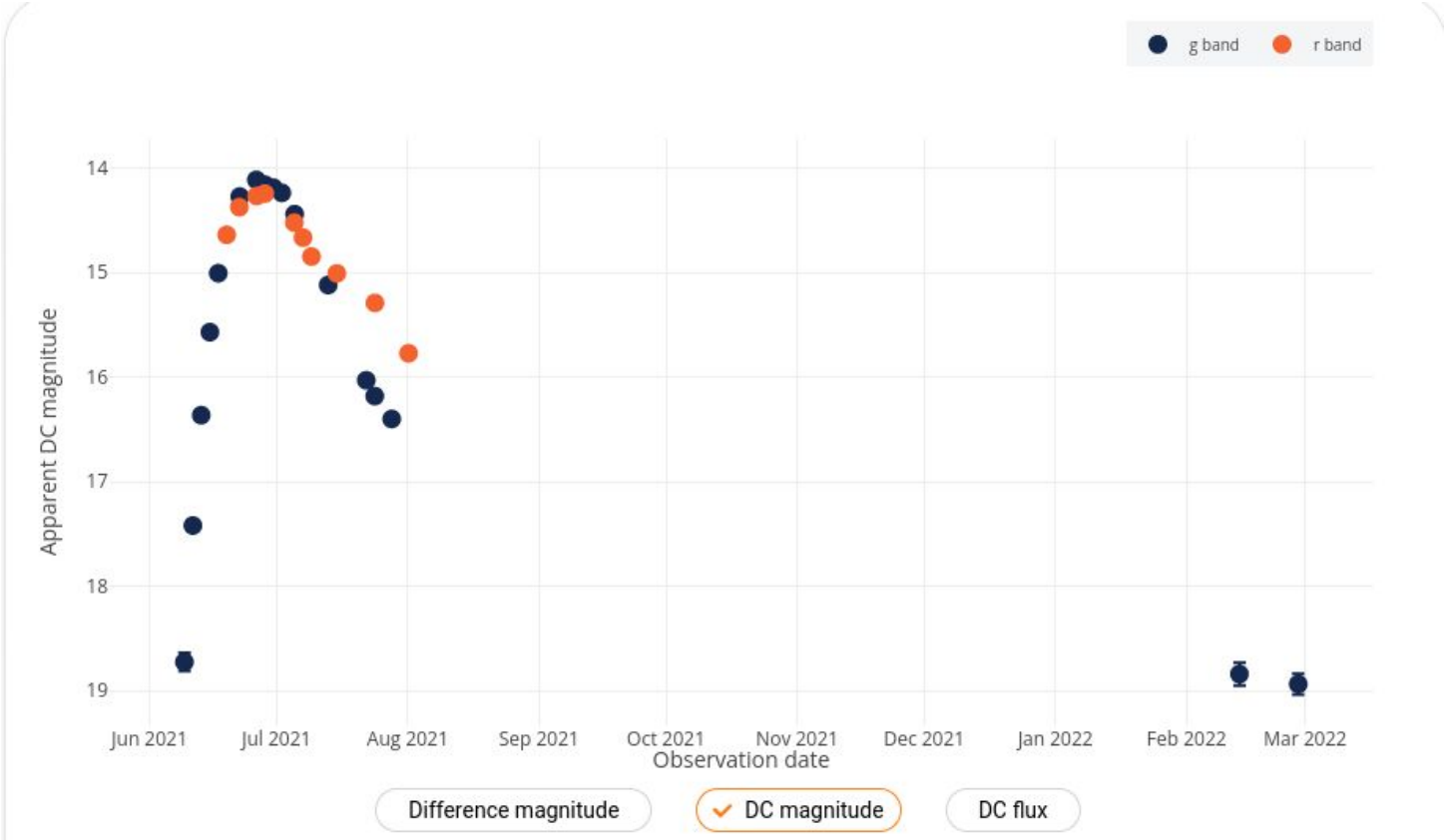
Monitoring the transient sky





Apparent magnitude (magpsf) : 14.12 ± 0.03

Lightcurve


g band
r band
14
15
16
17
18
19
Apparent DC magnitude
Jun 2021
Jul 2021
Aug 2021
Sep 2021
Oct 2021
Nov 2021
Dec 2021
Jan 2022
Feb 2022
Mar 2022
Observation date
Difference magnitude
DC magnitude
DC flux

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)

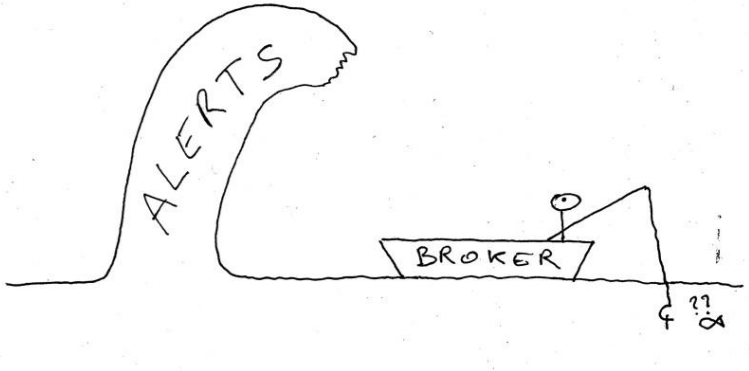
- Fink is a community-driven effort, open to anyone
- **Online since 11/2019 thanks to the Zwicky Transient Facility (ZTF)**

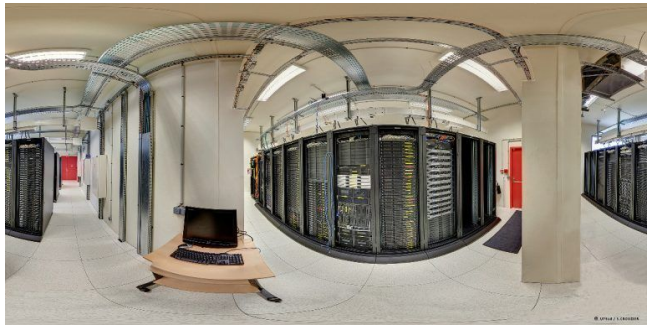
Challenges in the LSST era

Today : ZTF send ~ 200,000 alerts / night, ~ 10 GB / night

From 2025 : Rubin will send at most 10,000,000 alerts / night, ~ 1 TB / night

- Petascale challenge
  - LSST will last for 10 years
  - Billion of optical alerts are expected

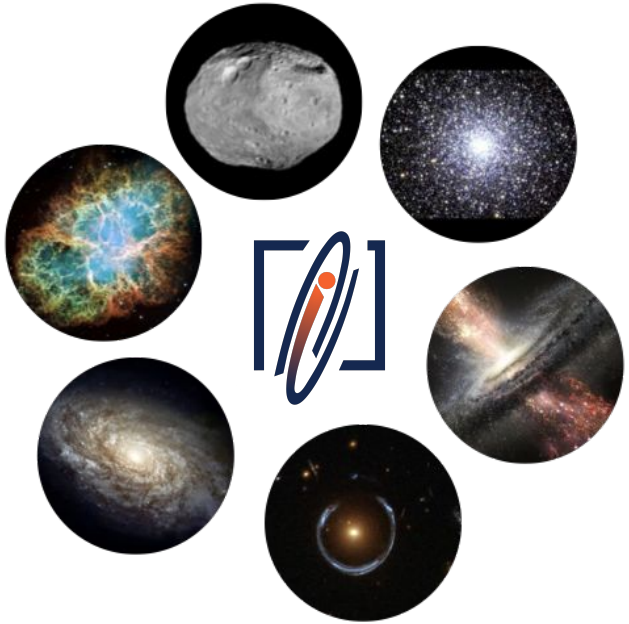




Early classification of the alerts

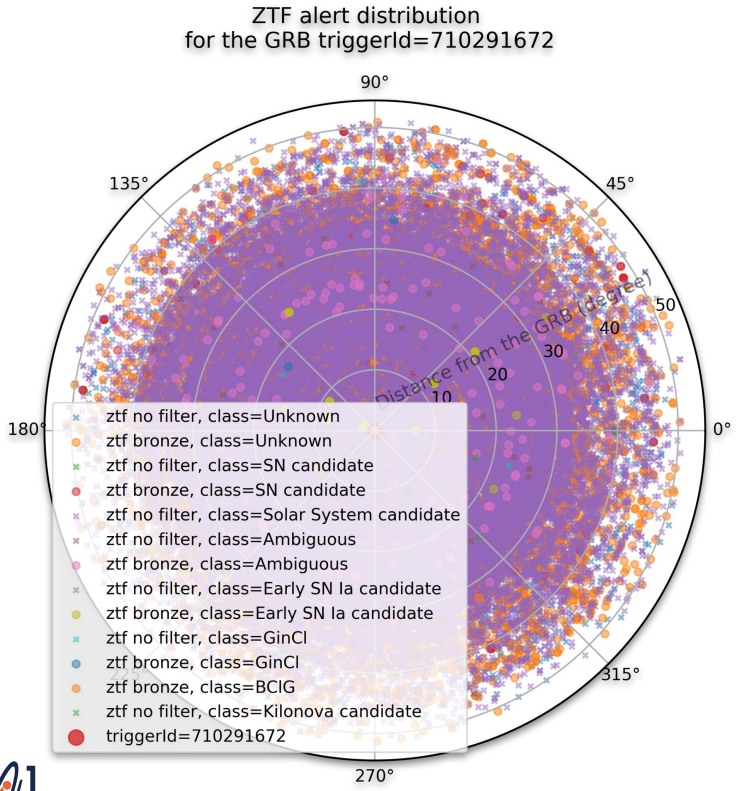
- Quickly identify the astronomical class of the alerts
- Current classification :
  - Supernovae
  - Kilonovae
  - Microlensing
  - Active Galactic Nuclei
  - **Multi-messenger astronomy (MMA)**
    - **EM, GW, neutrino/astro-particules**
  - **Asteroids/Comets**
  - Artificial satellites
  - UNKNOWN

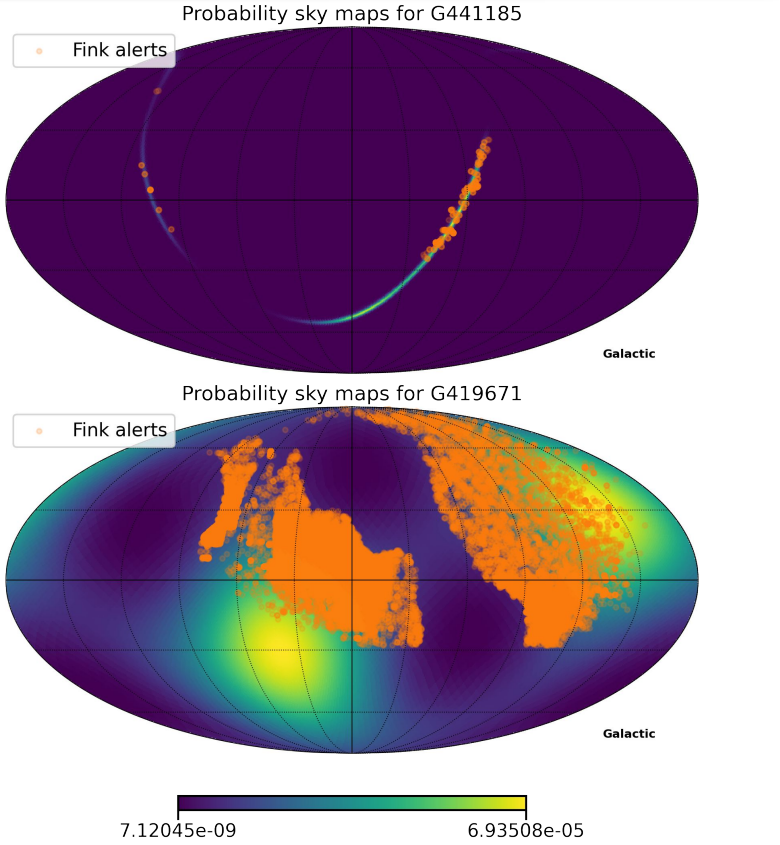
Almost 50% of alerts end up with no labels after the processing



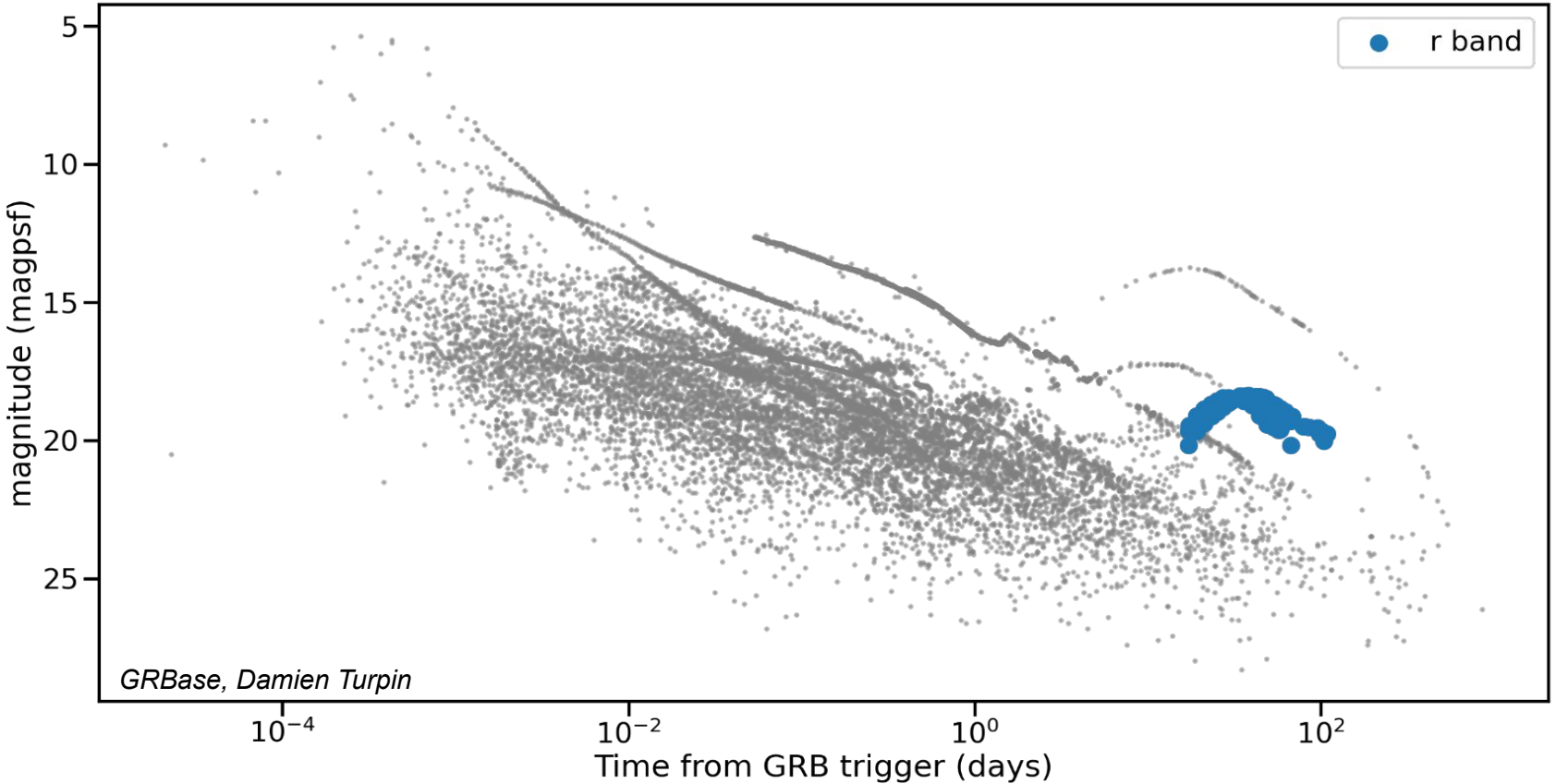
- https://github.com/astrolabsoftware/fink-science
- https://github.com/astrolabsoftware/fink-filters

Fink-MM: Challenges

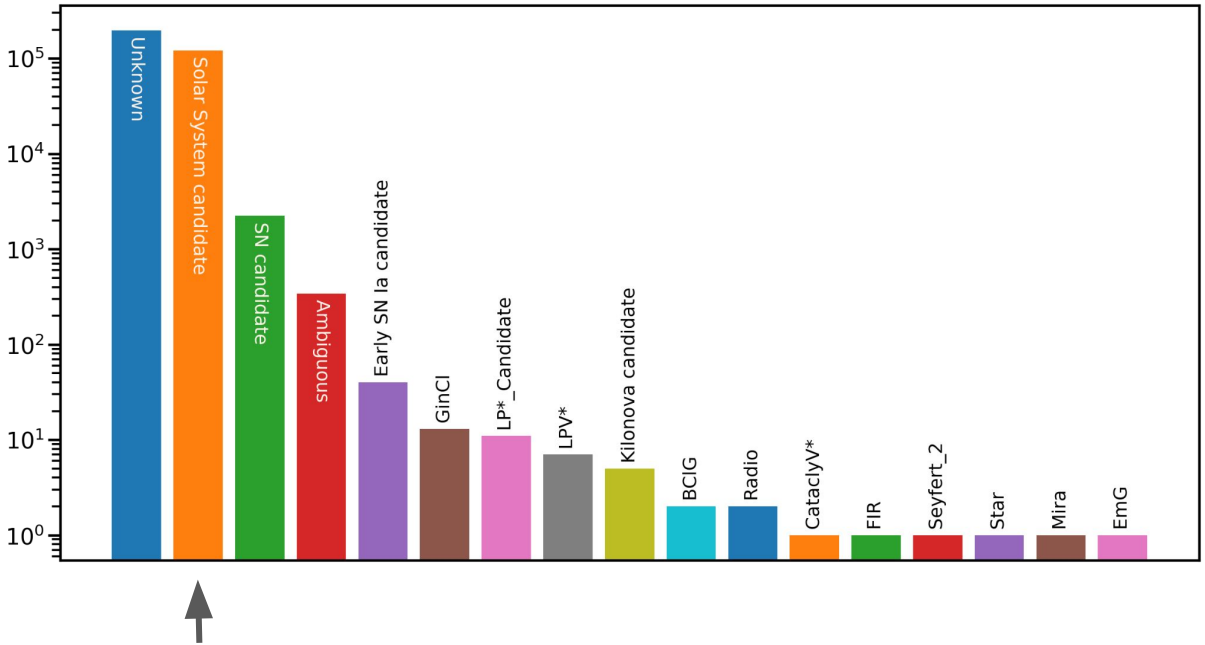




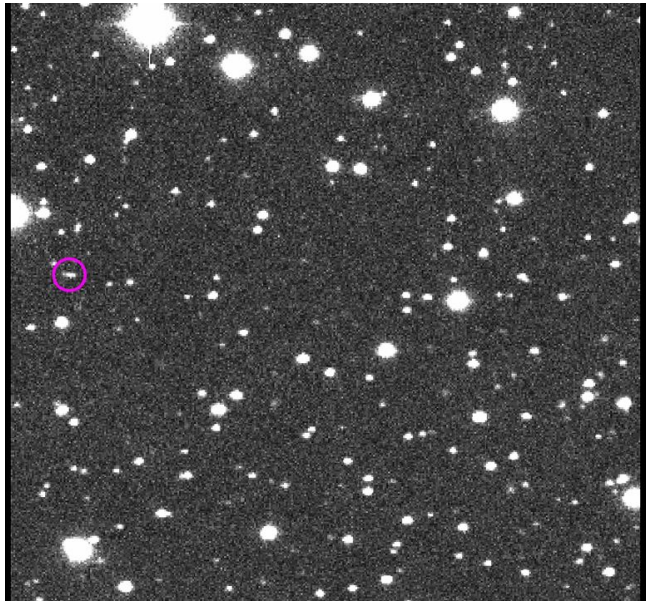
Fink-MM: Challenges



Fink-MM to Fink-FAT

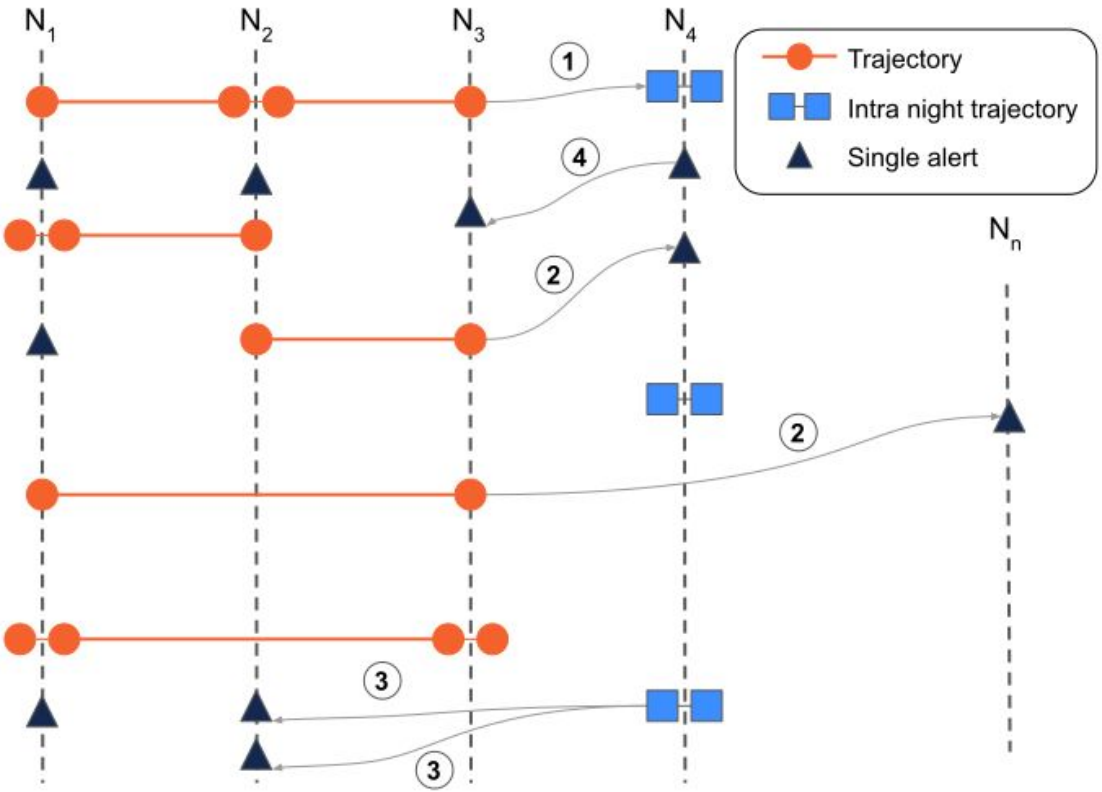


Le Montagner et al 2023, A&A



Credits: Nasa, Jet Propulsion Laboratory

Fink-FAT: Fink Asteroids Tracker



Fink-FAT: Results

- Two campaign (07/2022, 09/2022)
  - 07/2022 : One trajectory followed -> confirmation from follow-up (MPC number: 525570)
  - 09/2022 : Five trajectories followed

Internal name	Last observation(delay since follow-up)	Results
FF2023aaaaama	2022/08/28 (34 days)	Pasiphae (Jupyter satellite)
FF2023aaaaamb	2022/08/28 (28 days)	Sinope (Jupyter satellite)
FF2023aaaaalx	2022/08/22 (34 days)	Sinope (Jupyter satellite)
FF2023aaaaamc	2022/08/29 (33 days)	No clear association
FF2023aaaaamd	2022/08/31 (31 days)	No clear association

Conclusion

- Fink-MM: module deployed on Fink and returns in real-time the optical alerts associated with other messengers (GW, Neutrino, …)
  - A paper is ongoing.
- Fink-FAT: module deployed on Fink and returns a set of trajectories with orbit each night
  - A more powerful version is almost ready for production.
  - An automatic pipeline to submit the trajectories to the MPC is in progress.
- Fink-TOM: an automatic system to send the Fink alerts to the robotic network of telescopes from the SVOM mission is in progress
- Writing the thesis