



and high-energy transients



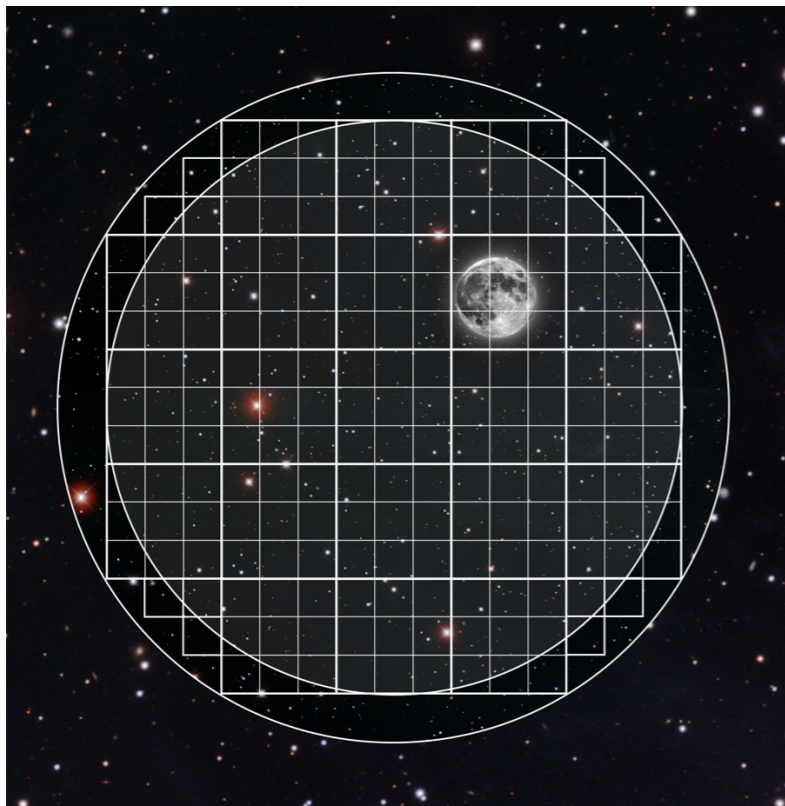
High-energy transients



Optical transients

In a nutshell

- telescope: 6.7-m equivalent
- world's largest CCD camera: 3.2×10^9 pixels
- resolves a *golf ball 24 kilometers away!*
- 6 optical bands: *ugrizy* (320-1050nm)



40 copies of the full moon

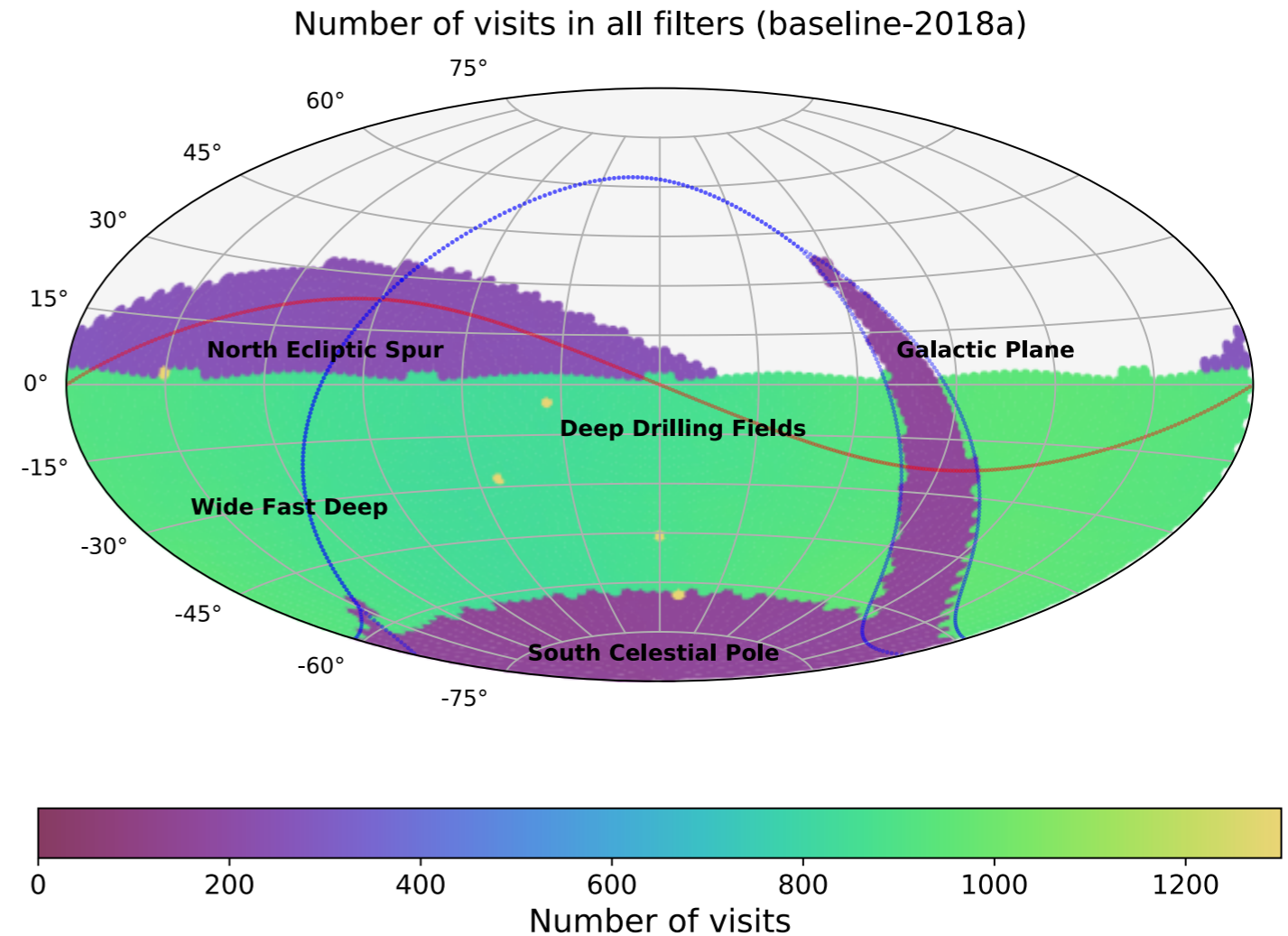


Rubin Obs/NSF/AURA

LSST a deep “video” of the sky

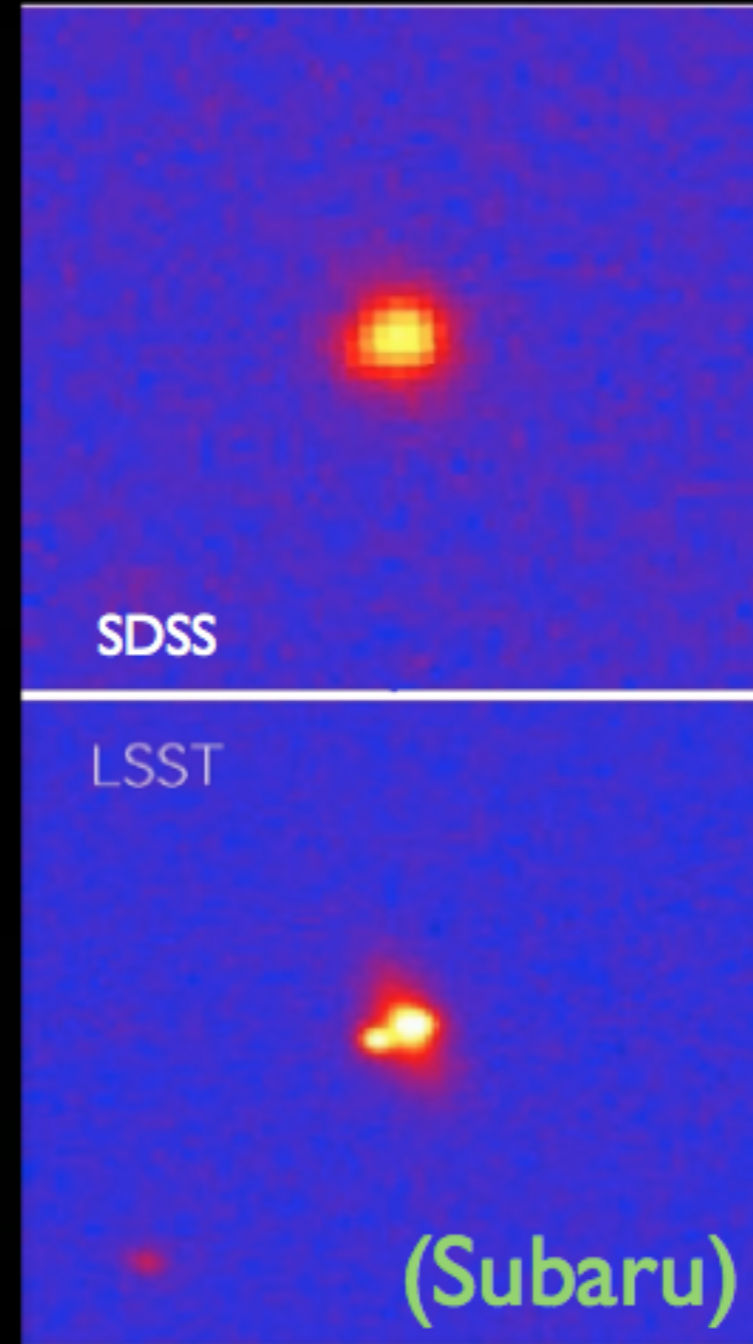


- Scanning the sky for 10 years
- 1,000 images/night = 15 TB/night
- 10 million transients **per night**



*Call for White Papers on LSST Cadence Optimization
Document-28382*

SDSS-LSST comparison: $LSST = d(SDSS)/dt$, $LSST = SuperSDSS$ 7x7 arcmin, gri



LSST data products

Now

Raw Data

Sequential 30s image, 20TB/night

37s

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

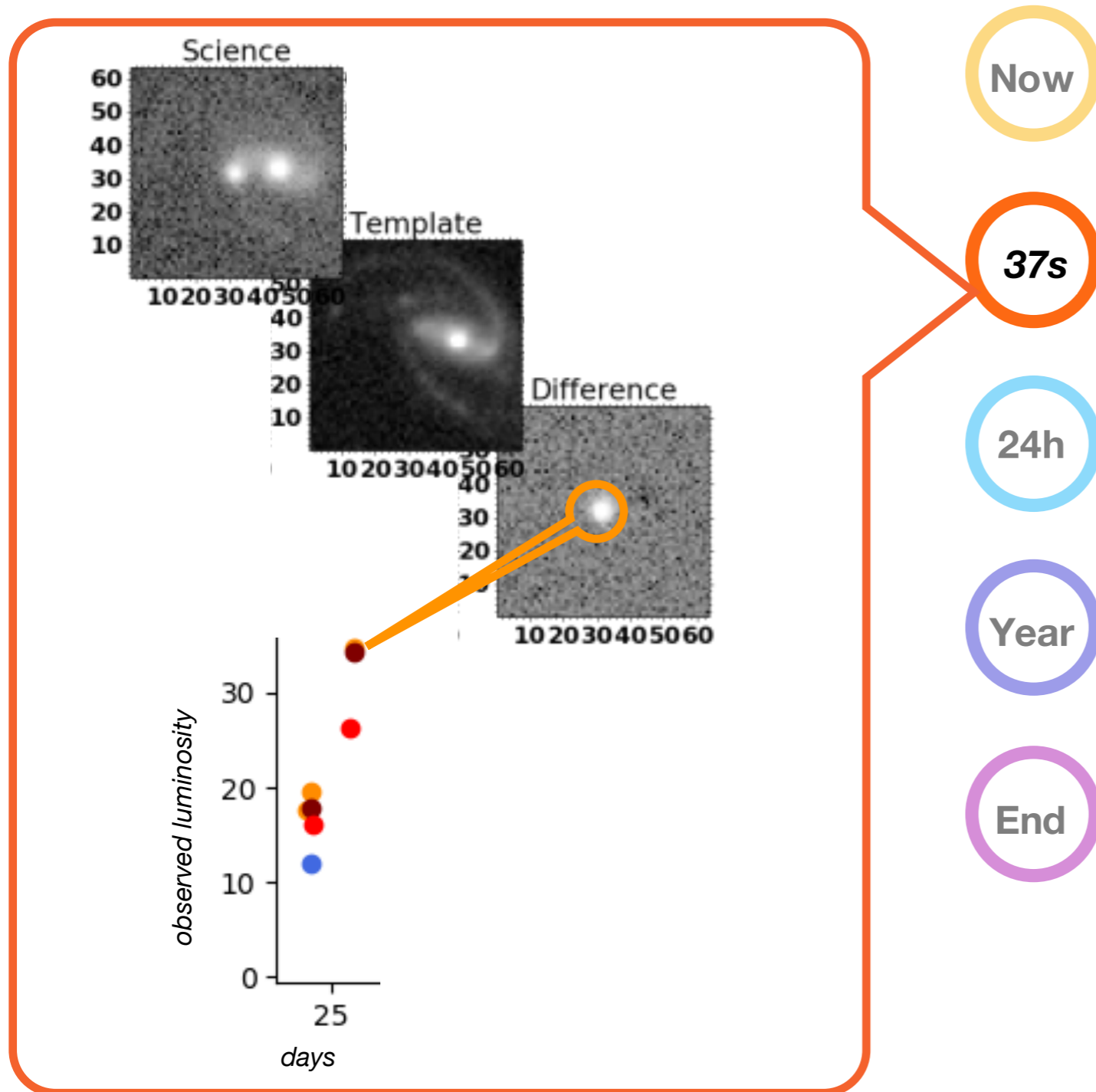
Accessible via the LSST Science Platform &
LSST Data Access Centers.

End

Final 10yr Data Release

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

LSST data products



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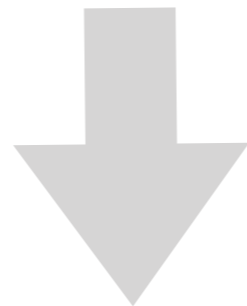
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LSST ~ 10 million transient alerts per night



promising candidates for <X science>

+ connecting with other telescopes and data?



LSST ~ 10 million transient alerts per night



Brokers

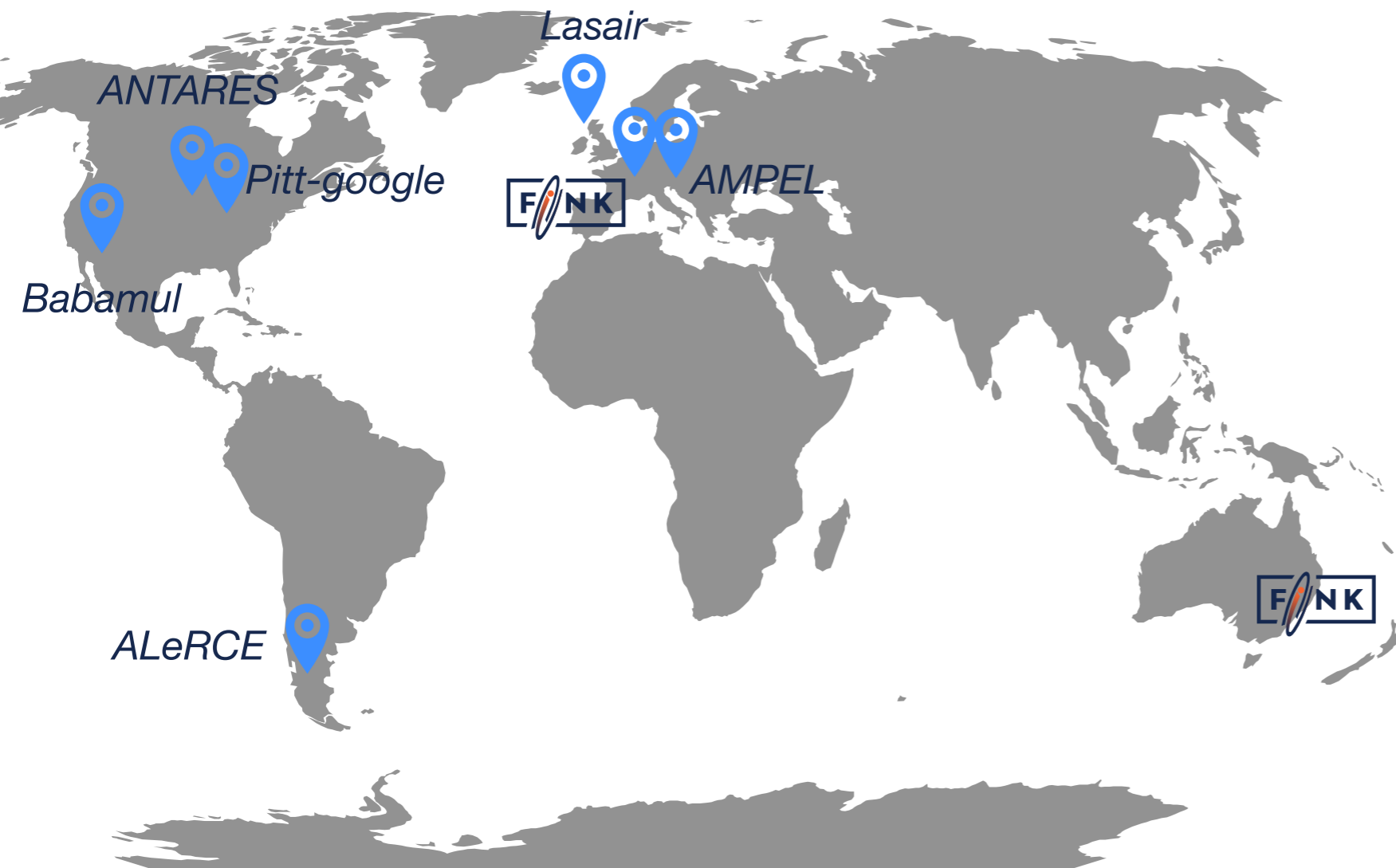


promising candidates for <X science>

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The broker panorama



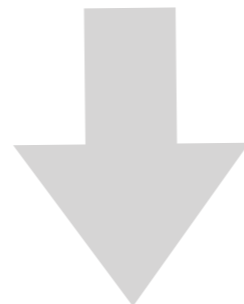
Two years ago, call for Rubin community brokers

- 14 Letters of Intent
- A lot of work
- Decision on August 2021!

Full stream brokers

- Will receive from Rubin ALL transient candidates within 37 seconds of detection
- Will do this for the 10 years of operations

LSST ~ 10 million transient alerts per night



promising candidates for <X science>

+ connecting with other telescopes and data?





- A community driven effort, *open to anyone*
- A community of *>40 researchers and engineers* *>7 countries* and growing!



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- Designed for Rubin with *big data technology* (e.g. distributed computation)
- Selected by Rubin Operations to *receive the full alert stream* for 10-years



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- Now processing ZTF II public alert stream available at fink-portal.org



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- First publication *A. Möller, J. Peloton, E.E.O. Ishida et al. MNRAS 2020, [arXiv: 2009.10185](https://arxiv.org/abs/2009.10185)*
- Funding to deploy at CC-IN2P3 for LSST

French computing centre where half of the LSST data will be processed

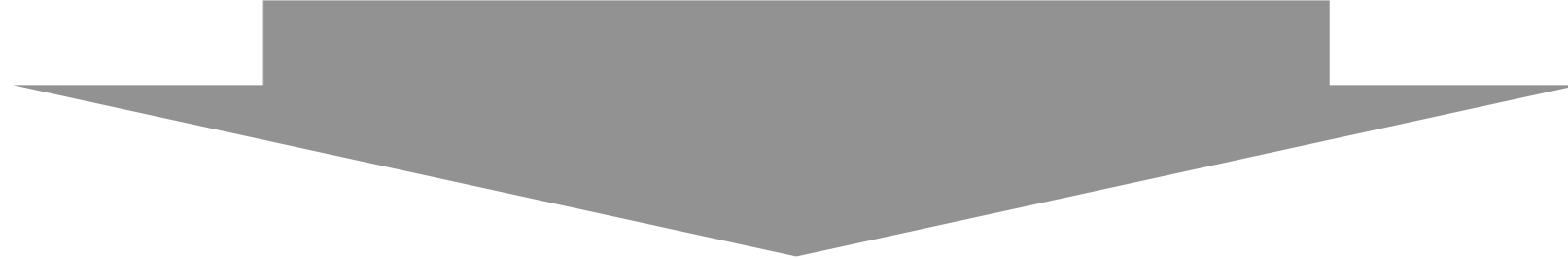


Fink in a nutshell

LSST ~ 10 million transient alerts per night



LSST ~ 10 million transient alerts per night



Cross-match



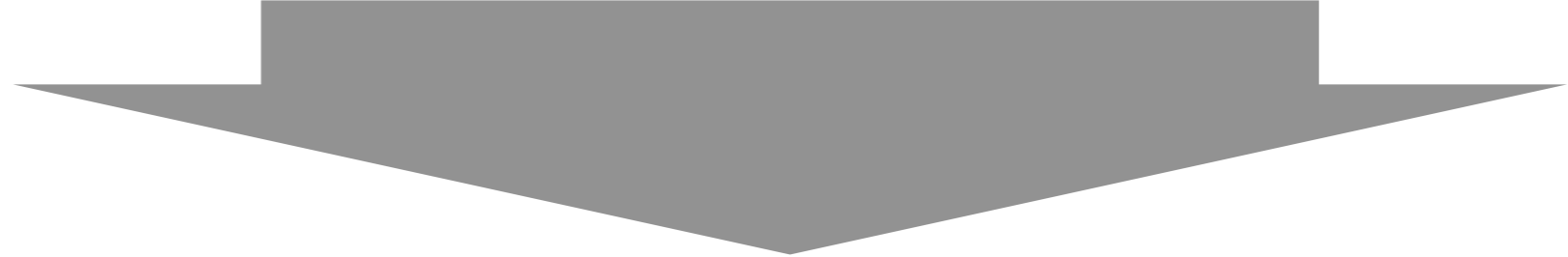
Catalogues

***Survey
streams***

- ***VOEvents / GCN***
- ***Dynamic catalogues***



LSST ~ 10 million transient alerts per night



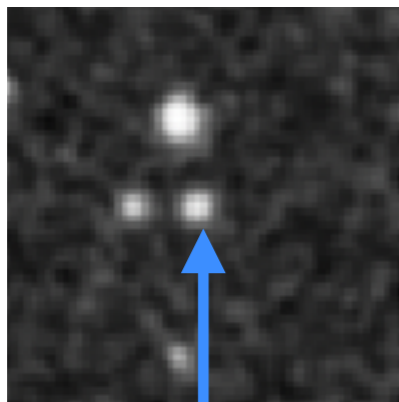
Cross-match



SIMBAD

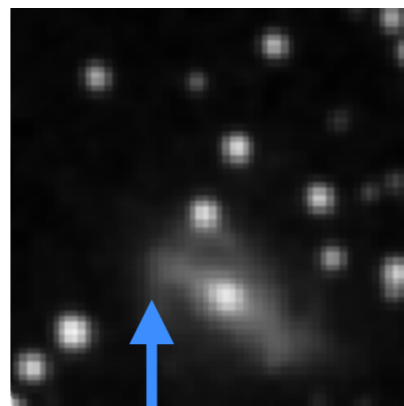


A known variable star....



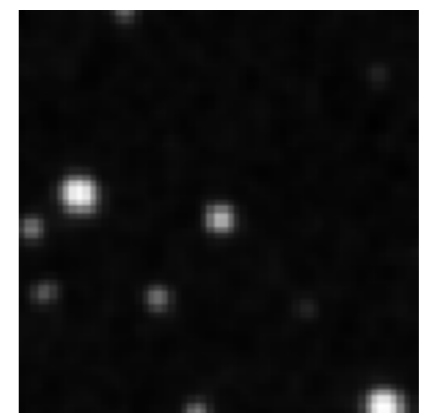
Known Variable Star

Extra-galactic?



Known galaxy close by

Or....



LSST ~ 10 million transient alerts per night

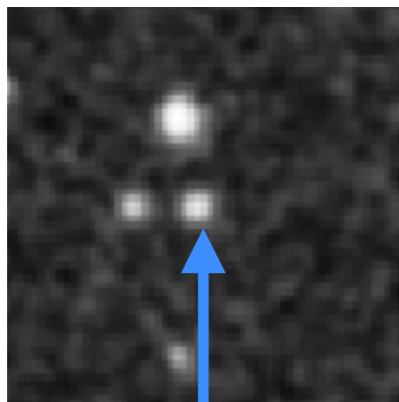
Cross-match



Collaboration with GRANDMA
Mangrove *Ducoin+20*

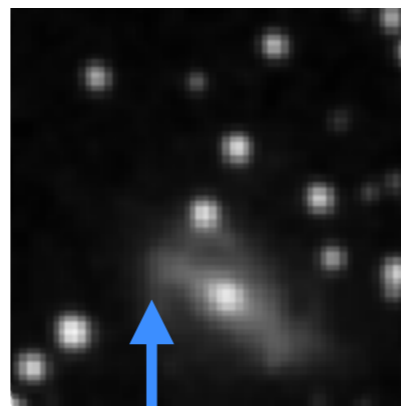


A known variable star....



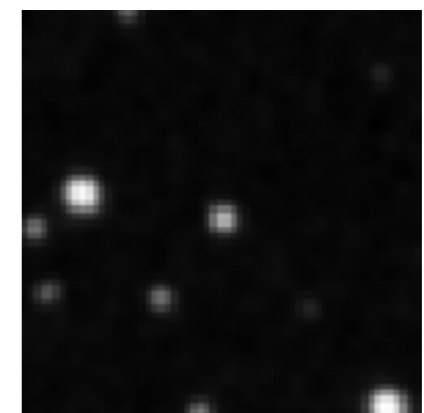
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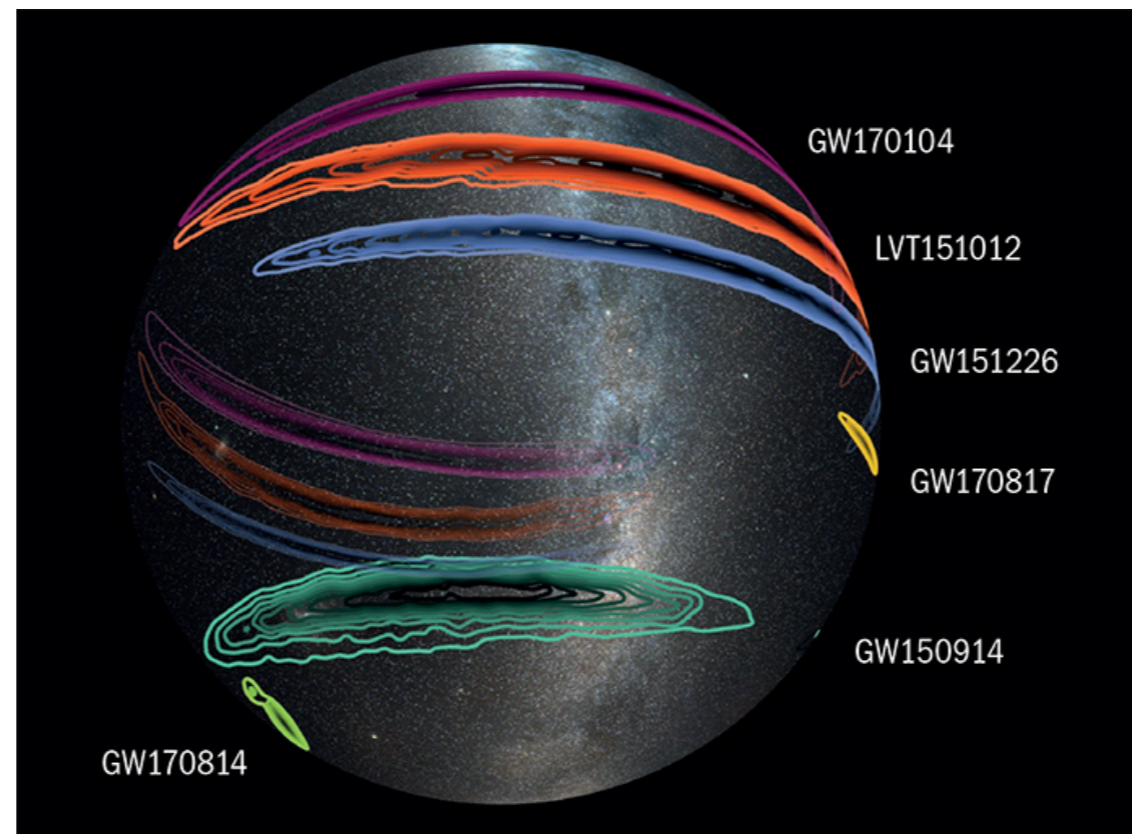
Cross-match



Catalogues

Survey
streams

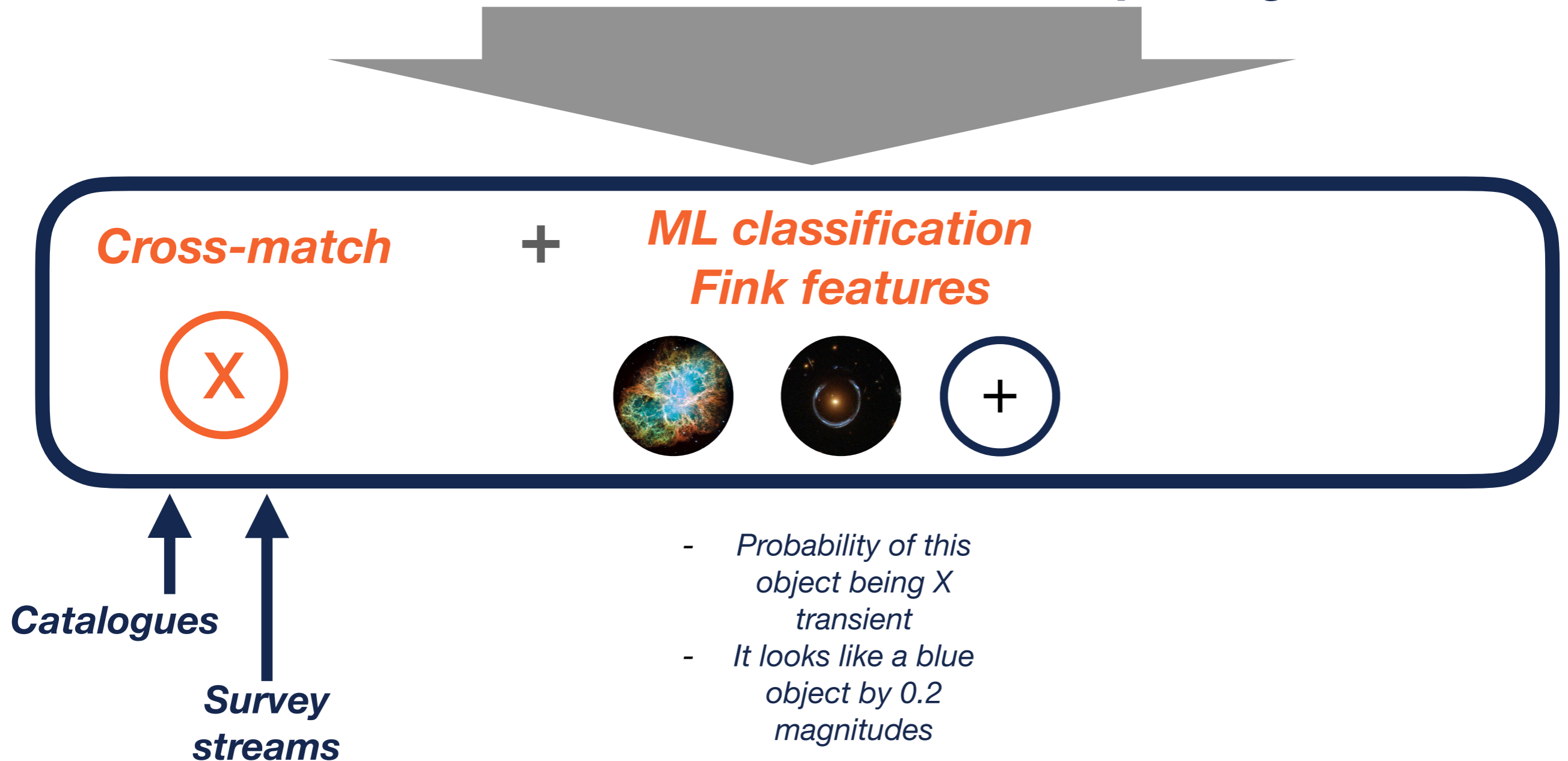
- *VOEvents / GCN*
- *Dynamic catalogues*



*footprint or real-time
catalogues*

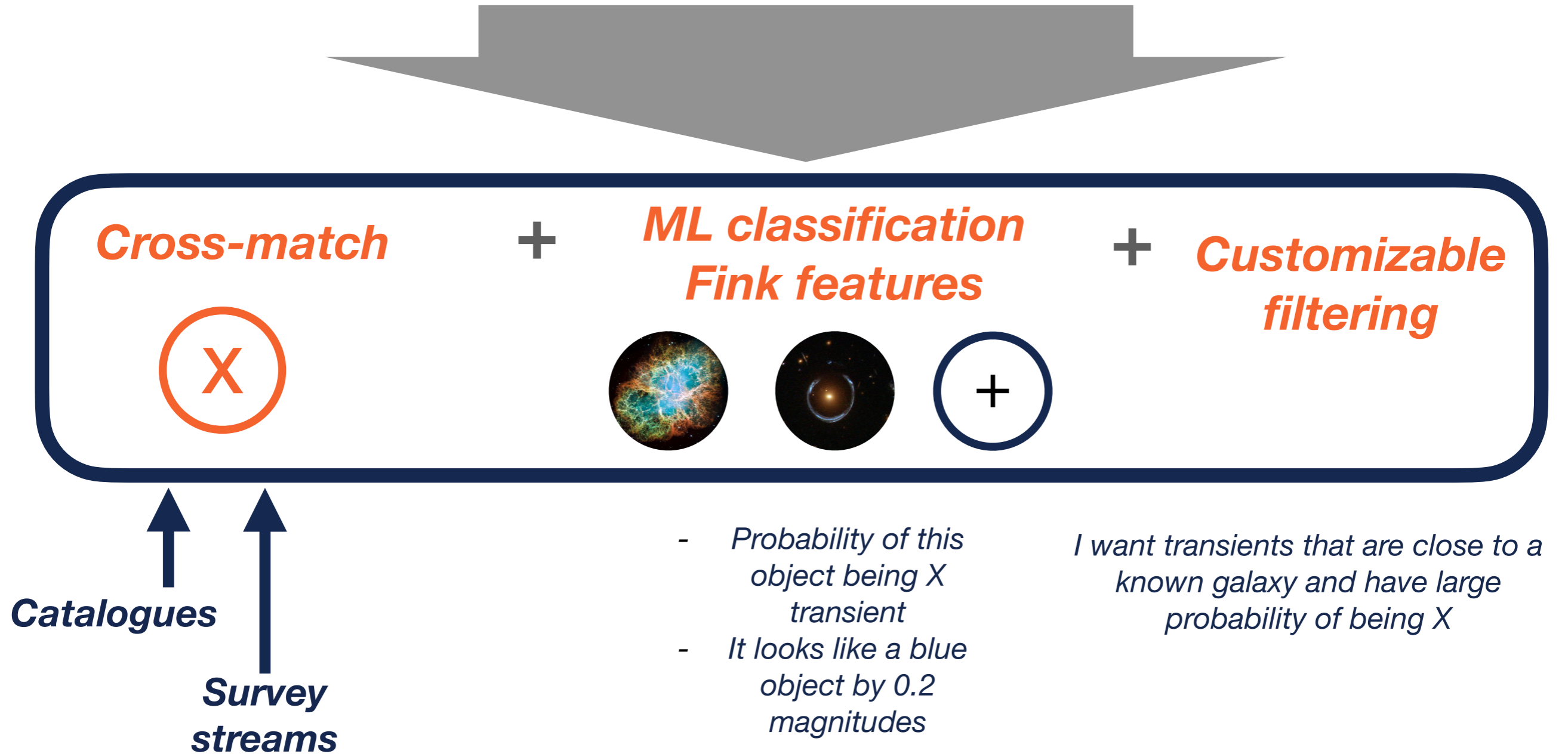


LSST ~ 10 million transient alerts per night

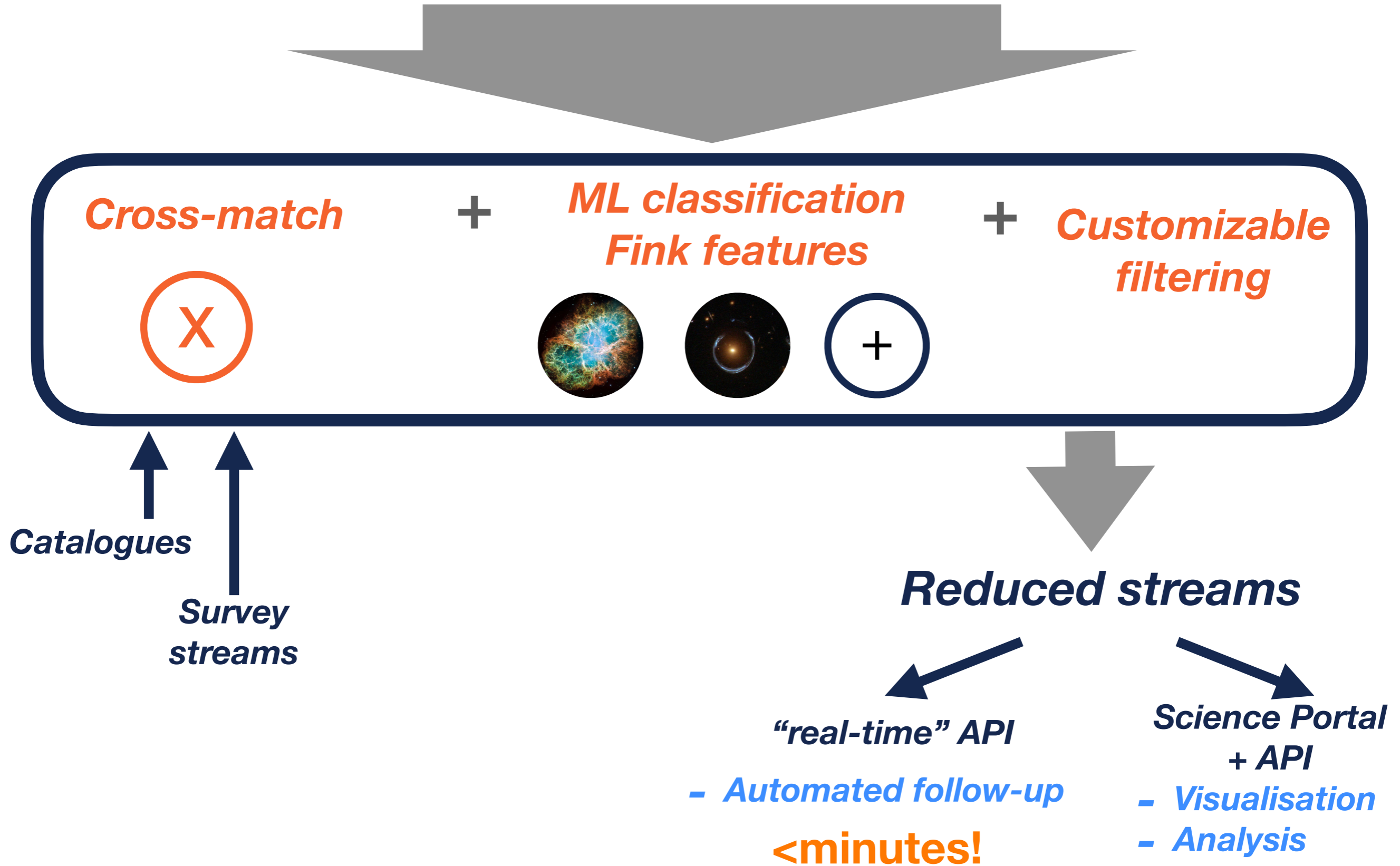


- Early Supernova with Active Learning *Leoni et al. in prep*
- Supernovae with RNN, SuperNNova *AM+2020*
- Microlensing LIA *Godines+2020*
- Kilonovae *Biswas+ in prep.*

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Ongoing projects

* Kilonovae:

- ZTF + Kilonova catcher citizen science *GRANDMA + Fink in prep.*

- **Microlensing**

* GRB afterglows *D. Turpin, J. Bregeon, O. Godet, ...*

- Swift-Fermi in preparation for SVOM
- **Satellites** and debris *S. Karpov et al. in prep.*
- Early **Supernova** with Active Learning *Leoni et al. in prep*
- **Supernovae** with RNN, SuperNNova *AM+2020*

* Anomaly detection



We welcome more collaborators!

contact@fink-broker.org

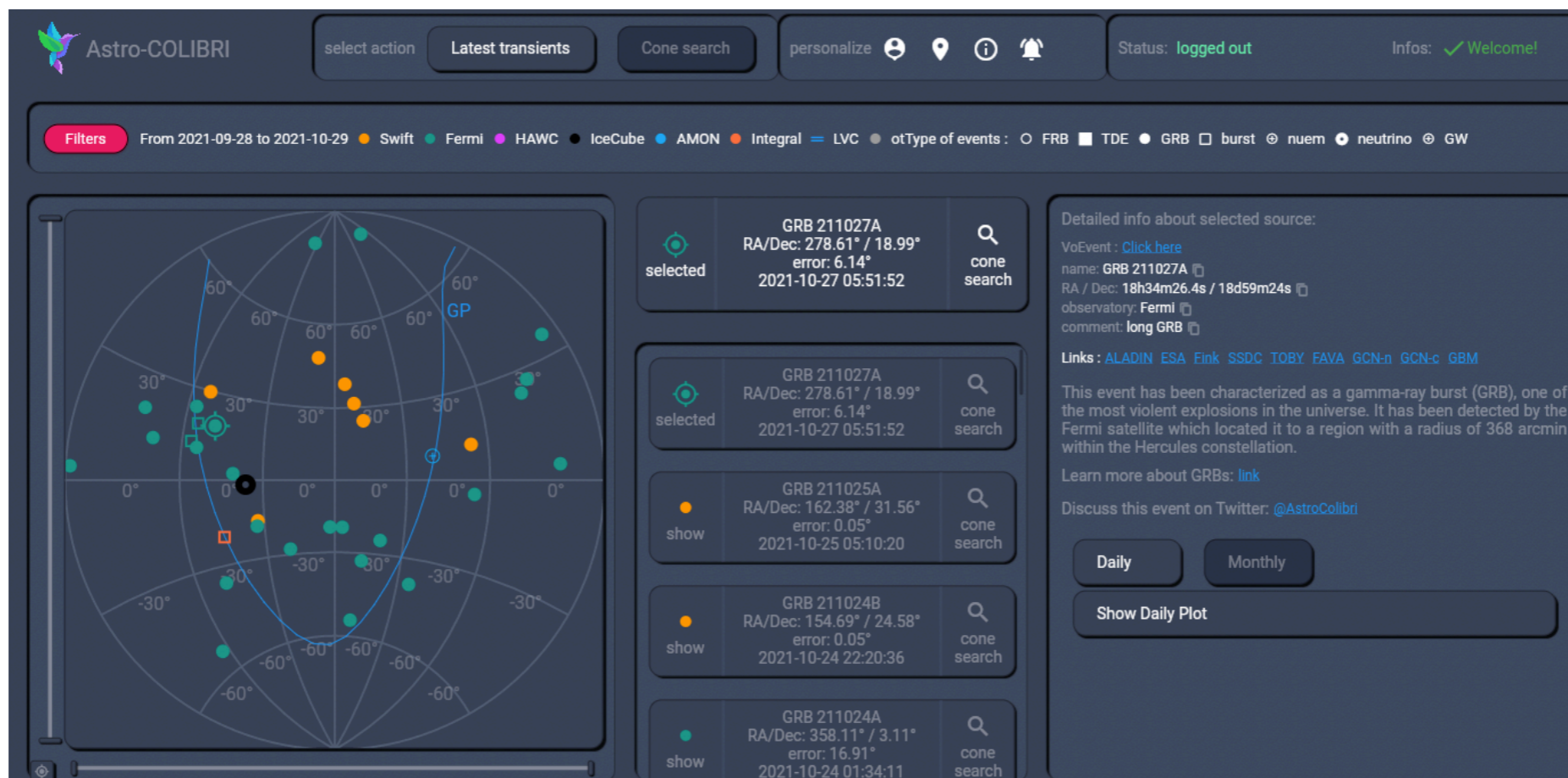


Fink is integrated with:

- Transient Name Server bot: reporting automatically SN candidates
- Las Cumbres Observatory Target and Observation manager: Gemini, LCO, SOAR
- Integration into Astro-COLIBRI for multi-wavelength/messenger



F. Schüssler et al. 2021





Deployment with ZTF

Summary statistics

Since 2019 we have received 123,237,400 alerts!

Equivalent to 571 nights

Processed alerts (quality cuts): 41,408,120

Monthly statistics: 2021/10

Total processed	1,624,096
Unknown	772,116
Tracklets	2,406
Solar System MPC	298,579
Solar System candidates	2,559
SN candidates	5,251
Early SN candidates	114
Kilonova candidates	3

CDS SIMBAD

543,484 matched with an object (33.5%)

7,728 matched with close-by galaxy (0.5%)



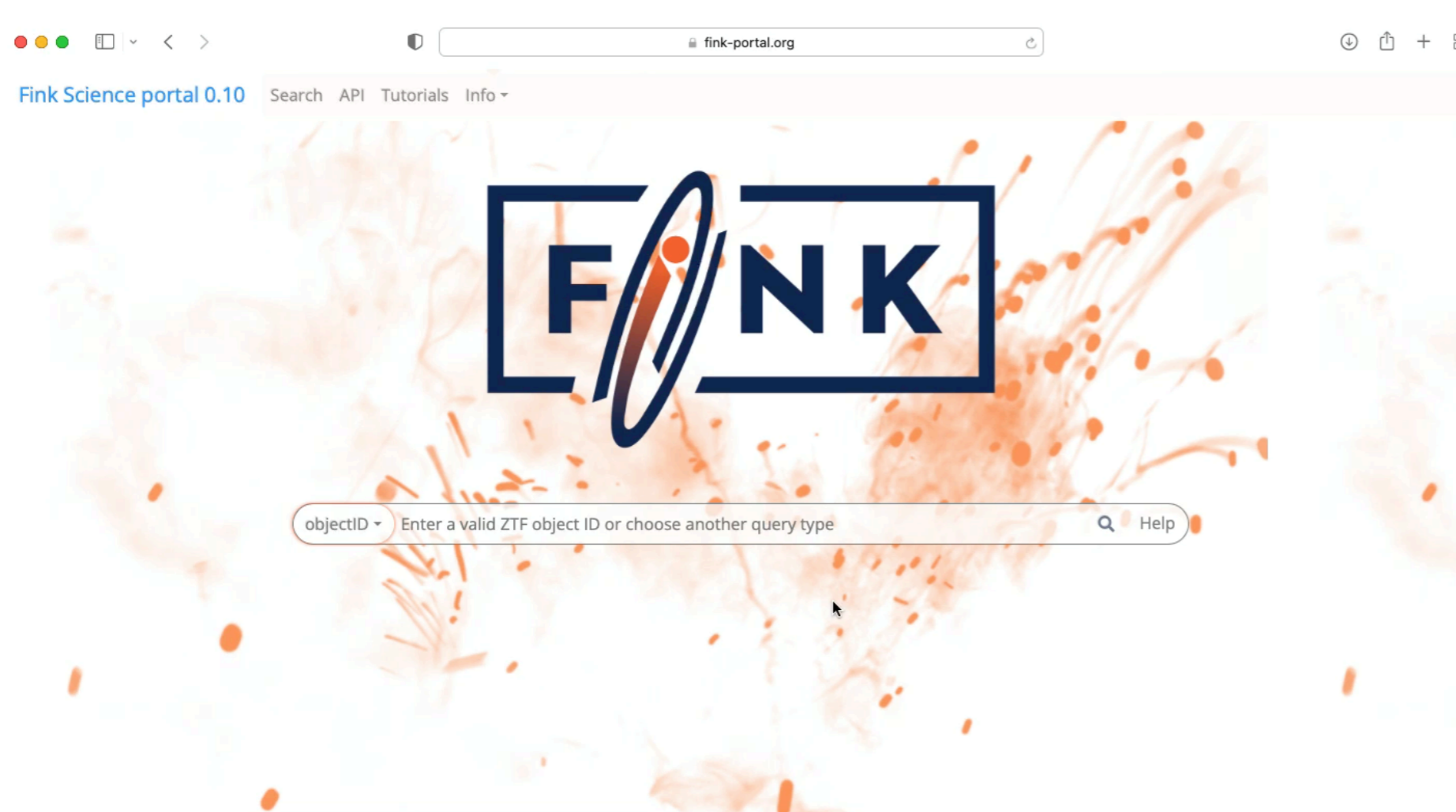


How to access

1. “real-time” API: Kafka filtered stream, slack bot, ...

2a. Science Portal <https://fink-portal.org>

2b. REST API




Fink case study: multi-messenger/wavelength astronomy

Goal

The goal of this notebook is to show how Fink can contribute to multi-messenger and multi-wavelength science. This notebook includes queries for science related to **Kilonovae** and **gamma ray bursts (GRBs) counterparts**.

Real-time analysis for follow-up coordination will be better done through the Fink livestreams which processes and makes available the alert data within minutes of reception. Access through this notebook uses the API access which is not real-time based. We aggregate the data into our API and Science Portal database at the end of each observing night. API access can be useful to analyze last night and older alerts. For example in case of reprocessing analysis in the search for low signal-to-noise events in gravitational wave or other wavelength detectors.

What is behind?

This notebook will use:

- **Fink cross-match** with close by sources in the [SIMBAD \(Wenger et al. 2020\)](#) catalogue (within 1") using [xmatch service](#) provided by the Centre de Données astronomiques de Strasbourg (CDS).
- **Fink's machine learning (ML) classification** scores trained with [\(Muthukrishna et al. 2019\)](#) and [\(Stachie et al. 2019\)](#):
 - Random Forest to classify Kilonovae (Biswas et al. in prep)
 - [SuperNova \(Möller & de Boissière 2019\)](#) to classify SNe at all light-curve epochs
 - Random Forest (Leoni et al. in prep) and [\(Ishida et al. 2019b\)](#) to classify early (pre-max) SN candidates
- **Fink's extra features** such as color `g-r` and `rate` when possible.

Environment set up

To run this notebook, you need to import the following libraries (already installed in colab):

```
[ ] import requests
import pandas as pd
import numpy as np

import matplotlib.pyplot as plt
import seaborn as sns
sns.set_context('talk')
```

1st case study: selecting kilonovae candidates

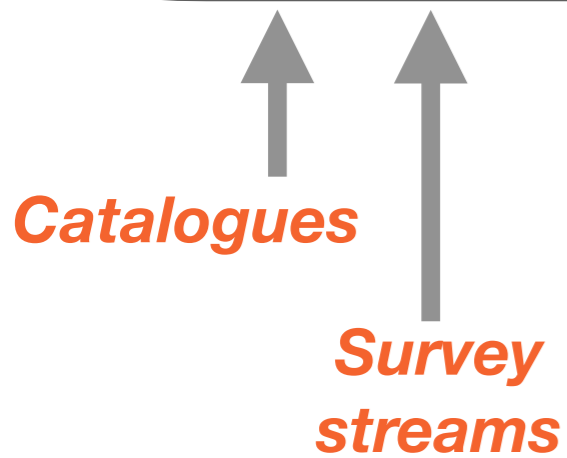
API query: latest alerts of kilonovae candidates

Kilonovae candidates is a tag defined and provided by Fink. It requires that the alert has no known transient association (from catalogues), it is relatively new (number of previous detections < 20) and when our ML algorithm trained to select early kilonovae have a probability higher than 50% of this object being a kilonova.

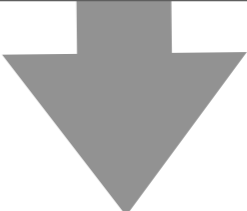
```
[ ] # Get latests 20 alerts associated to Kilonova events
r = requests.post(
  'http://134.158.75.151:24000/api/v1/latests',
  json={
    'class': 'Kilonova candidate',
    'limit': 20
  })
```

Feedback welcomed!

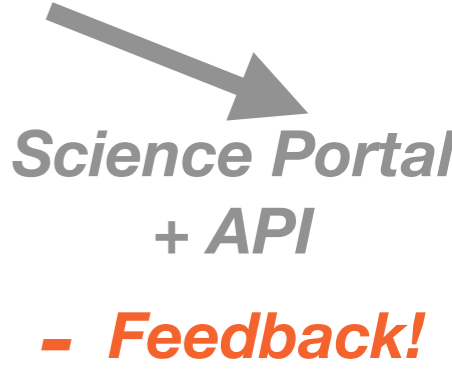
contact@fink-broker.org



- *VOEvents / GCN*
- *Dynamic catalogues*



Reduced streams



Your science case, your expertise



- Connecting optical big data with multi-wavelength & messenger transients
- Is already processing ZTF data stream (MoU 2020).
- Rubin community broker
- First science modules deployed: SNe, GRB, microlensing, ...
- Automatic filtered streams <minutes for follow-up coordination
- Analysis capabilities with the web portal and API (python callable)



We want to connect to new teams, collaborations and facilities!