



# The transient sky from the Rubin/LSST alert stream

Julien Peloton (IJCLab) for the Fink team  
15/12/2020

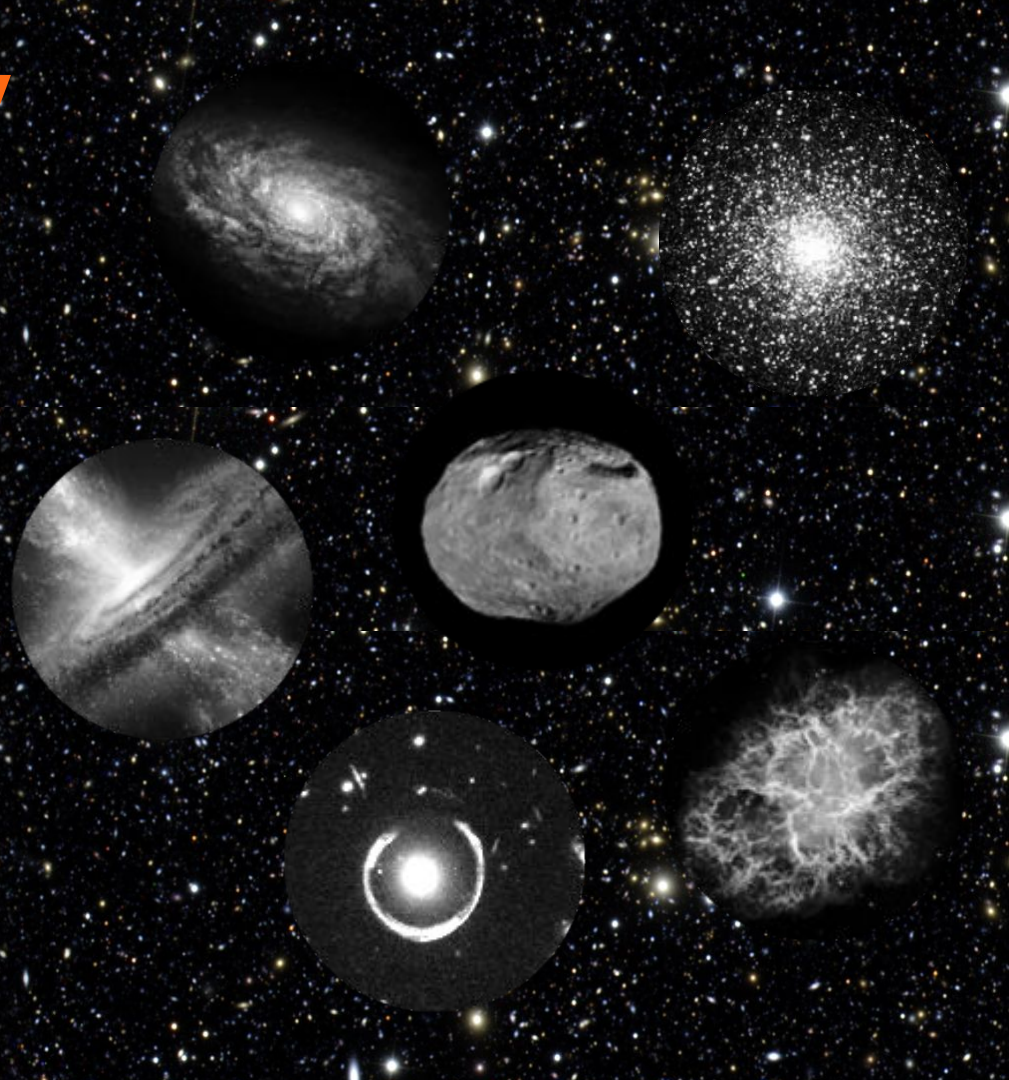


# Transient sky

The sky is not “static”: it changes all the time!

Many different phenomena over wide timescales:

- Solar System objects
- Supernovae
- Binary/merging stars or black holes
- Active Galactic Nuclei
- Exoplanet transits
- Microlensing events
- Gamma ray bursts
- ... (and the list is long!)

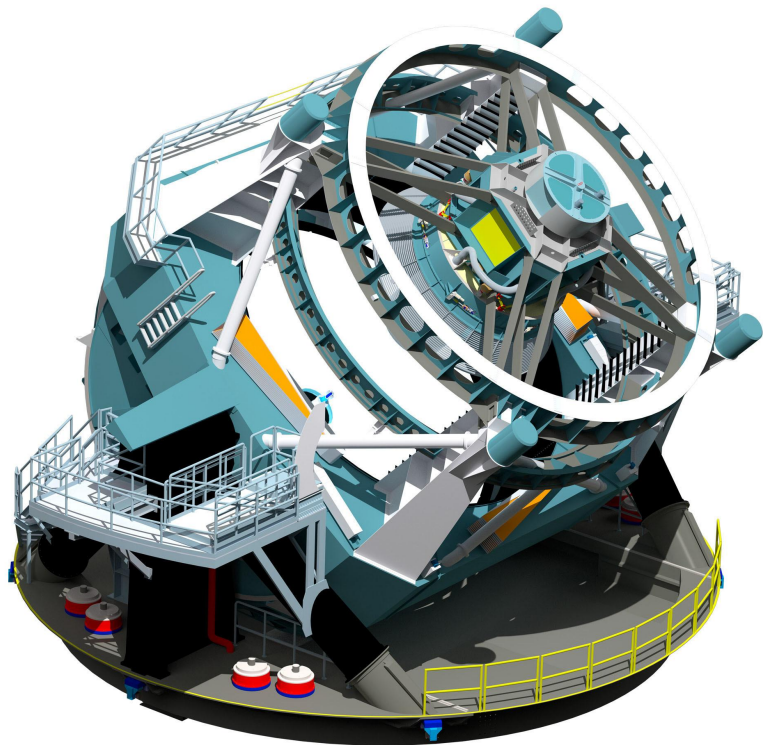




# The Rubin Observatory Legacy Survey of Space and Time (aka LSST)



# Rubin data products



**Now**

## Raw Data

Sequential 30s image, 15TB/night

**60s**

## Prompt Data Product

Difference Image Analysis  
Alerts: up to 10 million per night

**Public data!**

**24h**

## Prompt Products DataBase

Images, Object and Source catalogs from DIA  
Orbit catalog for ~6 million Solar System bodies

**Year**

## Annual Data Release

Accessible via the LSST Science Platform &  
Rubin Data Access Centers.

**End**

## Final 10yr Data Release

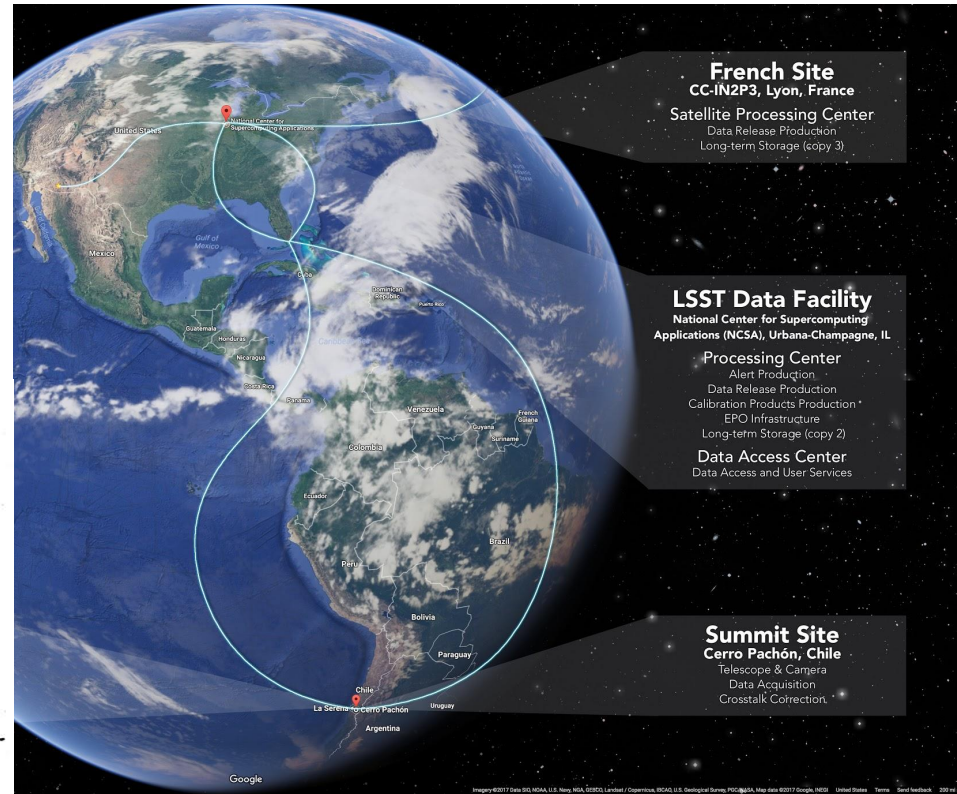
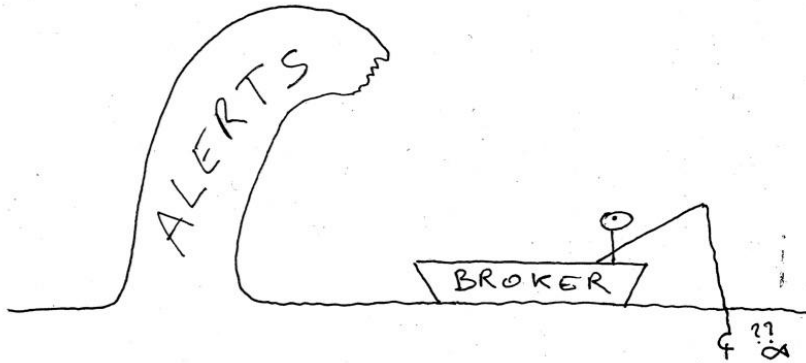
Images: 5.5 million x 3.2 Gpx  
Catalog: 15PB, 37 billion objects



# Alert data challenge

Planned: **10 million alerts per night...**

- Current serialisation implies ~100KB/alert, **1TB/night**, 3PB in 2030.



# Open data, oh yes, but...

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Many problematics related to the **size** and **heterogeneity** of the datasets

- **Access at scale:** data exploration with >> TB
- **Reproducible analysis:** versioning of tools and data
- **Sustainable effort:** the survey is for 10 years!

Opening data is usually not enough, it should come with dedicated services





# Fink

Project started in 2019 within LSST-France, to tackle Rubin alert stream challenges

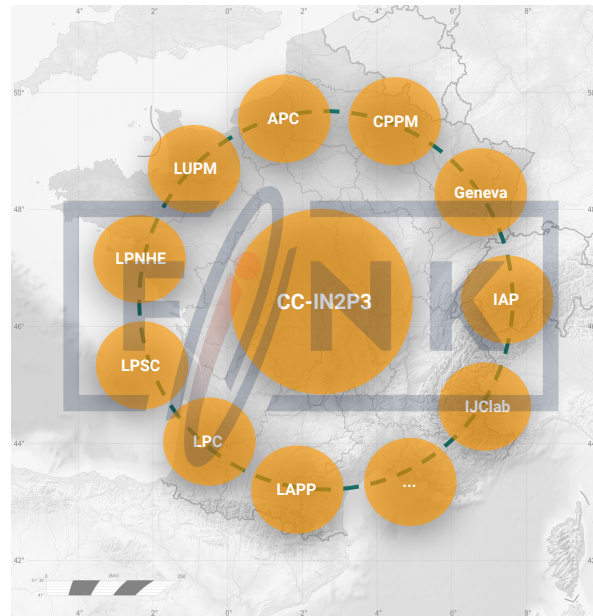
- Strong big data and machine learning component
- Cloud-based analysis

International collaboration, with roots in France

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

First paper mid-2020 (MNRAS)

- arXiv: 2009.10185
- 30 co-authors with 20 affiliations



Machine learning & science leads:  
Emille Ishida & Anais Möller

Technology lead:  
Julien Peloton

# Fink scientific objectives

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- Goal: collect & extract science from the Rubin alerts, and give data access to the community
- Community-driven effort, open source
- Deployed at VirtualData cloud (UPSaclay)
- Current fields of expertise
  - Supernovae & Kilonovae
  - Microlensing
  - Multi-messenger astronomy
    - GRB, X, neutrino, GW...
  - Anomaly detection
- Workshops & hackathons to teach new techniques

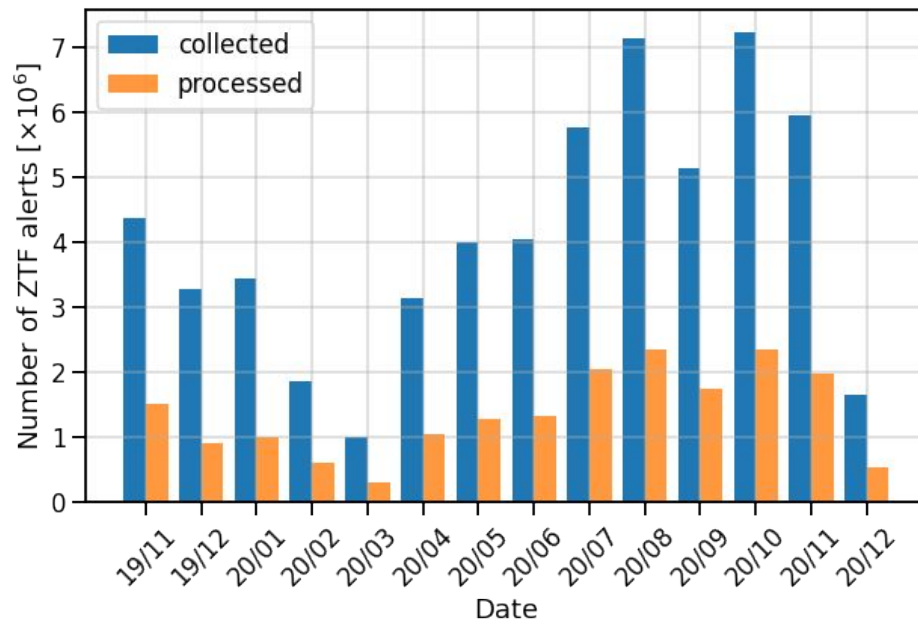




# Processing ZTF data

We can already test Fink on real alert data

- MoU with Zwicky Transient Facility (ZTF), “pathfinder” for Rubin.
- ~200,000 alerts per night (~20GB/night)

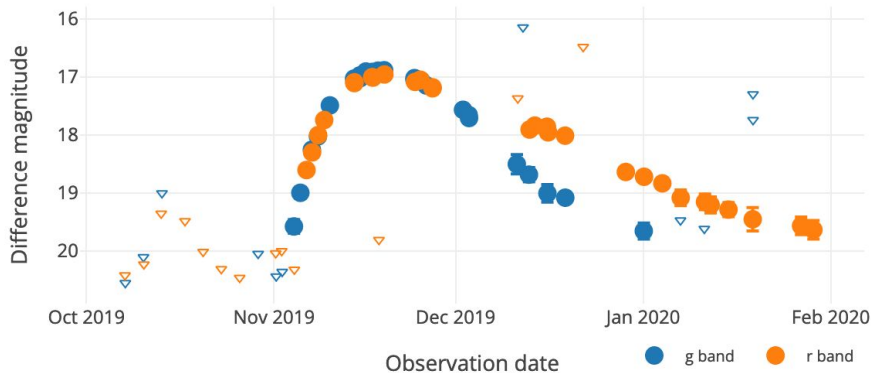


# Alert content

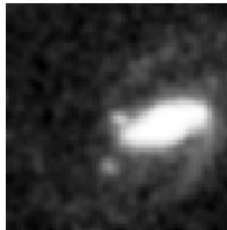
## Alerts based on Difference Image Analysis

Each ZTF alert contains

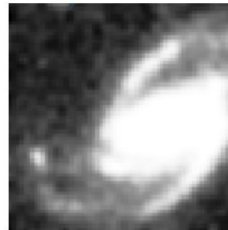
- Information about the new detection (magnitude, position, ...)
- Neighbours information (Gaia, Panstarrs)
- Historical information if the object has been seen previously
- Small images around the detection (30x30 pixels)



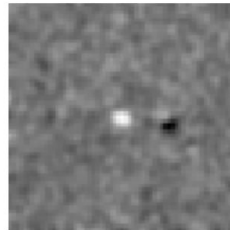
Science



Template



Difference



Rubin alert content will be similar.

# Fink science output

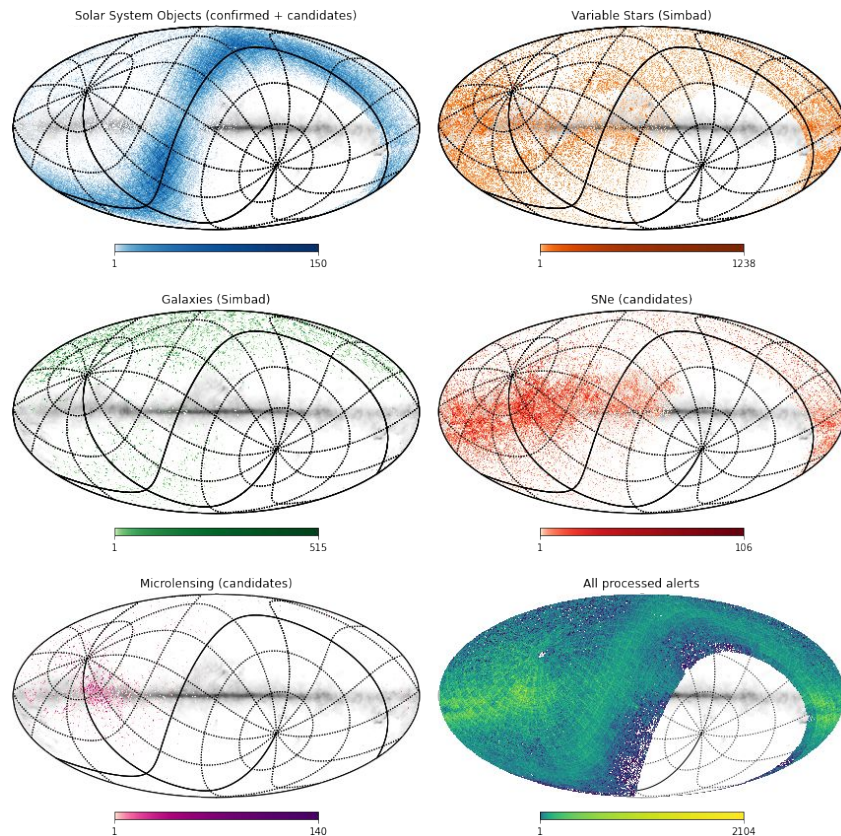
More than 60 million alerts collected, and 18 million alerts processed in 1 year.

**Cross-matching** (e.g. with CDS xmatch service) + **classification** (machine learning based algorithms)

Several categories out

- **Supernovae & core-collapse**
- **Microlensing**
- **Variable stars**
- **Solar System objects**

....



# Accessing Fink data

Fink Science portal - beta version

Explore ▾

Two entry points for users:

- Live streams
  - Personalisable filters to select objects/parameters of interest
  - Data received “live”
  - Demo...
- Science Portal
  - Exploration of the full Fink data set in your browser (+ REST API)
  - All data will remain accessible for the full survey duration
  - Currently: several TB of data, deployed on the VirtualData cloud
  - Demo...



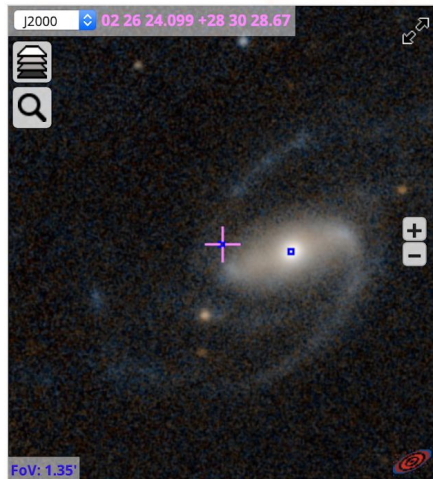


# Looking at object data

Fink Science portal - beta version

Explore ▾

 ZTF19acnjwgm



Download Object Data

Summary

Supernovae

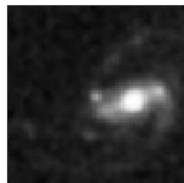
Variable stars

Microlensing

Solar System

GRB

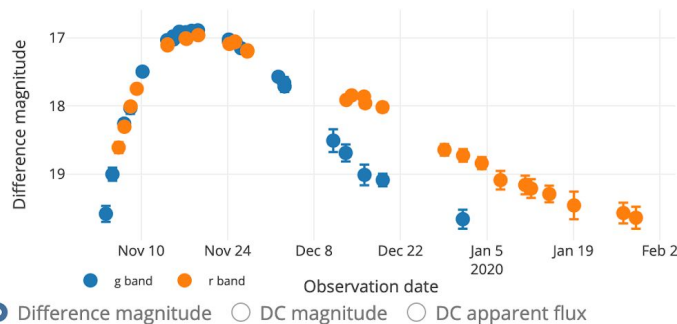
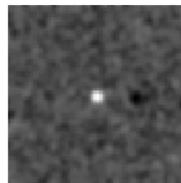
Science



Template



Difference



ObjectID: ZTF19acnjwgm

Fink class: SN candidate

# General properties

Date: 2020-01-29 03:18:40.003

RA: 36.6004139 deg

Dec: 28.5079626 deg

# Variability

Dmag (latest): 0.069

Dmag (reference): 1.795

# Neighbourhood

SIMBAD: Transient

PS1: 142200365998718368

Distance (PS1): 5.40 arcsec

Distance (Gaia): 13.16 arcsec

Distance (ZTF): 1.78 arcsec

TNS

SIMBAD

NED



# Looking at object data

Fink Science portal - beta version

Tabs to trigger different views of the object Explore ▾

 ZTF19acnjwgm

Summary

Supernovae

Variable stars

Microlensing

Solar System

GRB

J2000 02 26 24.099 +28 30 28.67

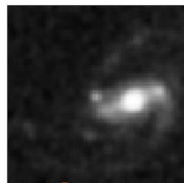


CDS Aladin view

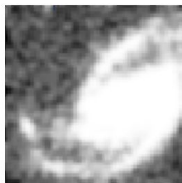
FoV: 1.35'

Download Object Data

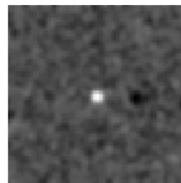
Science



Template

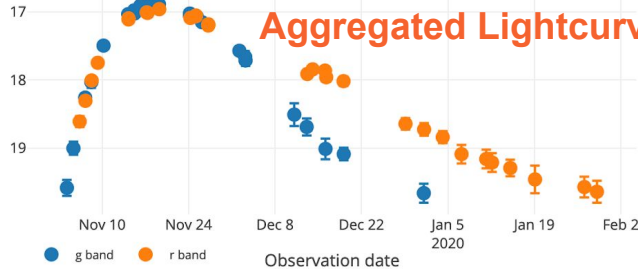


Difference



Stamps from the last alert

Difference magnitude



ObjectID: ZTF19acnjwgm

Fink class: SN candidate

# General properties

Date: 2020-01-29 03:18:40.003

RA: 36.6004139 deg

Dec: 28.5079626 deg

Selected properties from the last alert

# Variability

Dmag (latest): 0.069

Dmag (reference): 1.795

# Neighbourhood

SIMBAD: Transient

PS1: 142200365998718368

Distance (PS1): 5.40 arcsec

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TNS

SIMBAD

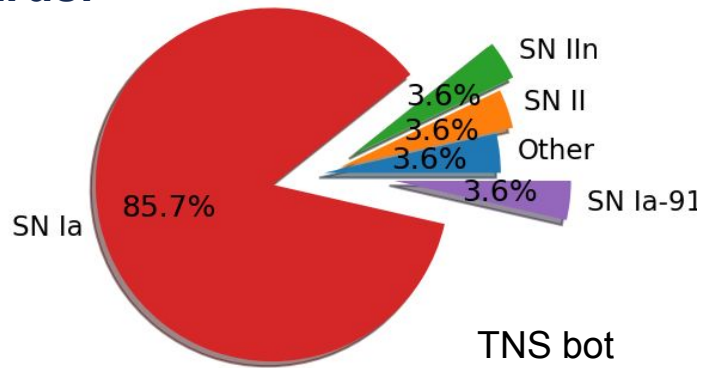
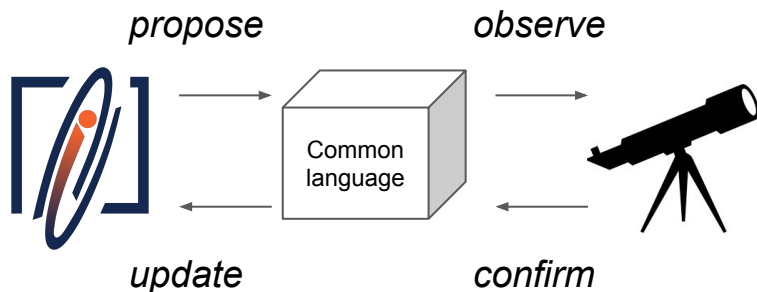
NED

Download object data (all alerts)

Links to external data sets

# Coordination & interoperability

- Identifying interesting Rubin alerts is only part of the story: we need coordination with other facilities, follow-up resources and existing networks.
- More diverse data means, better science analysis. But
  - How to interoperate between collaborations? Between users?
  - How to coordinate with existing follow-up resources and surveys?
  - Just opening data is not enough - one also needs to develop **interoperability**, by e.g. **developing standards**.



# Take away

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Fink is a broker designed to tackle Rubin alert big data challenges

- Enabling science by applying state-of-the-art technology.
- Data is publicly available, and new projects are welcome!
- Rubin selection ongoing

But to efficiently exploit the data, one needs to

- Develop services to tackle associated challenges
  - Provide also formation about new techniques
- Enforce interoperability by developing standards and common languages (e.g. IVOA)

**We need you!**







<https://fink-broker.org>

