FINK tools for amateur follow-up of SSO

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Fink: cloud-based broker

Brokers are software serving the scientific community by **ingesting**, classifying, filtering, and **redistributing** alerts from telescopes and surveys.
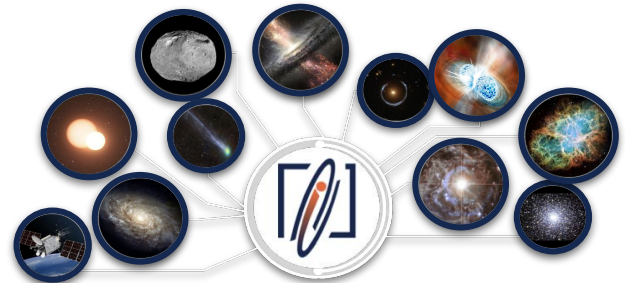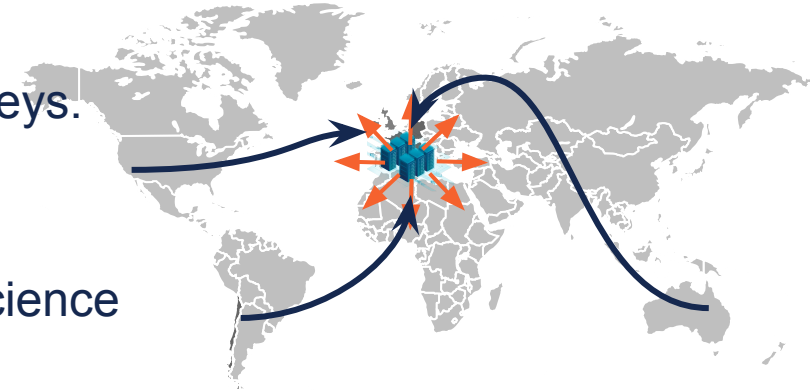
60+ members, 15+ scientific topics covered
- Solar system, galactic and extragalactic science

Services deployed on large OpenStack clouds (UPSaclay & CC-IN2P3)
- Scalable to millions of alerts per night

Operating 24/7 since 2019, serving 100+ unique users per day (scientists, follow-up facilities & amateurs*)

*e.g. In GRANDMA

ZTF/Fink statistics

210 million alerts received, 143 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

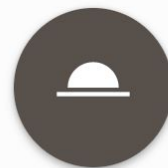

2019-2021
75,925,464 alerts
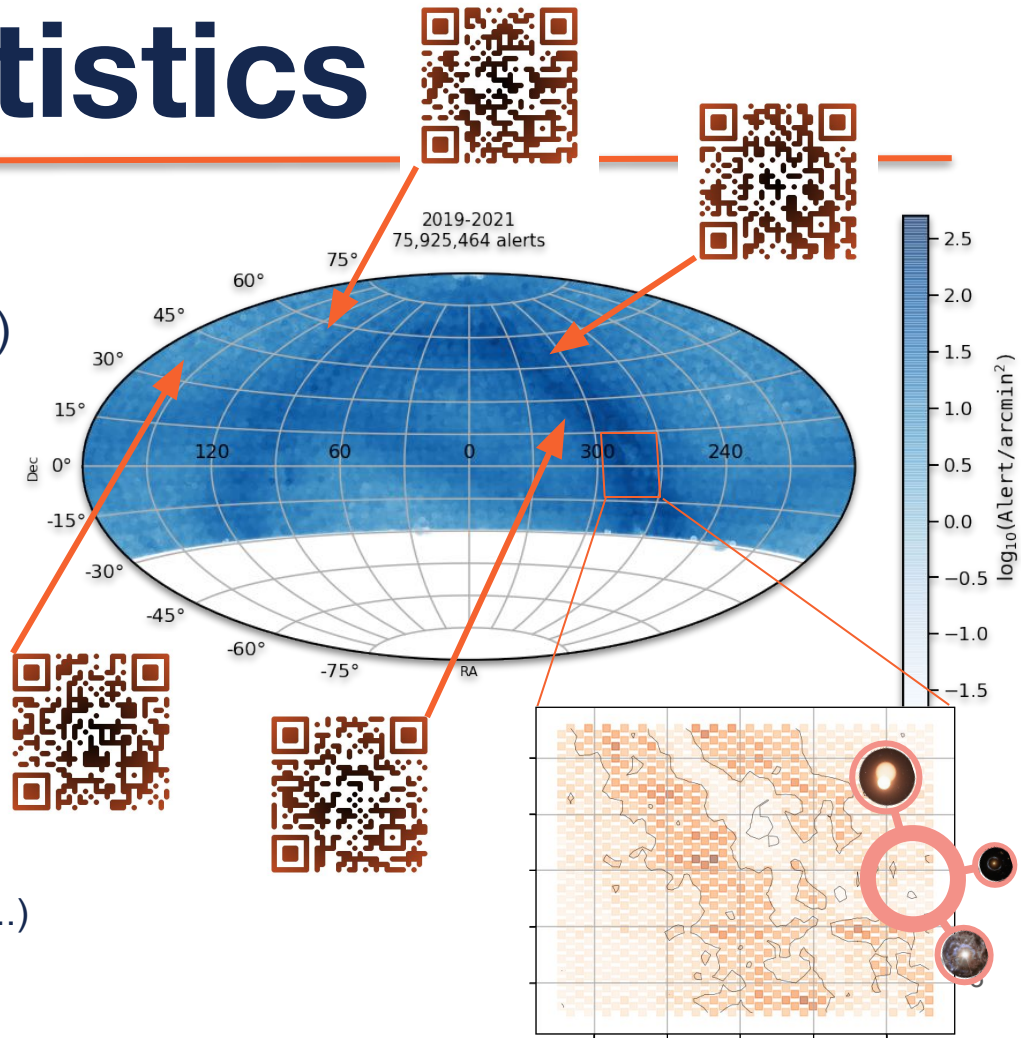
Solar System: what we know

We can already capitalise on the huge data set in Fink from the MPC database

- **16M solar system alerts**, which is about **500,000 unique objects**
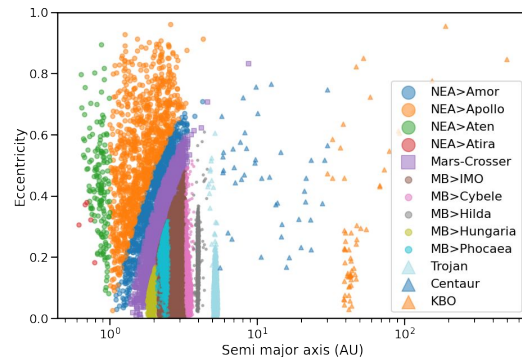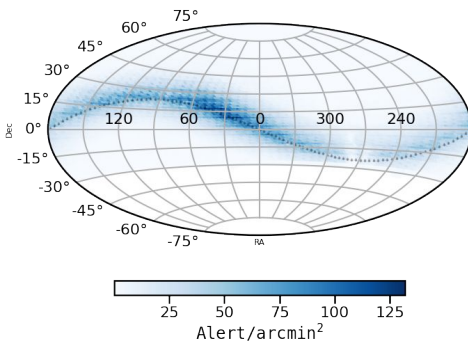
One of the difficulty is to get auxiliary data at this scale.

- https://ssp.imcce.fr/webservices
- Ephemerides: Miriade
- ID & properties: SsODNet

How to retrieve data

https://fink-portal.org

How to retrieve data

Fink-Asteroids Tracker

Fink-FAT aka Fink Asteroids Tracker based on ArXiv:2305.01123

Challenge: Tracking systems over thousands (up to millions) of alerts leads to a very large combinatorial number.

- **Filtering** (FINK alone)
    - reduce the number of alerts for the linking step
    - return a sample of independent asteroid candidate alerts
- **Linking** (FINK-FAT)
    - create a set of trajectory (linked alerts) from the asteroid candidates
- **Fitting** (FINK-FAT)
    - Find the orbital parameters of the trajectories

Candidate Results

Tested between 2019-11-01 and 2023-11-24 (975 observing nights):
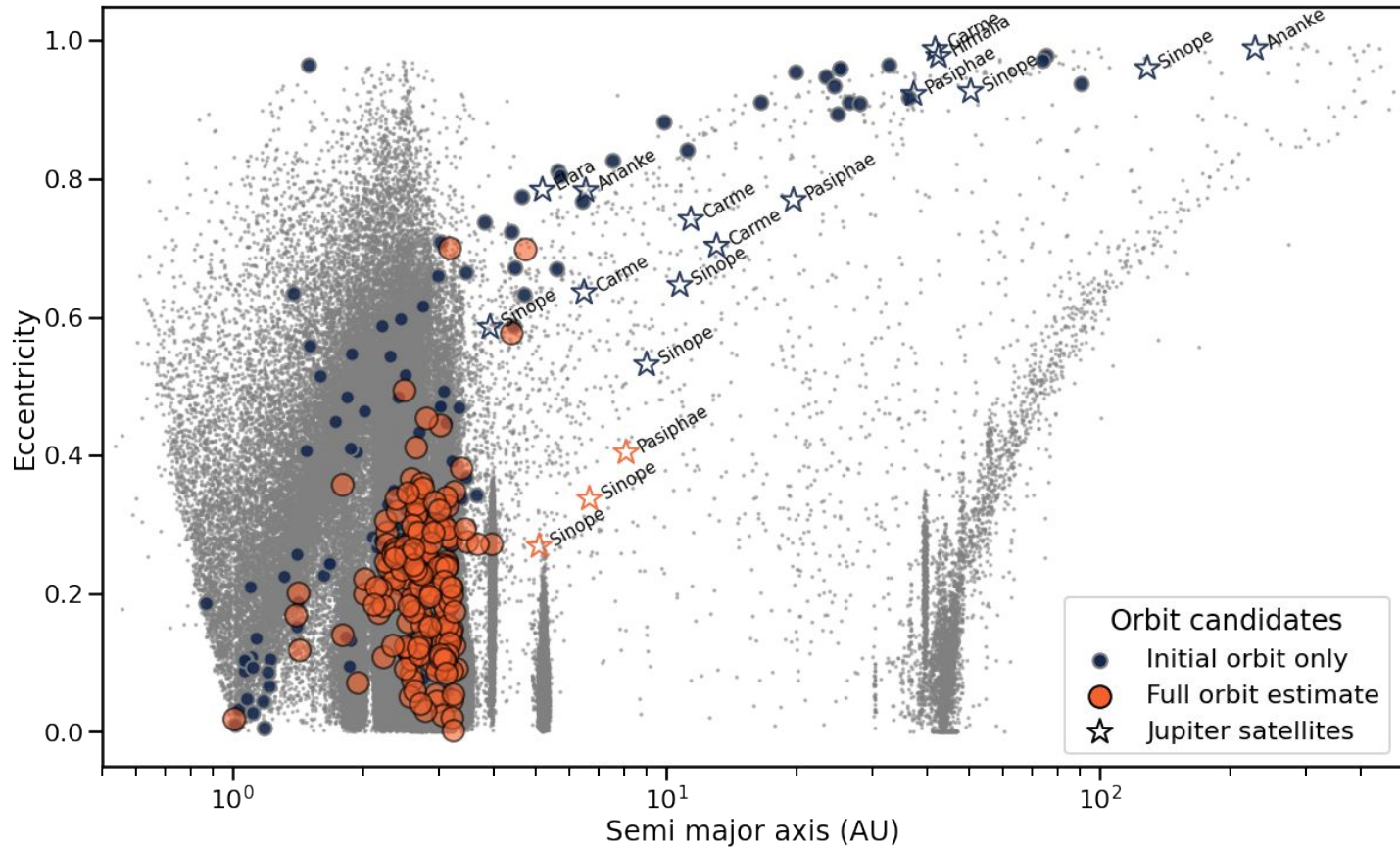
- **Input:** 596,107 alert candidates
- **Output:** 1,855 trajectories including 818 orbits with error estimation

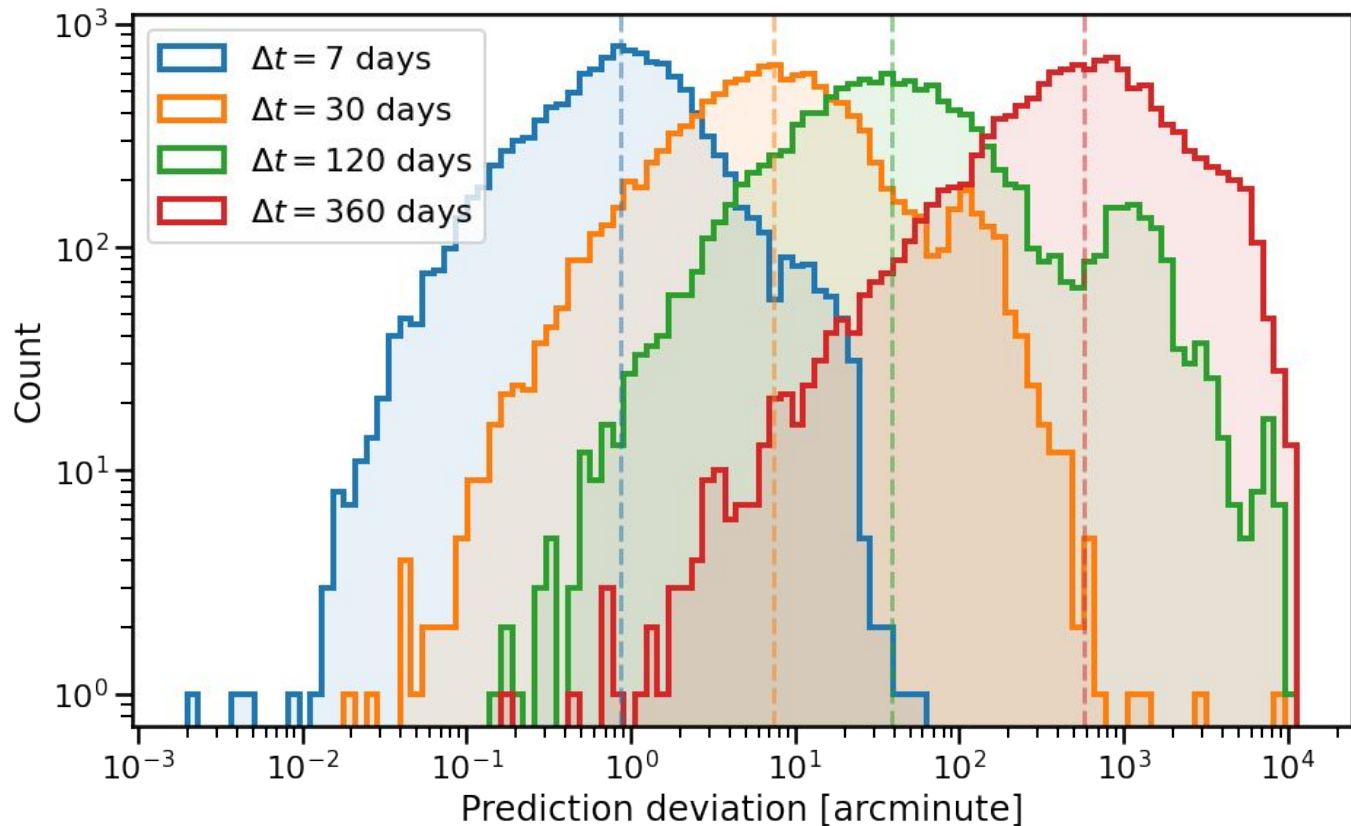Most of trajectories have six measurements (~20 days), so they are very preliminary!
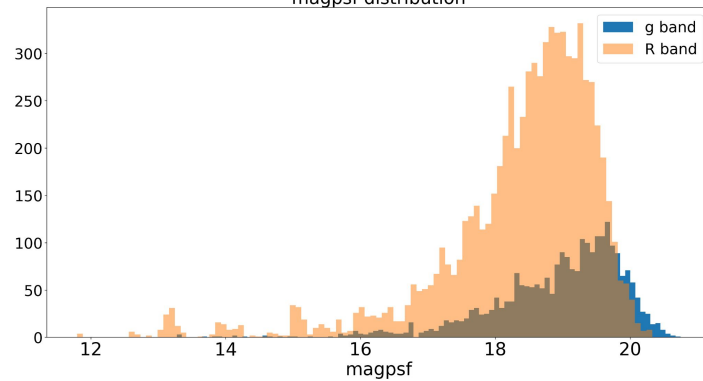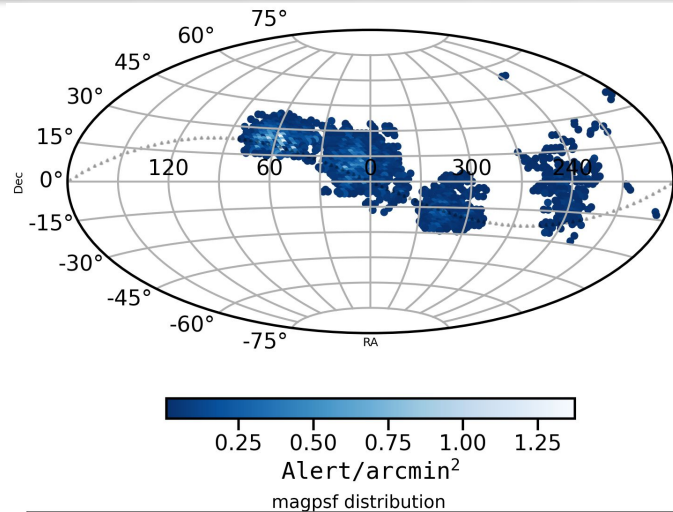
Follow-up

Follow-Up

Fink-FAT Open Questions

- How do we interact together?
  - Observation campaign (trajectories mainly during Autumn)
  - How do we know that an amateur follows a trajectory?
  - What are the tools/services you would like to see in Fink?

Useful links

Fink website: https://fink-broker.org

Fink Science Portal: https://fink-portal.org

Fink-FAT: https://github.com/FusRoman/fink-fat

Documentation: https://fink-broker.readthedocs.io

Tutorials (notebooks): https://github.com/astrolabsoftware/fink-tutorials