



# Using machine learning to find astronomical transients

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São Paulo, Brazil*

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Clermont Ferrand, France*



# How to find astronomical transients ?

- Context
- Step 1: how to be in the loop?
- Step 2: construct a machine learning classifier
  - Make sure you understand why it works
- Step 3: tell the world
- Step 4: make a better machine learning model
- Step 5: keep an open mind

*Context ...*

Astronomy has been,  
traditionally,  
an experience of  
solitude ...



The old astronomer, poem by Sarah Williams,  
illustration by *Charlie Bowater*


*The paradigm shift:*

# Machine Learning was not a choice




**SDSS**  
2000 - now  
*Primary mirror: 2.5 m*

120 TB



**ZTF**  
2018 - now  
*Primary mirror: 1.2 m*

1.4 TB/night



**VERA C. RUBIN  
OBSERVATORY**

15 TB/night

From 2024  
*Primary mirror: 8.4 m*

# Summit on January, 2023



Rubin Observatory/NOIRLab/NSF/AURA/Y. AlSayyad

# Mirror in 2015



# The Vera Rubin Observatory Large Survey of Space and Time (LSST)

## In a nutshell:

- telescope: 8.4m primary mirror
- world's largest CCD camera:  
3.2 Gpixels

## In numbers:

- 10-year survey, starting 2024+
- 1,000 images/night = 15TB/night
- 10 million transient candidates per night
  - Publicly available...
  - ... but huge!



# To keep in mind ...

- 1) Very big data
- 2) Survey mode observation strategy



# To keep in mind ...

- 1) Very big data
- 2) Survey mode observation strategy
- 3) *Multi-messenger astronomy is now a thing*



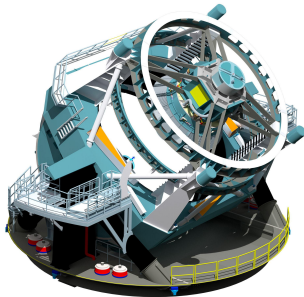
# Step 1

How to be in the loop?

# The data path



*every ~30 seconds down to  
mag ~24*

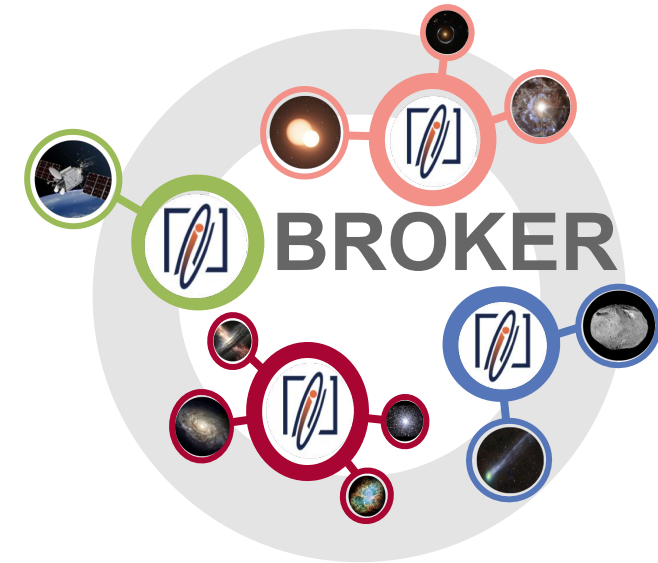
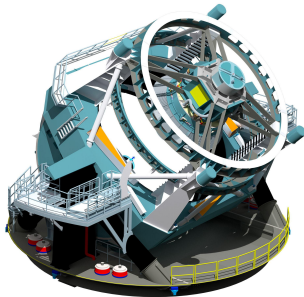


*From detection to science*

# The data path



*every ~30 seconds down to mag ~24*

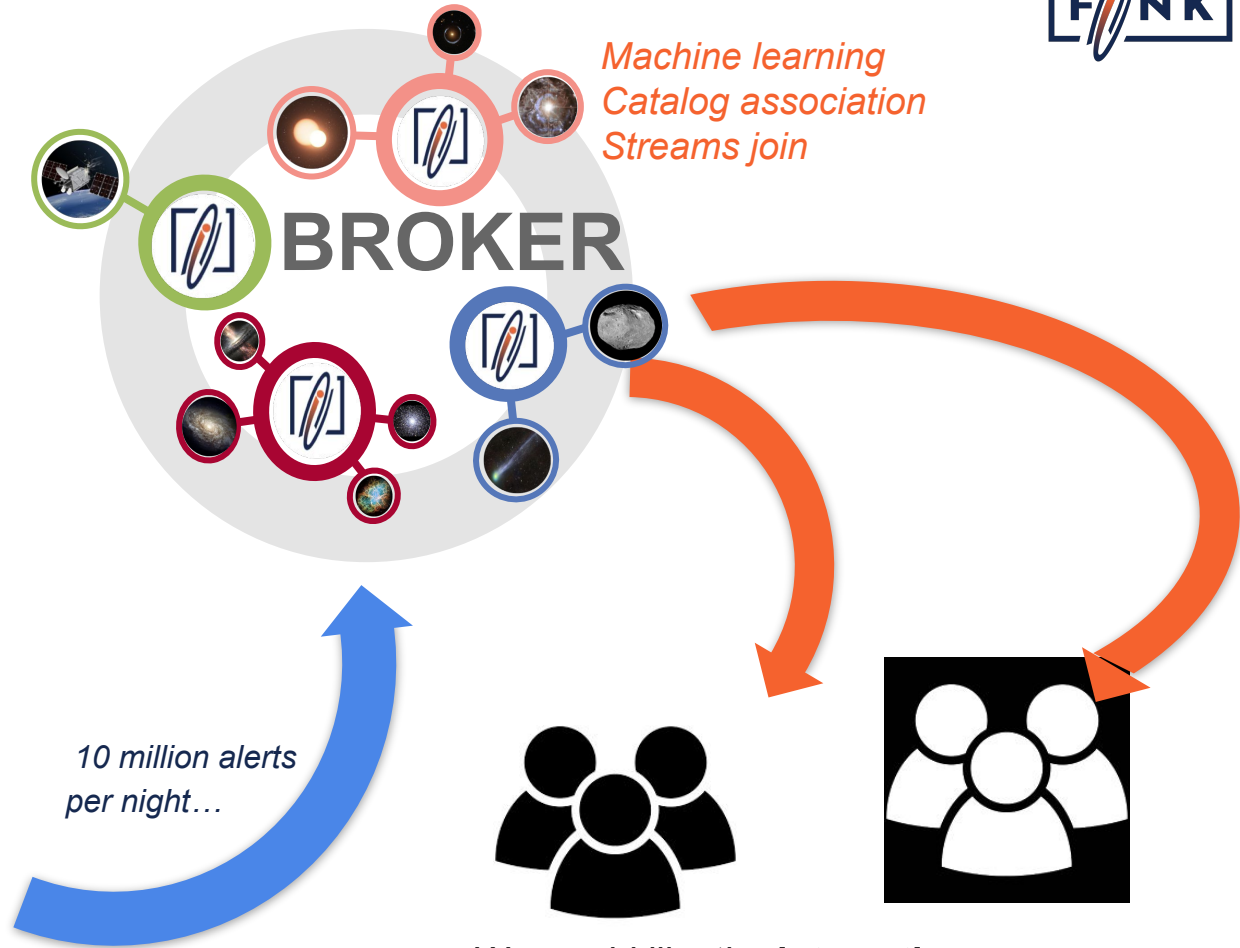
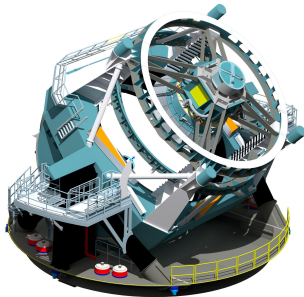


*10 million alerts per night...*

# The data path



every ~30 seconds down to mag ~24

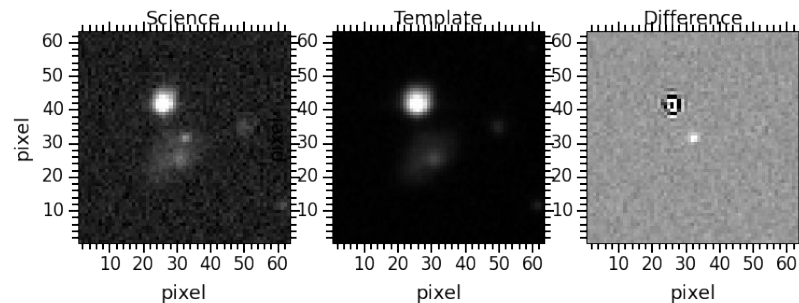
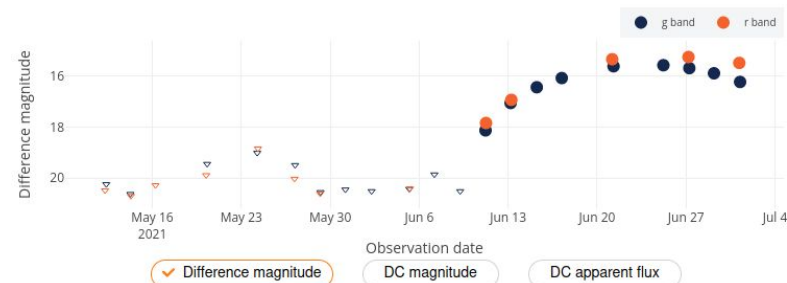


# (What is an alert?)

## Alerts based on Difference Image Analysis

Each alert contains

- Information about the new detection (magnitude, position, ...)
- Neighbours information (xmatches, etc)
- Historical information if the object has been seen previously
- Small images around the detection (60x60 pixels)

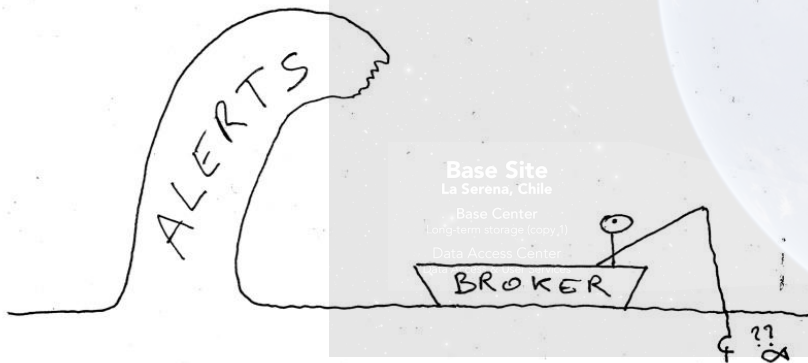


# Alert data challenge

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

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

Fink is made for LSST



**LSST**  
Large Synoptic Survey Telescope

LSST Operations:  
Site & Data Flow

**HQ Site**  
Tucson, AZ  
Science Operations  
Observatory Management  
Education & Public Outreach

**Base Site**  
La Serena, Chile  
Base Center  
Long-term storage (copy 1)  
Data Access Center

**French Site**  
CC-IN2P3, Lyon, France  
Satellite Processing Center  
Data Release Production  
Long-term Storage (copy 3)

**LSST Data Facility**  
National Center for Supercomputing  
Applications (NCSA), Urbana-Champaign, IL  
Processing Center  
Alert Production  
Data Release Production  
Calibration Products Production  
EPO Infrastructure  
Long-term Storage (copy 2)  
Data Access Center  
Data Access and User Services

**Summit Site**  
Cerro Pachón, Chile  
Telescope & Camera  
Data Acquisition  
Crosstalk Correction

Google

Image ©2017 Data SCS NOAA, U.S. Navy NGA, GEBCO, Copernicus, NOAA, U.S. Geological Survey, FRC@ESA, Map data ©2017 Google, HERE, United States, Terra, Sand Imágenes, 2008-14



# Rubin broker landscape

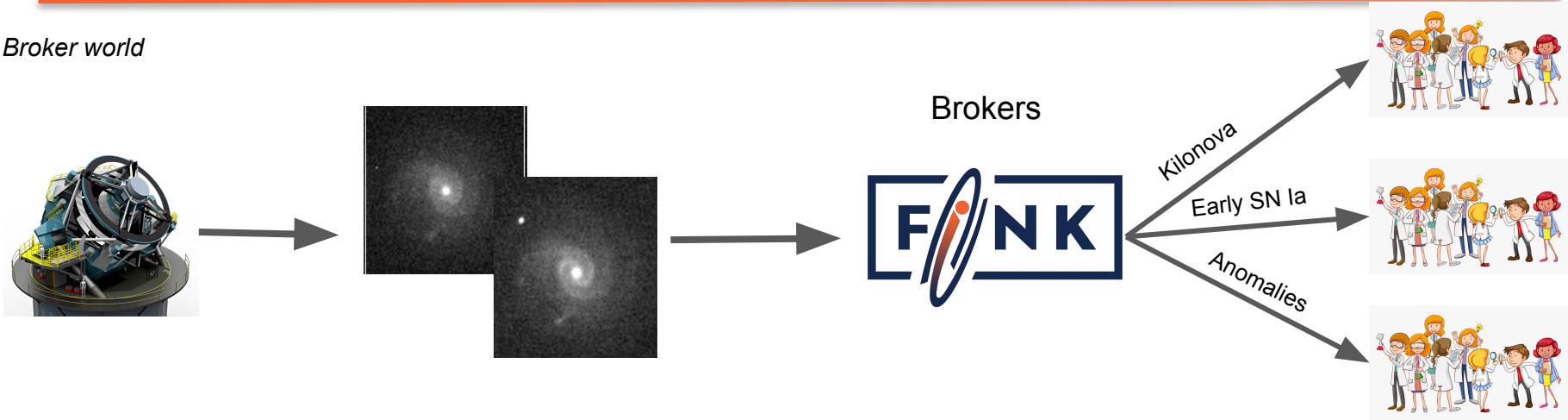
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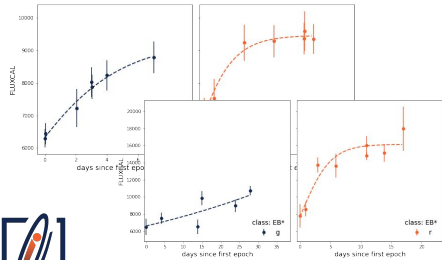


# How to classify alerts?

Broker world



Domain specialist world



You can access this via the Fink Science portal or the API

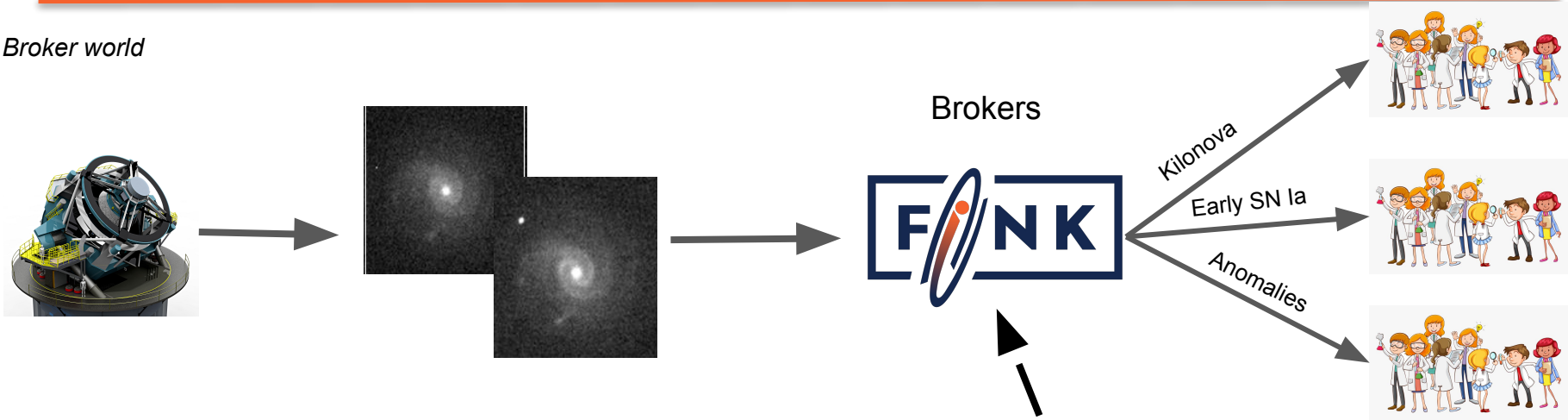
*All alerts data is public!*

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

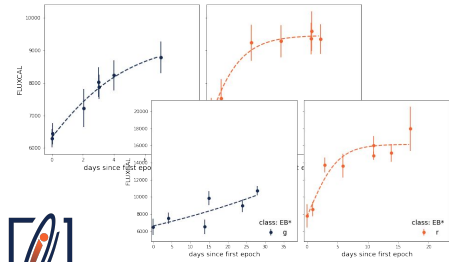


# How to classify alerts?

Broker world



Domain specialist world



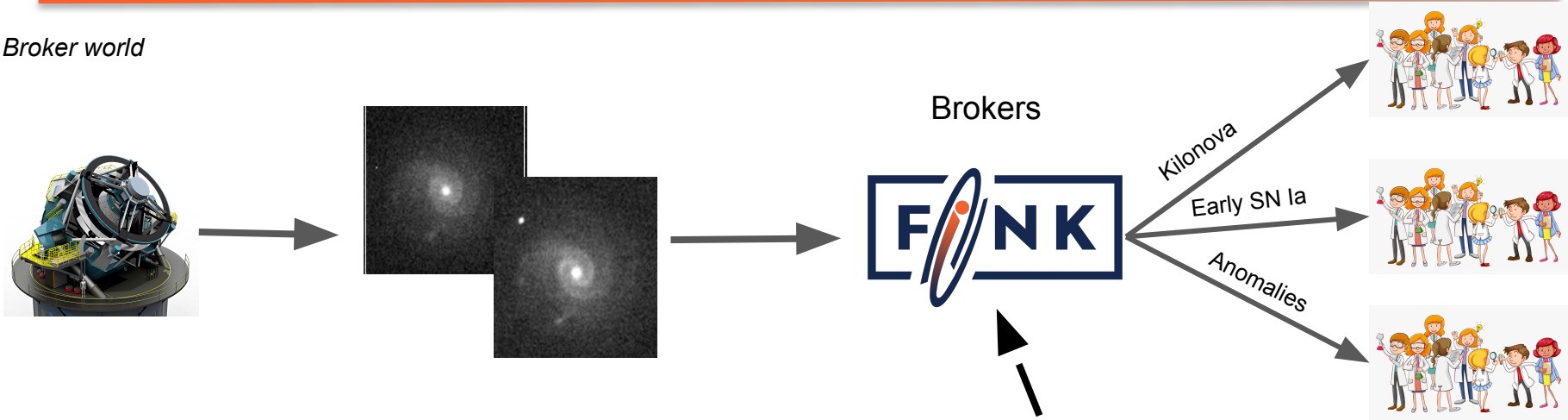
Filter

Catalog or stream xmatch

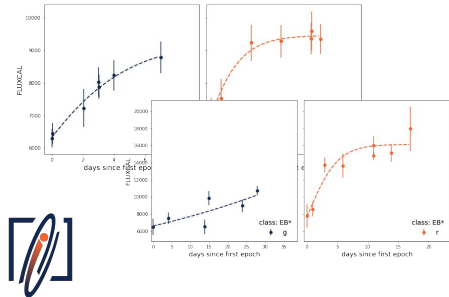
**Taylored science module**

# How to classify alerts?

Broker world



Domain specialist world



Taylorred science module

$f(\text{alerts}; ++)$  => class scores  
Boolean

# Step 2

Construct a machine learning classifier

Machine Learning:

*(a personal favorite)*

Supervised definition

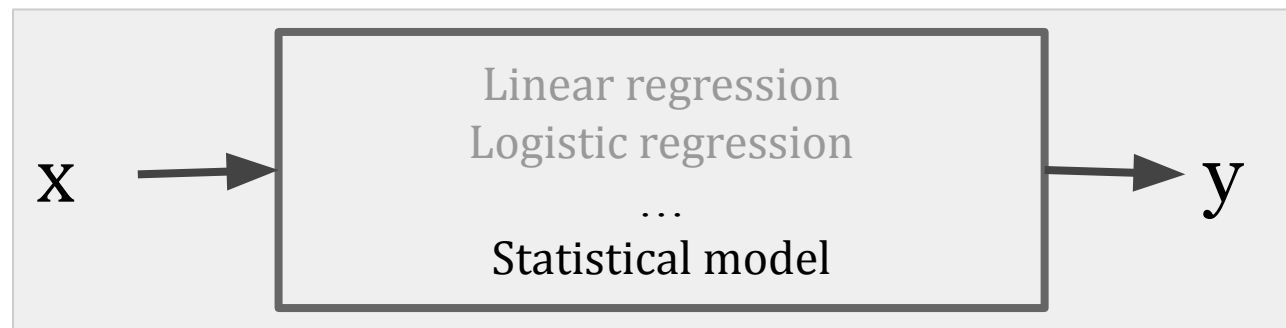
Hypothesis:



Hypothesis:



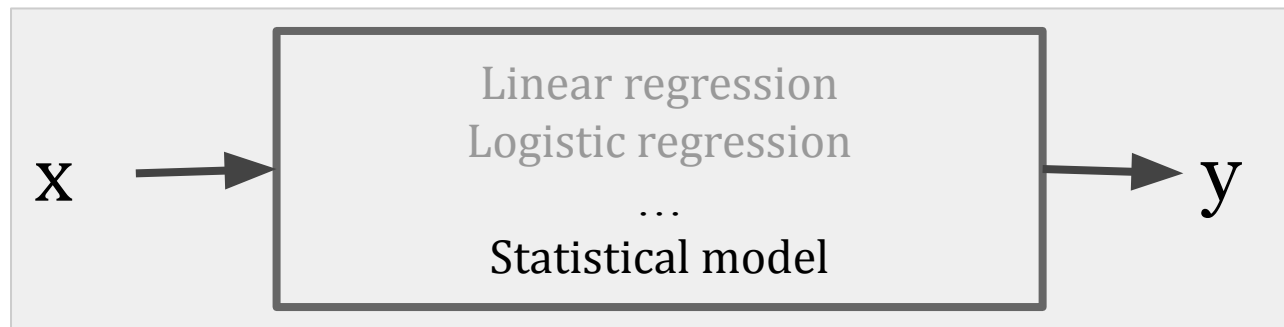
Physical modeling:



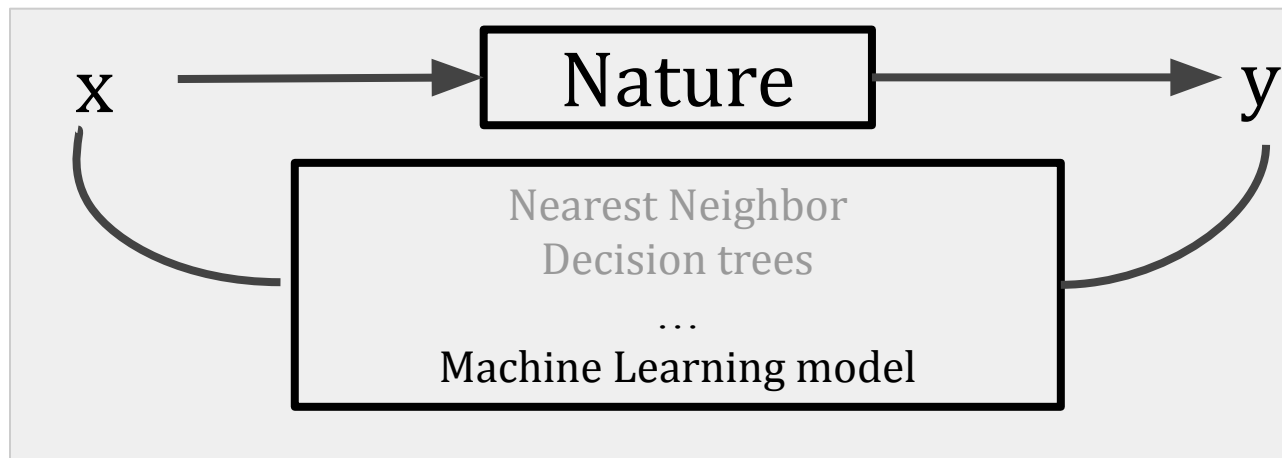
Hypothesis:



Physical modeling:



Algorithmic modeling:

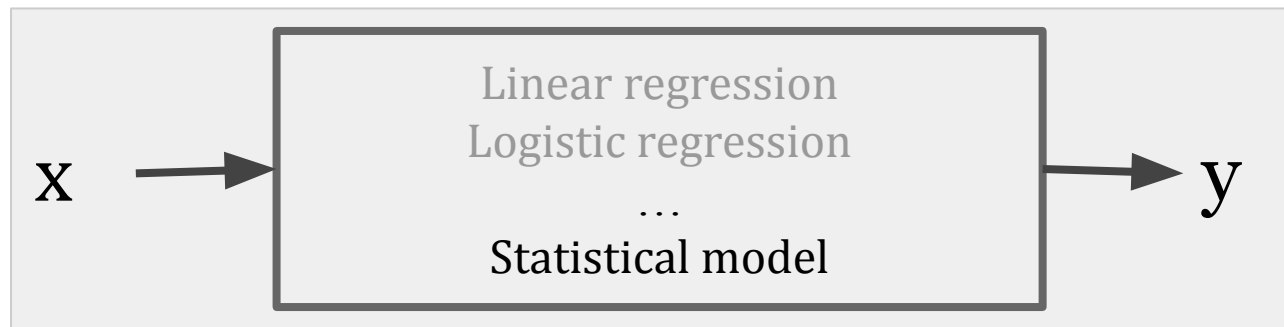




Hypothesis:

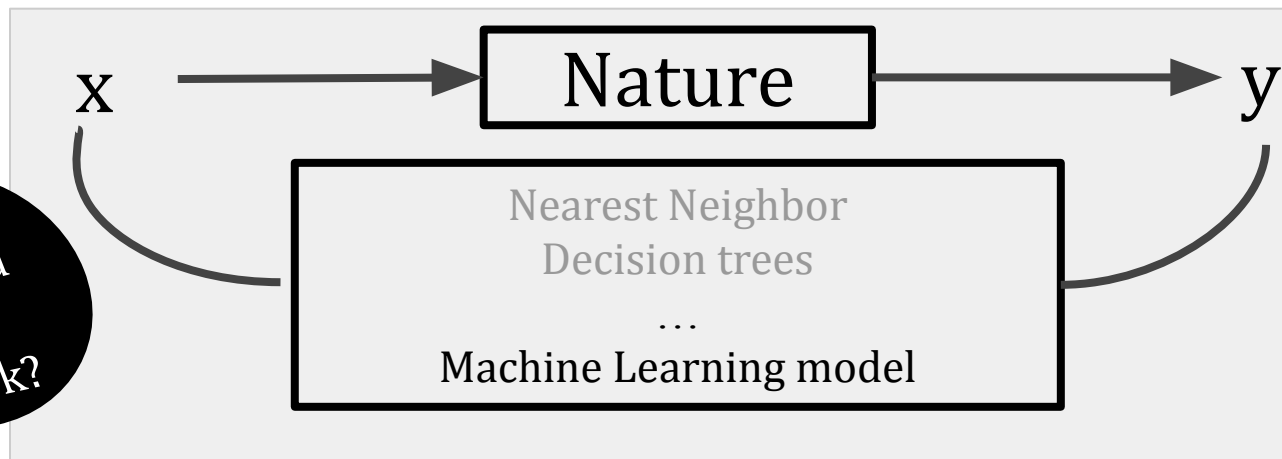


Physical modeling:



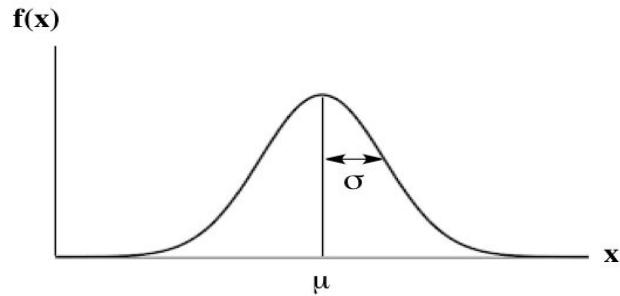
Algorithmic modeling:

Why should this work?



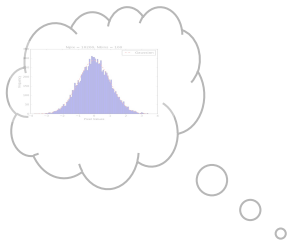
# Representativeness

Probability distribution,  $P$



$$(\mu_P, \sigma_P)$$

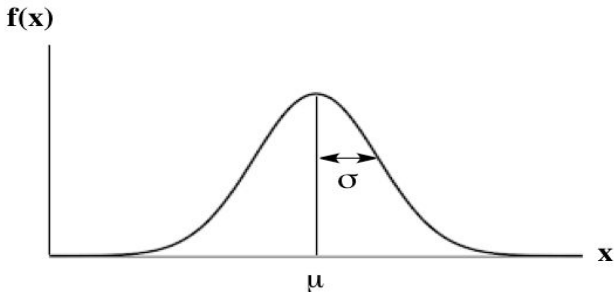
Sample,  $S_1$



$$(\mu_{S_1}, \sigma_{S_1})$$

# Representativeness

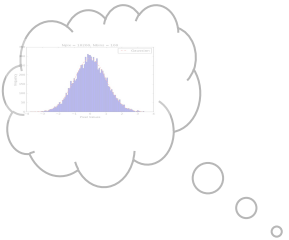
Probability distribution,  $P$



$$(\mu_P, \sigma_P)$$



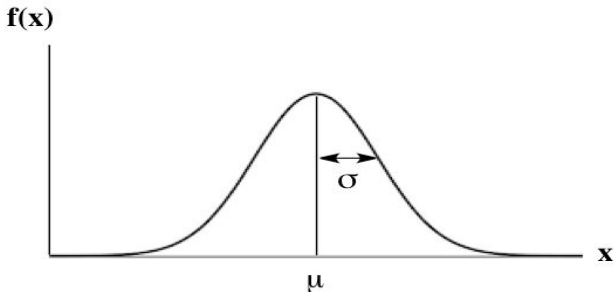
Sample,  $S_1$



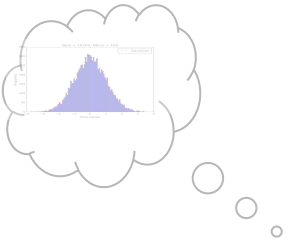
$$(\mu_{S_1}, \sigma_{S_1})$$

# Representativeness

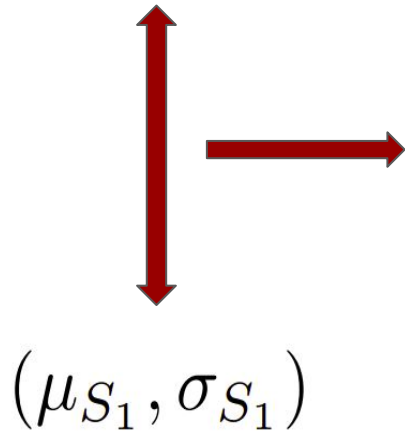
Probability distribution,  $P$



Sample,  $S_1$



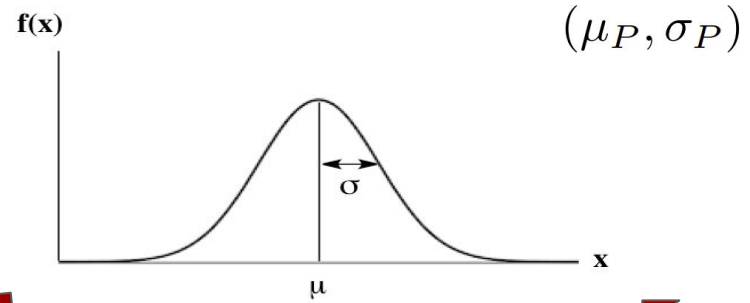
$$(\mu_P, \sigma_P)$$



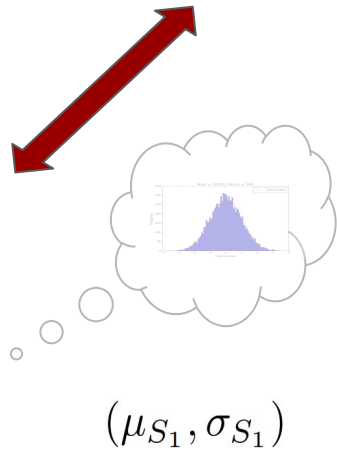
$S_1$  is representative of  $P$

# Representativeness

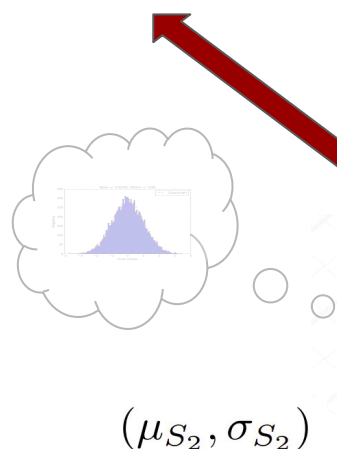
Probability distribution,  $P$



S1

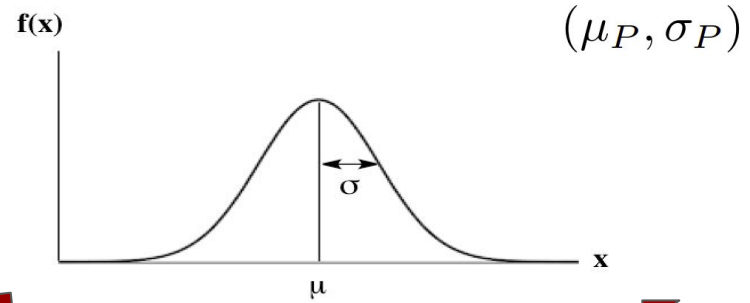


S2

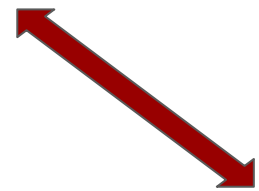
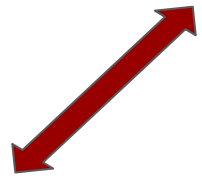


# Representativeness

Probability distribution,  $P$



S1



S2

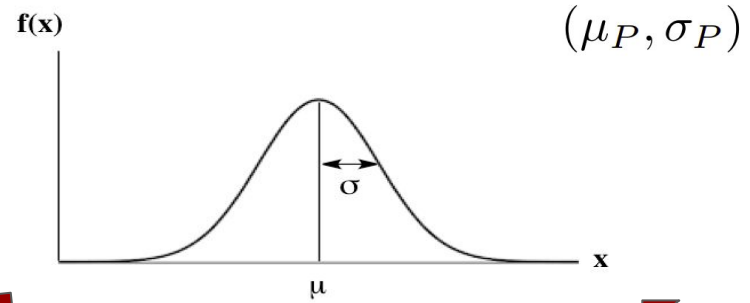


$(\mu_{S1}, \sigma_{S1})$

$(\mu_{S2}, \sigma_{S2})$

# Representativeness

Probability distribution,  $P$



This is why it works!

Training

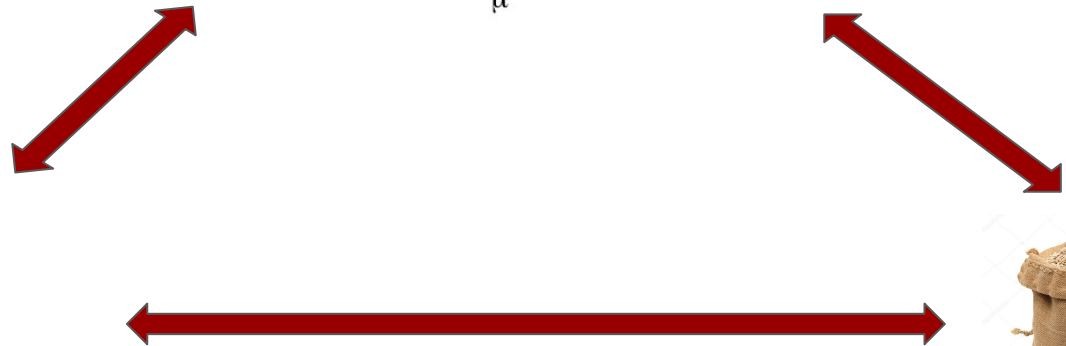


$(\mu_{S_1}, \sigma_{S_1})$

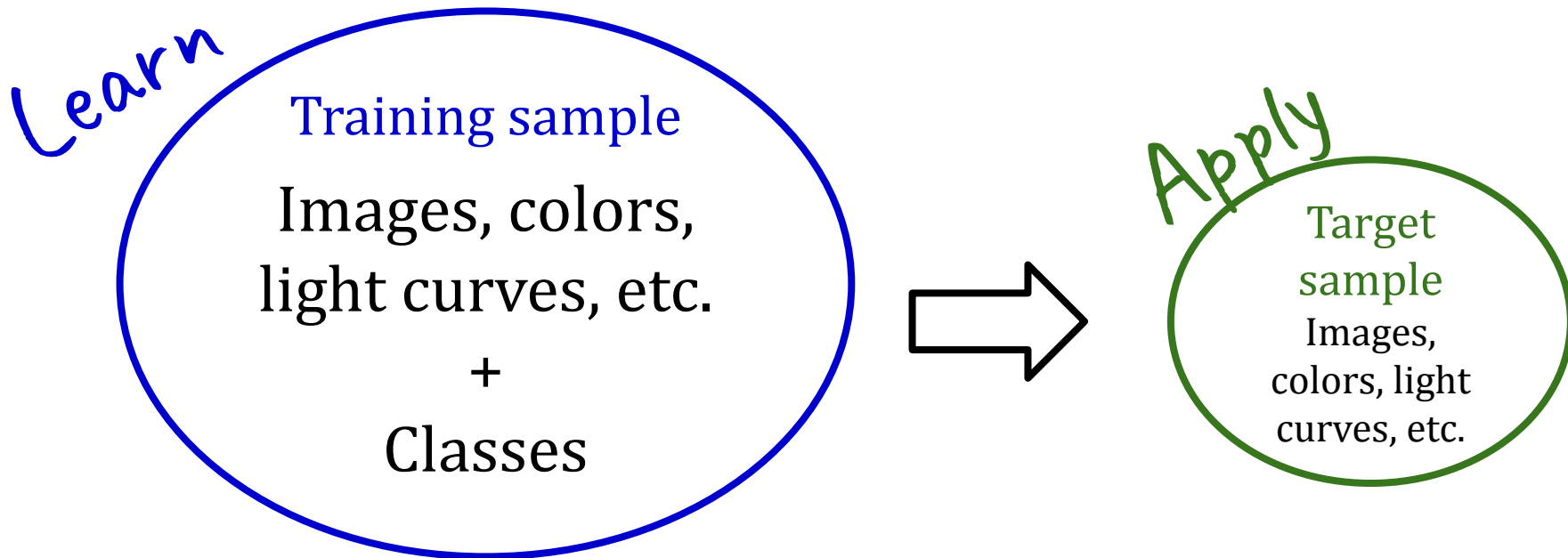
Target



$(\mu_{S_2}, \sigma_{S_2})$



# Ideal Supervised learning situation



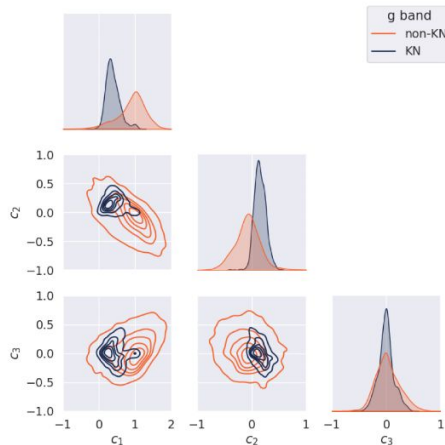
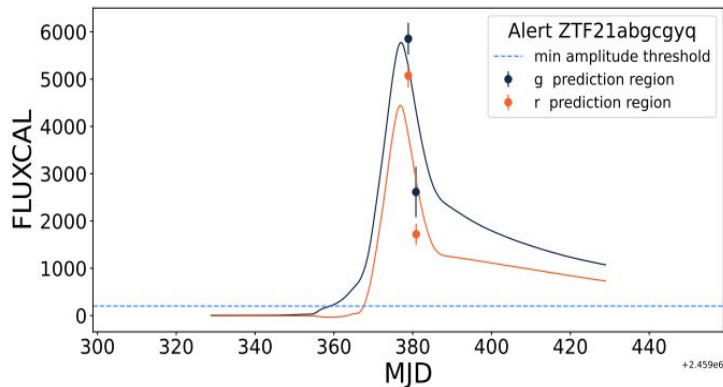


# Case study: Kilonova

**Problem 1:** there are no labels, only 1 confirmed detection- with a GW counterpart

**Problem 2:** we need to find it fast

*Transfer Learning*



Data set:

Simulated ZTF light curves

Feature extraction:

Principal components from perfect sims

Classifier:

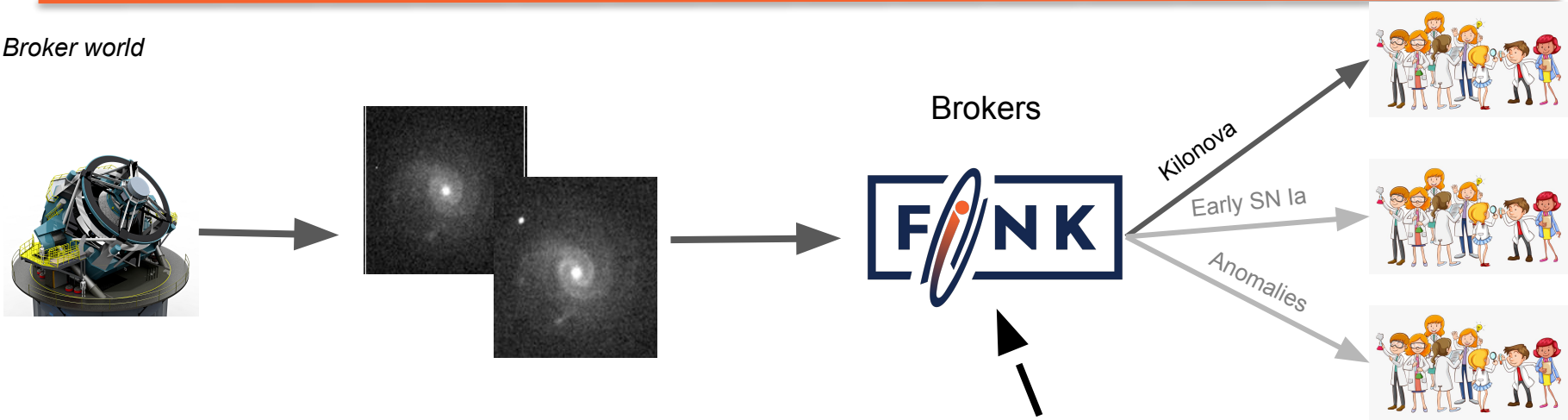
Random Forest

<https://fink-portal.org/ZTF21abgcqyg>

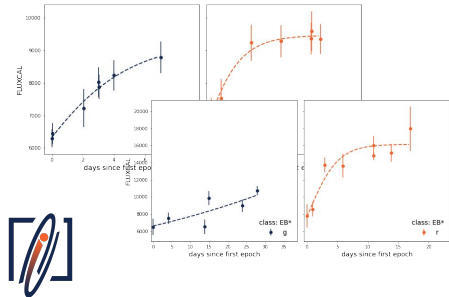


# How to classify alerts?

Broker world



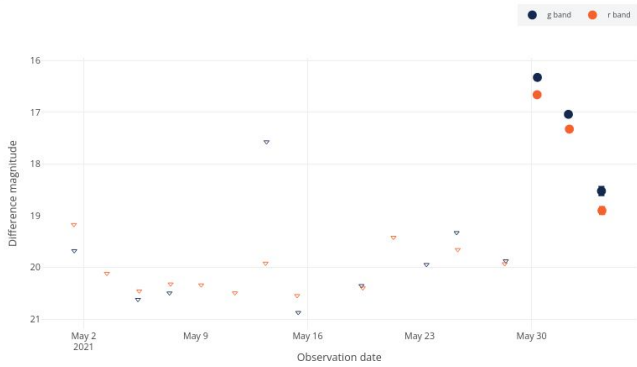
Domain specialist world



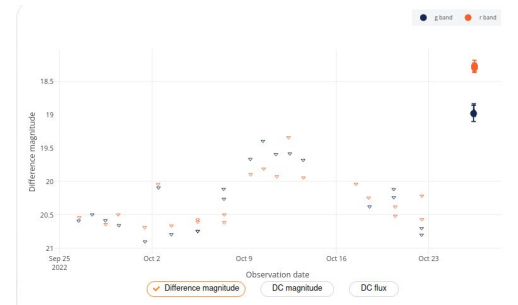
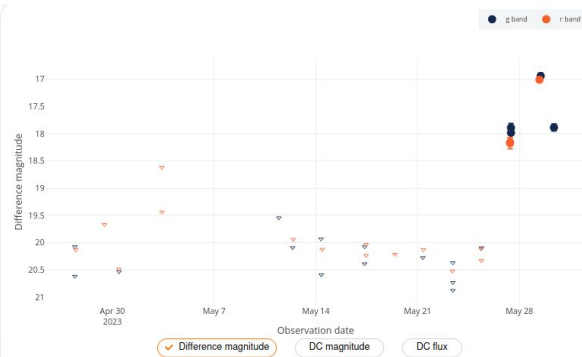
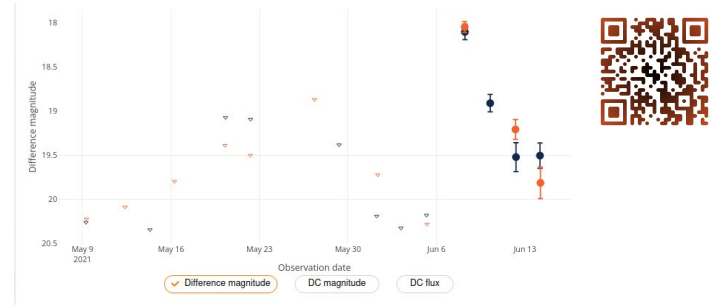
**Taylorred science module**

$f(\text{alerts}; ++)$  => *class scores*  
*Boolean*

# Case study: Kilonova



*Recent candidates*

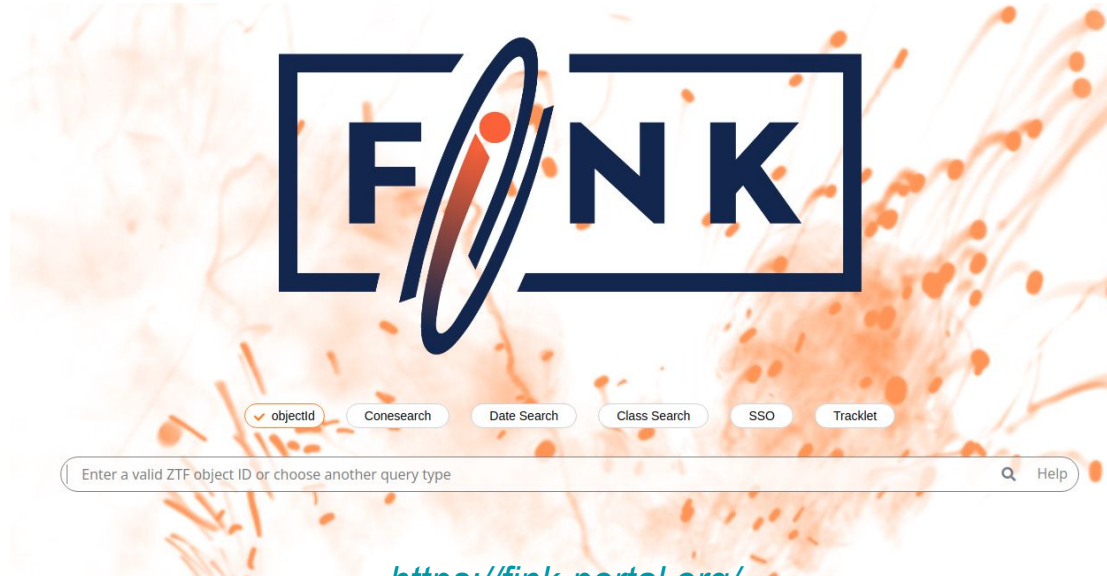


# Step 3

Tell the world

# Once the module is integrated...

---



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

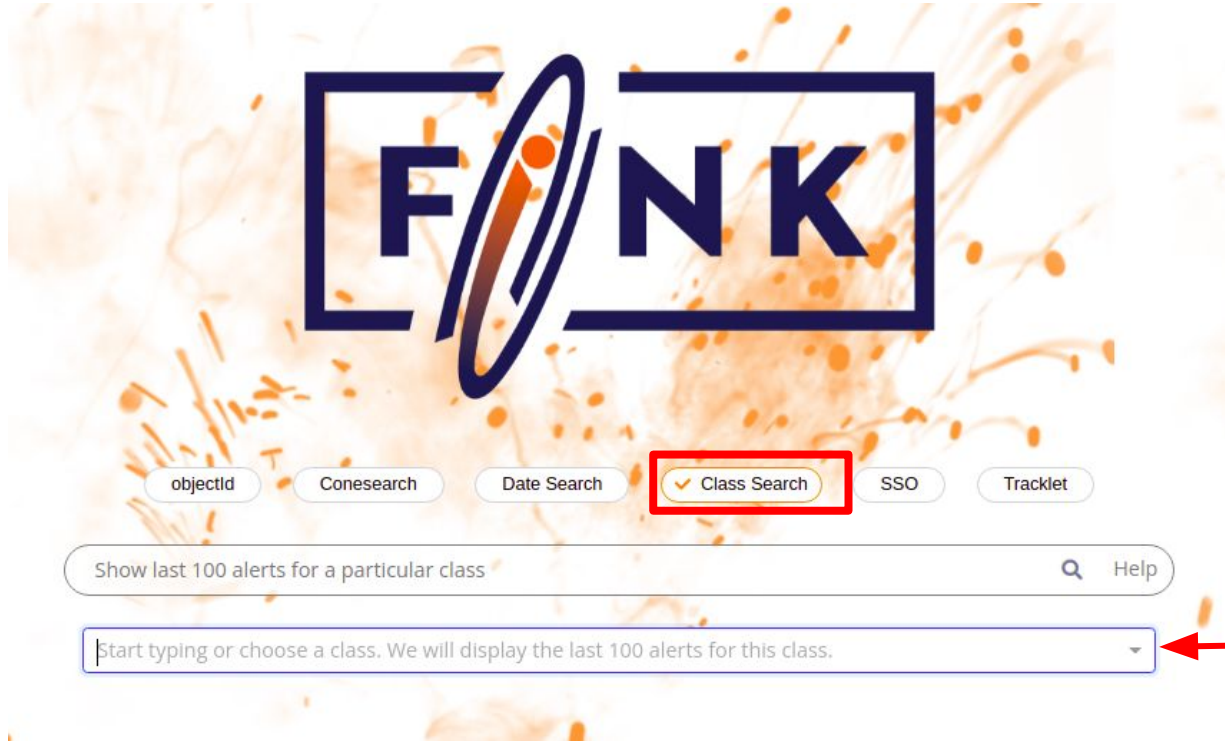
Tutorials: <https://github.com/astrolabsoftware/fink-tutorials>



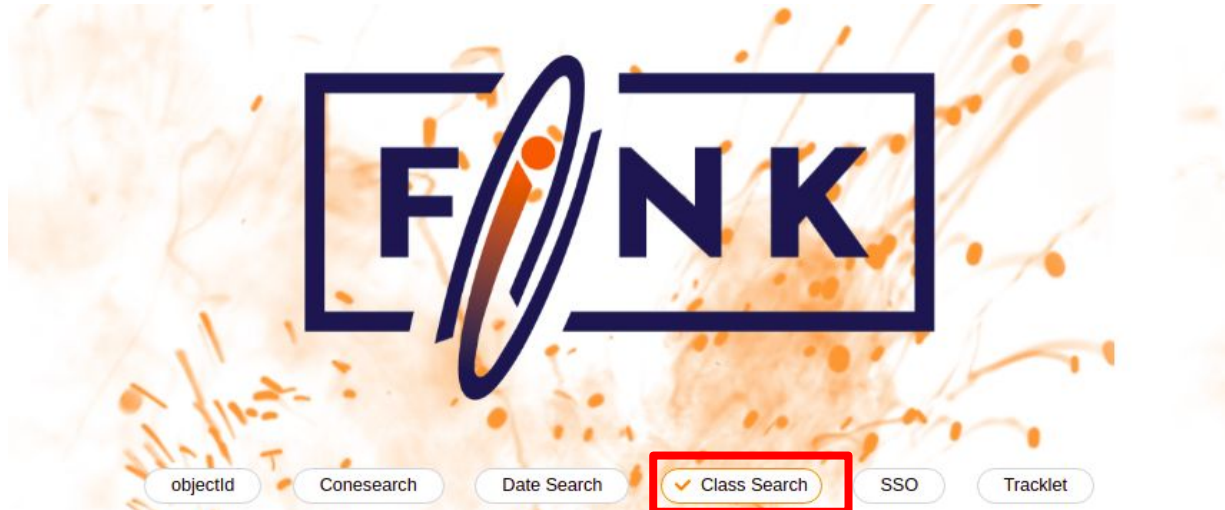
*PS: while LSST does not arrive, we are operating with ZTF (~ 200k alerts/night)*

# Once the module is integrated...

---



# Once the module is integrated...



Fink derived classes

**Early Supernova Ia candidates**

Supernova candidates

Kilonova candidates

Microlensing candidates



# Once the module is integrated...

objectId Conesearch Date Search **Class Search** SSO Tracklet

Show last 100 alerts for a particular class

Early Supernova Ia candidates

Info **Table** Sky map

Add more fields to the table

<input type="checkbox"/> i:objectId	<input type="checkbox"/> i:ra	<input type="checkbox"/> i:dec	<input type="checkbox"/> v:lastdate	<input type="checkbox"/> v:classification	<input type="checkbox"/> i:ndethist
filter data...					
<a href="#">ZTF22aajpzwm</a>	295.3652803	51.2627246	2022-05-15 10:50:42.000	Early SN Ia candidate	11
<a href="#">ZTF22aaiiho</a>	273.9674927	12.0377664	2022-05-15 10:38:34.002	Early SN Ia candidate	14
<a href="#">ZTF22aaijnqy</a>	266.8819962	45.3039968	2022-05-15 09:50:30.998	Early SN Ia candidate	18
<a href="#">ZTF22aahivky</a>	298.6266396	61.2873429	2022-05-15 09:46:58.999	Early SN Ia candidate	19
<a href="#">ZTF22aaihxyz</a>	264.6423366	9.1645982	2022-05-15 09:36:47.002	Early SN Ia candidate	15
<a href="#">ZTF22aaiiho</a>	273.9674591	12.0377098	2022-05-15 09:05:59.001	Early SN Ia candidate	13





# On

Search Statistics API Tutorials Info

Load fail,  
refresh  
the page

Last emission date:  
2022-05-15 10:50:42.000

Days since first detection:  
5

Last magnitude (band g):  
18.43

Total number of detections:  
11

## Early SN Ia candidate

Constellation: Cygnus



[Go to ZTF22aajpzwm](#)

jectId

er data...

jpzwm

iiho

jnqy

hivky

ihxzh

iiho

264.6423366

9.1645982

2022-05-15 09:36:47.002

Early SN Ia candidate

15

273.9674591

12.0377098

2022-05-15 09:05:59.001

Early SN Ia candidate

13



Load fail,  
refresh  
the page

Last emission date:  
2022-05-15 10:38:34.002

Days since first detection:  
16

Last magnitude (band g):  
18.71

Total number of detections:  
14

## Early SN Ia candidate

Constellation: Ophiucus



[Go to ZTF22aaiiho](#)

Info Table S

Add more fields to

**i:objectId**

filter data...

ZTF22aajpzwm

ZTF22aaiiho

ZTF22aaijnqy

ZTF22aahivky

ZTF22aaihzh

264.6423366

9.1645982

2022-05-15 09:36:47.002

Early SN Ia candidate

15

ZTF22aaiiho

273.9674591

12.0377098

2022-05-15 09:05:59.001

Early SN Ia candidate

13



Load fail,  
refresh  
the page

Last emission date:  
2022-05-15 09:36:47.002

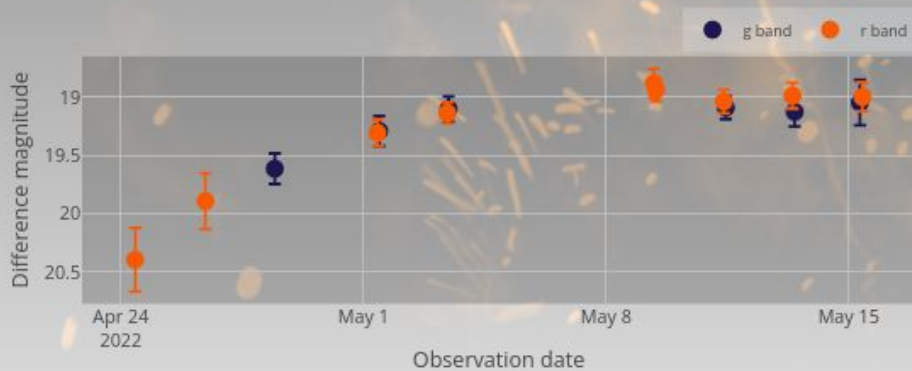
Days since first detection:  
20

Last magnitude (band r):  
19.00

Total number of detections:  
15

### Early SN Ia candidate

Constellation: Ophiucus



[Go to ZTF22aalhxzh](#)



Info Table

Add more fields to

**i:objectId**  
filter data...

ZTF22aajpzwm

ZTF22aaiiho

ZTF22aaijnqy

ZTF22aahivky

ZTF22aalhxzh

ZTF22aaiiho

264.6423366

273.9674591

9.1645982

12.0377098

2022-05-15 09:36:47.002

2022-05-15 09:05:59.001

Early SN Ia candidate

Early SN Ia candidate

15

13

review

**i:ndethist**

1

4

8

9





# ZTF23aaejvsg

● EARLY SN IA CANDIDATE ● SN CANDIDATE ● UNKNOWN

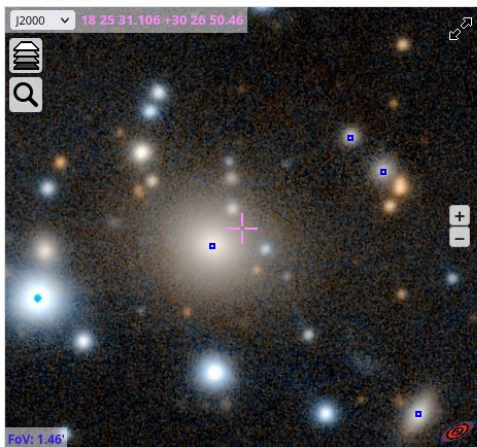
Discovery date: 2023-04-08 09:38:32.004

Last detection: 2023-04-26 11:07:38.997

Number of detections: 15

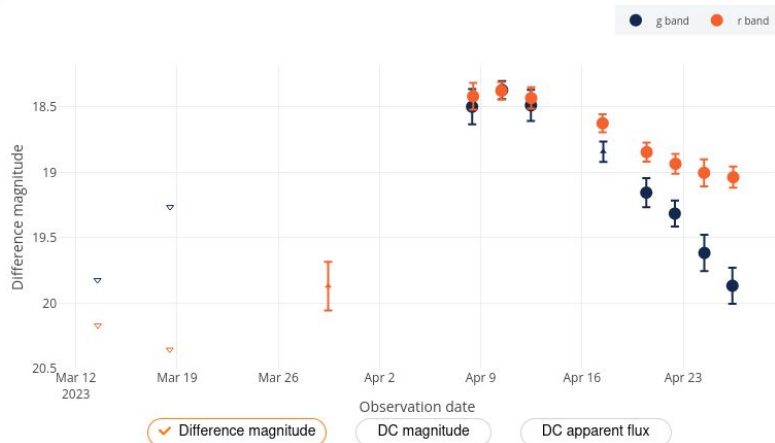
Number of low quality alerts: 2

Number of upper limits: 4



Individual alert classification

■ Early SN Ia candidate: 53% ■ Unknown: 7% ■ SN candidate: 40%



Circles (●) with error bars show valid alerts that pass the Fink quality cuts. In addition, the *Difference magnitude* view shows:

- upper triangles with errors (▲), representing alert measurements that do not satisfy Fink quality cuts, but are nevertheless contained in the history of valid alerts and used by classifiers.
- lower triangles (▽), representing 5-sigma mag limit in difference image based on PSF-fit photometry contained in the history of valid alerts.

- ◇ Last alert cutouts
- 📍 Coordinates
- 📄 Last alert content
- 📄 Download data
- 🌐 Other brokers
- 🗺 Neighbourhood
- 🔗 Share



# Once the module is integrated...

API: <https://fink-portal.org/api>

```
import requests
import pandas as pd

# Get all classified SN Ia from TNS between March 1st 2021 and March 5th 2021
r = requests.post(
    'https://fink-portal.org/api/v1/latests',
    json={
        'class': '(TNS) SN Ia',
        'n': '100',
        'startdate': '2021-03-01',
        'stopdate': '2021-03-05'
    }
)

# Format output in a DataFrame
pdf = pd.read_json(r.content)
```

dius)

Your class

pdf = pd.read\_json(r.content)



# How to get alerts + added values?

---

API: <https://fink-portal.org/api>

Extragalactic tutorial:

<https://github.com/astrolabsoftware/fink-notebook-template/blob/main/extragalactic/extragalactic.ipynb>

Implement your own filter in Fink:

<https://fink-broker.readthedocs.io/en/latest/science/filters>

```
# Get latests Early SN candidates (200 max)
r = requests.post(
    '{} /api/v1/latests'.format(APIURL),
    json={
        'class': 'Early SN Ia candidate',
        'n': '200',
        'startdate': '2021-04-01', # use a start date
        'stopdate': '2021-04-13', # use a stop date
    }
)

# Format output in a DataFrame
pdf = pd.read_json(r.content)
```



# Download service



▼ objectId

ConeSearch

Date Search

Class Search

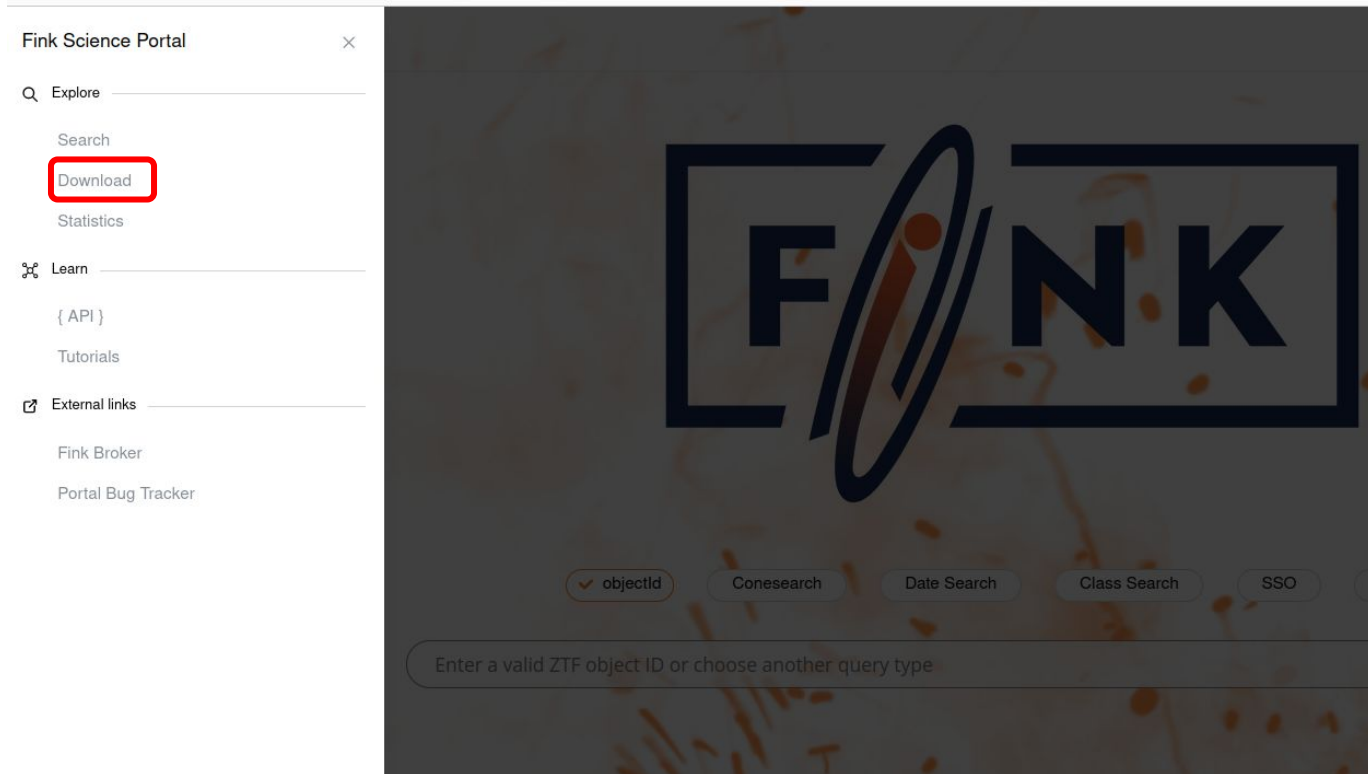
SSO

Enter a valid ZTF object ID or choose another query type



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

# Download service



The screenshot displays the Fink Science Portal interface. On the left, a navigation menu is visible with the following items: 'Explore', 'Search', 'Download' (highlighted with a red box), 'Statistics', 'Learn', '{ API }', 'Tutorials', 'External links', 'Fink Broker', and 'Portal Bug Tracker'. The main content area features the FINK logo, which consists of the letters 'F', 'I', 'N', and 'K' in a stylized font, with the 'I' being a vertical bar with a red dot above it, all enclosed in a dark blue square frame. Below the logo, there are several search filters: 'objectid' (selected), 'Conesearch', 'Date Search', 'Class Search', and 'SSO'. At the bottom, there is a search input field with the placeholder text 'Enter a valid ZTF object ID or choose another query type'.

Documentation: [https://fink-broker.readthedocs.io/en/latest/services/data\\_transfer](https://fink-broker.readthedocs.io/en/latest/services/data_transfer)





# Download service



## Select data source

Source: ZTF

## Filter alerts

Dates: 2022-10-03 - 2022-10-10

Classe(s): ['SN candidate', 'Unknown']

Conditions: ndethist>10

## Select content

Content: Lightcurve

## Submit

Trigger your job!



Description



Log in



Data Source

Choose the type of alerts you want to retrieve



ZTF



ELASTICC

Filters

Date Range \*

Pick up start and stop dates (included).

October 3, 2022 – October 10, 2022



Alert class

Select all classes you like! Default is all classes.

(Fink) Supernova candidates

Unknown



All classes

(Fink) Early Supernova Ia candidates

(Fink) Kilonova candidates

(Fink) Microlensing candidates

(Fink) Solar System (MPC)

(Fink) Solar System (candidates)


Alert


Submit



Documentation: [https://fink-broker.readthedocs.io/en/latest/services/data\\_transfer](https://fink-broker.readthedocs.io/en/latest/services/data_transfer)

# Download service



 Log in


You need an account to retrieve the data. See [fink-client](#) if you are not yet registered.

Alert content


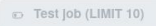
Choose the content you want to retrieve


Lightcurve (~1.4 KB/alert)  Cutouts (~41 KB/alert)  Full packet (~55 KB/alert)

Submit

 **Estimated number of alerts: 525,812 (48.81%) or 0.70 GB**

*You are about to submit a job on the Fink Apache Spark & Kafka clusters. Review your parameters, and take into account the estimated number of alerts before hitting submission! Note that the estimation takes into account the days requested and the classes, but not the extra conditions (which could reduce the number of alerts).*

 Your topic name is: ftransfer\_ztf\_2023-04-26\_296224

Monitor your job

Get your data

Once data has started to flow in the topic, you can easily download your alerts using the [fink-client](#). Install the latest version and use e.g.

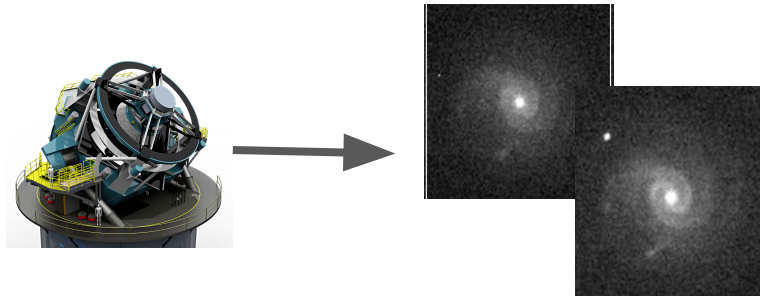
```
fink_datatransfer \  
  -topic ftransfer_ztf_2023-04-26_296224 \  
  -outdir ftransfer_ztf_2023-04-26_296224 \  
  -partitionby finkclass \  
  --verbose
```



Documentation: [https://fink-broker.readthedocs.io/en/latest/services/data\\_transfer](https://fink-broker.readthedocs.io/en/latest/services/data_transfer)

# Case study: Kilonova

Broker world



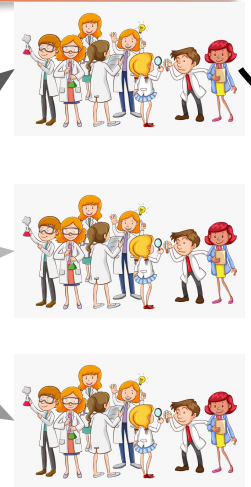
Brokers



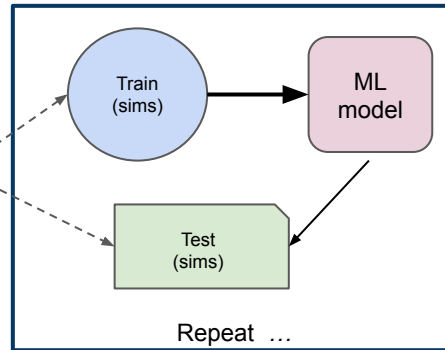
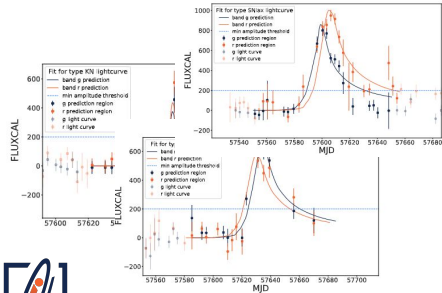
Kilonova

Early SN Ia

Anomalies



Domain specialist world



Trained ML model

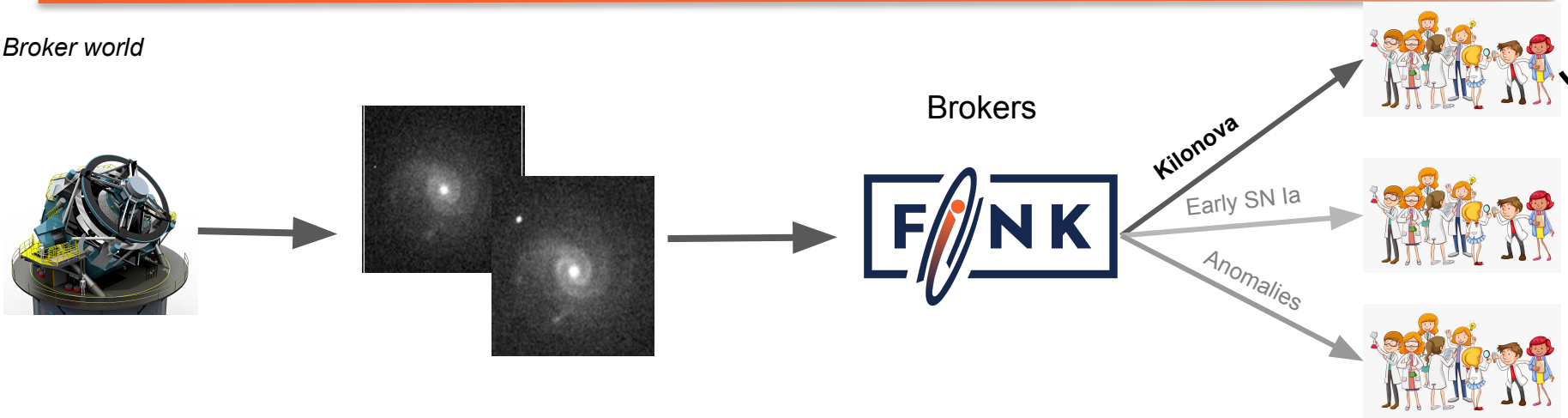
+

PCA feature extraction, selection cuts and PC base

Extra imaging from professional and amateur astronomers

# Case study: Kilonova

Broker world



## GRANDMA Observations of ZTF/Fink Transients during Summer 2021

*Aivazyan et al., 2021, arxiv:astro-ph/2202.09766*

- 35 million candidate alerts
- 100 surviving selection cuts
- 6 followed-up by GRANDMA

*Extra imaging from  
professional and  
amateur  
astronomers*

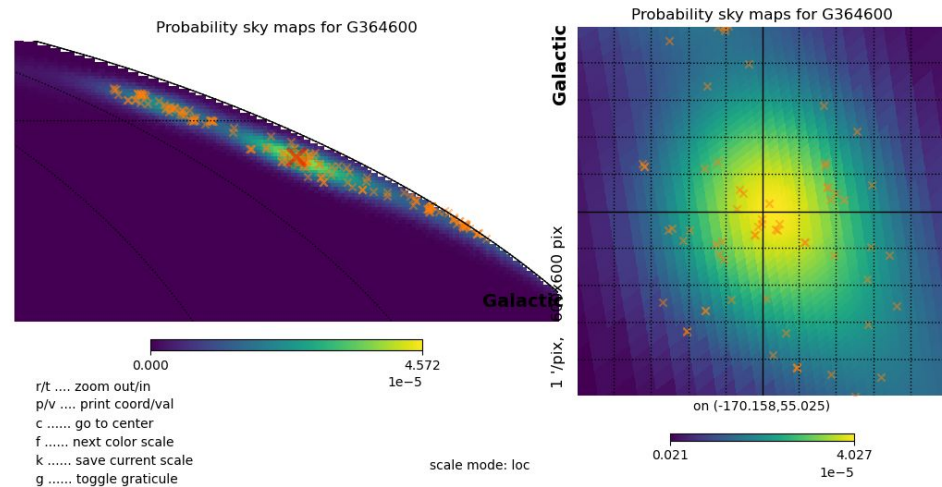


# Connection with GW

Fink has already some tool to play with GW sky maps

<https://fink-portal.org/api> → Gravitational Waves → tutorial!

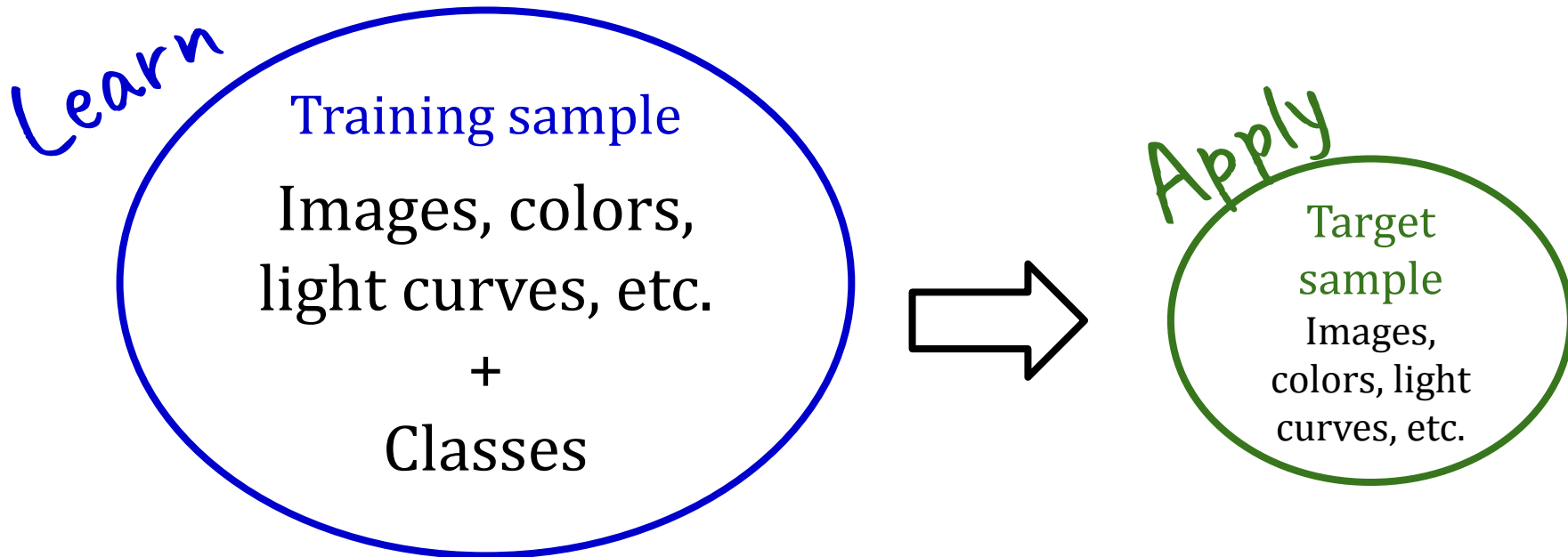
```
# Query Fink
data = gzip.open(fn, 'rb').read()
r = requests.post(
    'https://fink-portal.org/api/v1/bayestar',
    json={
        'bayestar': str(data),
        'credible_level': credible_level,
        'output-format': 'json'
    }
)
```



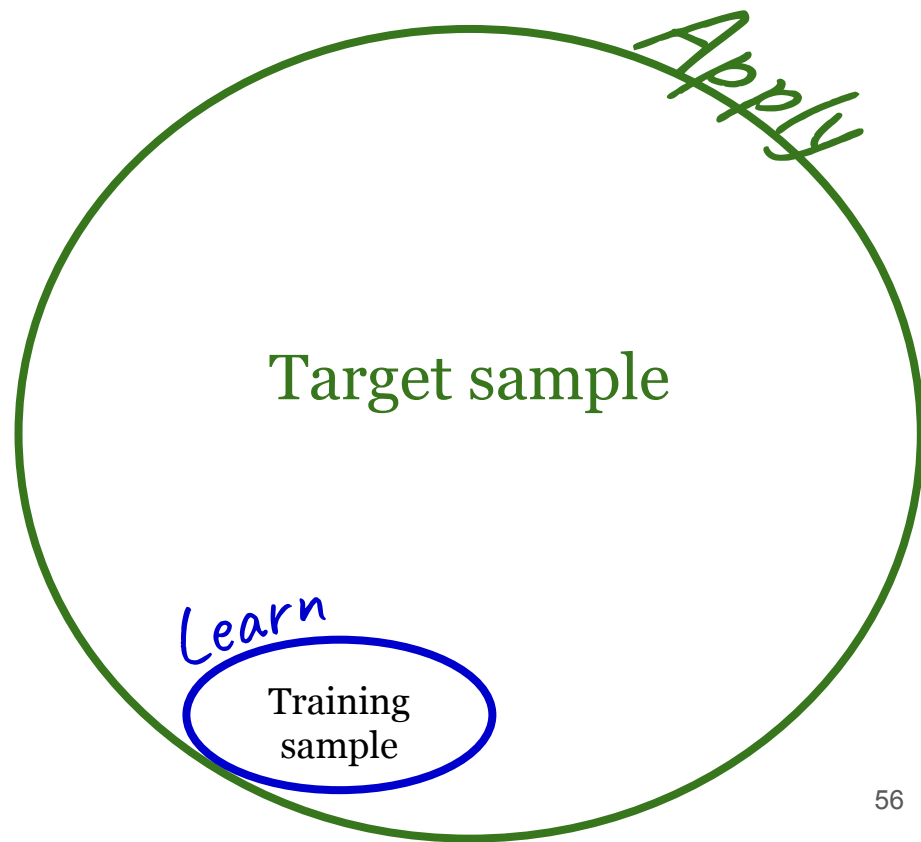
# Step 4

Make a better machine learning model

# Ideal Supervised learning situation

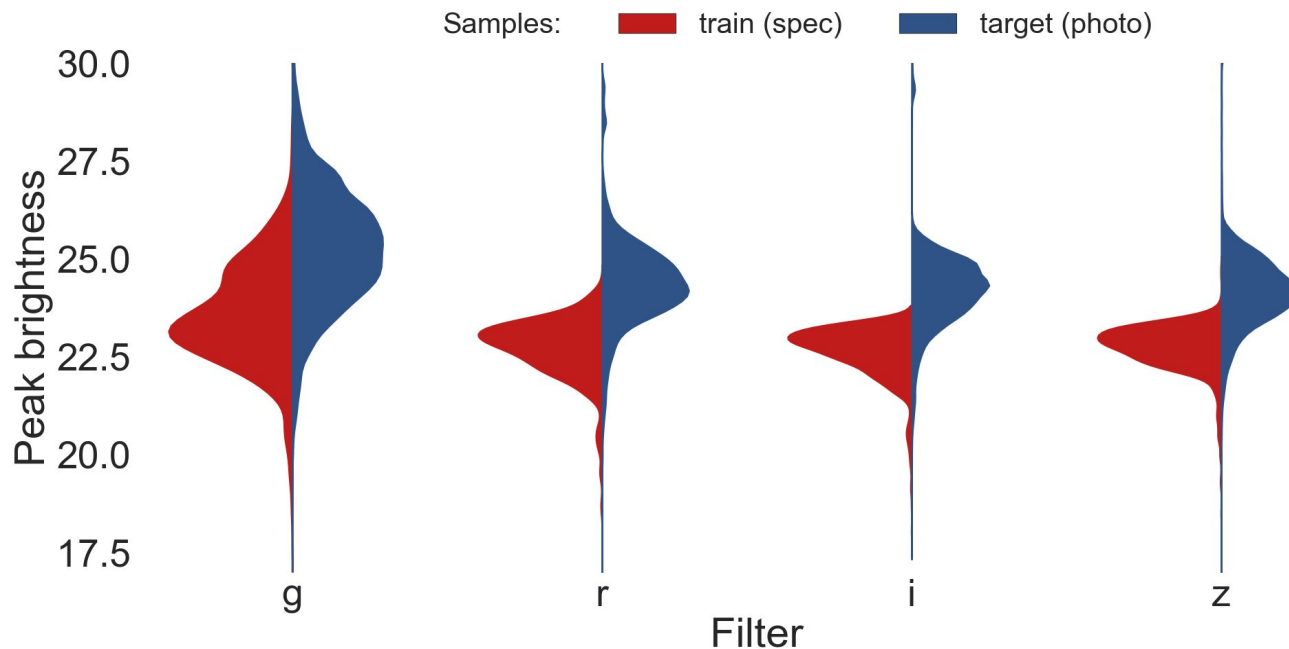


# Real astro-learning situation



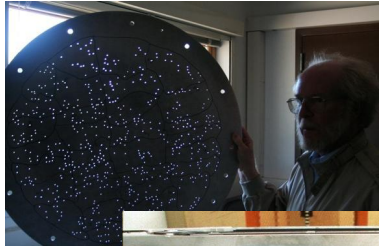


# Real astro-learning situation



# Very common situation

*Labels are often far too expensive!*



Given limited resources, we need recommendation systems!

amazon

35% OF AMAZON'S REVENUE ARE GENERATED BY IT'S RECOMMENDATION ENGINE.

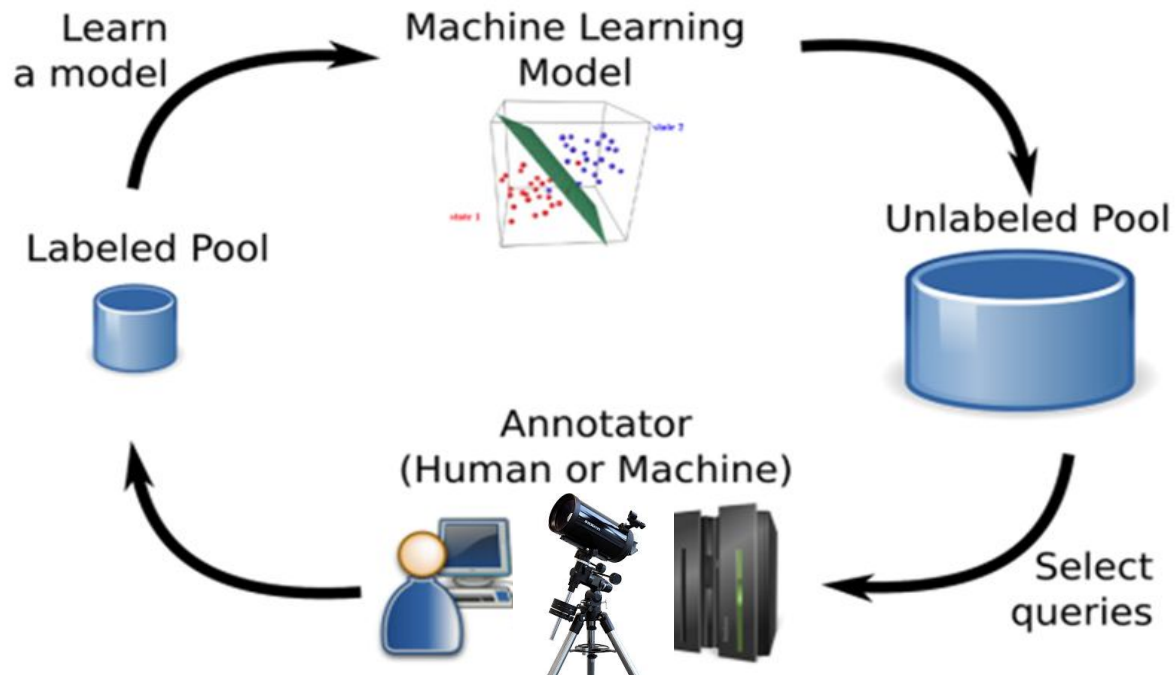
NETFLIX

75% OF USERS SELECT MOVIES BASED ON NETFLIX'S RECOMMENDATIONS.



# Active Learning

*Optimal classification, minimum training*

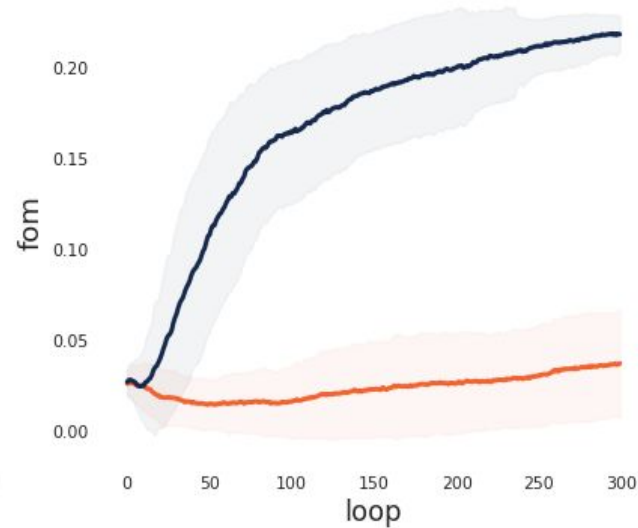
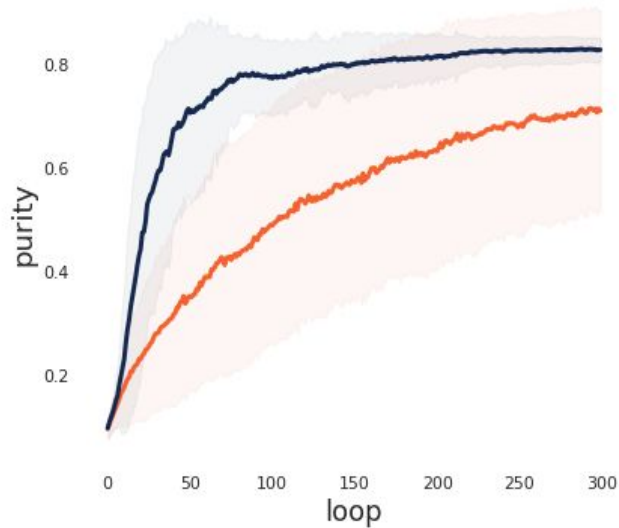


# Model trained on ZTF alerts



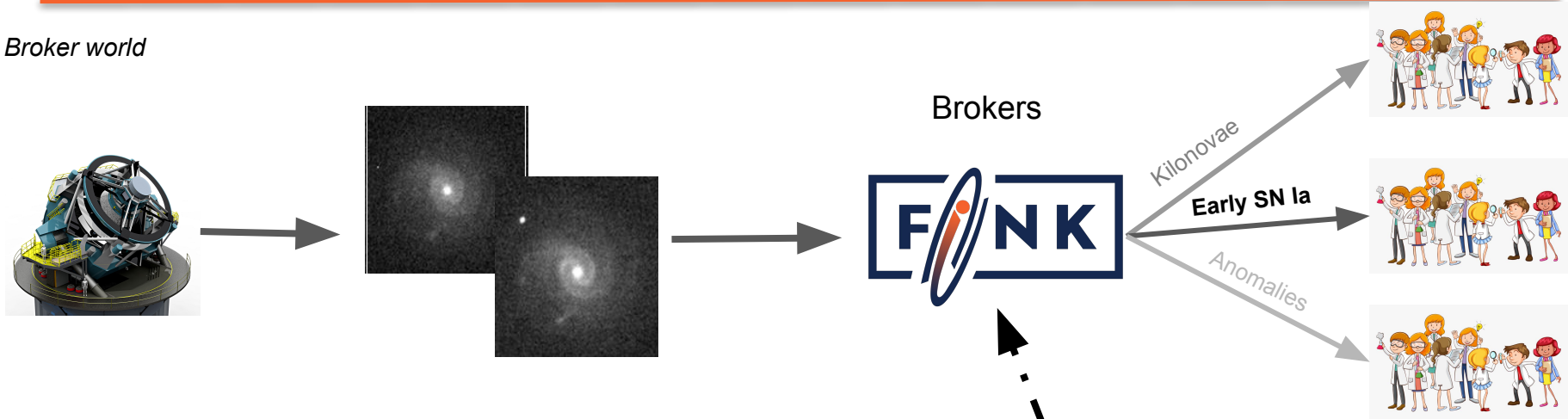
Results after 300 loops:

*Training: 310 alerts*  
*Testing: > 52 000 alerts*

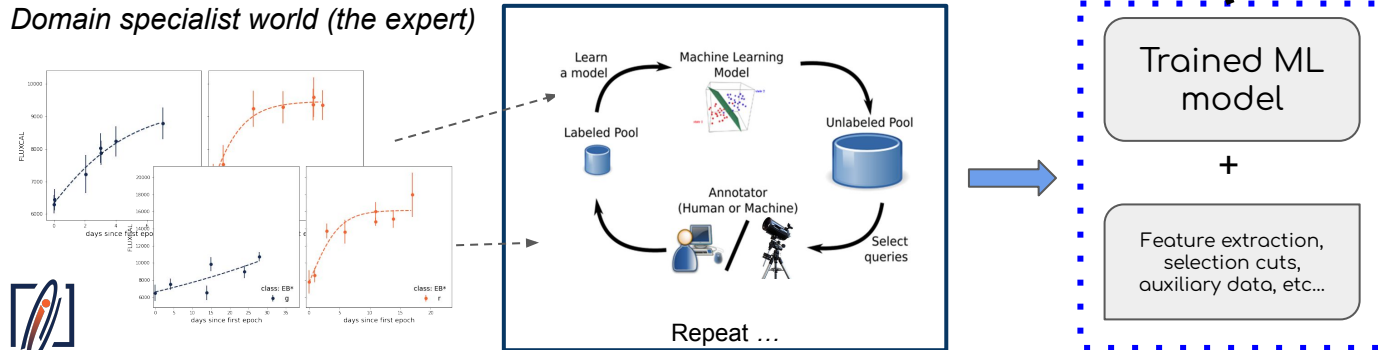


# Back to the broker ...

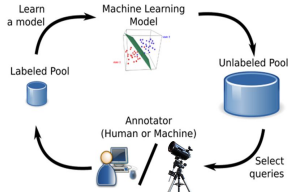
Broker world



Domain specialist world (the expert)



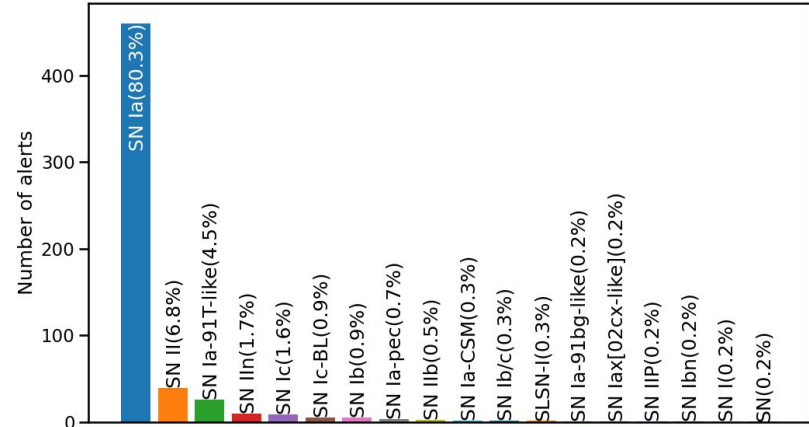
# Fink Early SNIa classifier



+



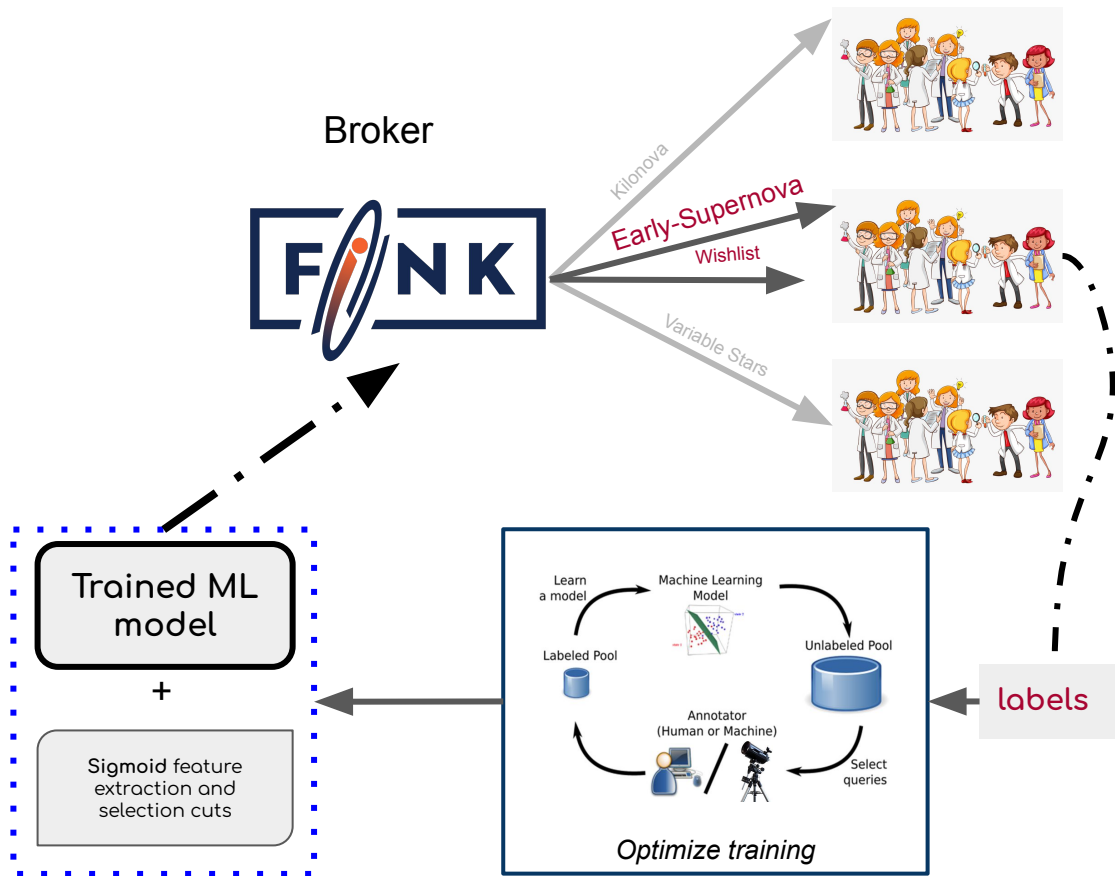
- Only rising candidates
- from November/2020 to March/2022 Fink communicated 4661 early SNIa candidates to TNS
- 573 spectroscopically classified



# For Rubin ...



*Automatic re-training  
once informative new  
labels are made available*



# The difficult part is data treatment/gathering

- The power of machine learning is in its connection with domain knowledge
- There are caveats in using machine learning and we should avoid off-the-shelf and black boxes applications
- ML for science must be personalized



# Step 5

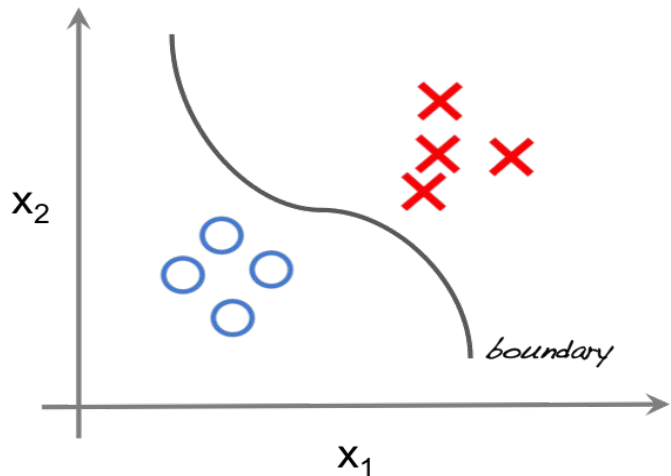
Keep an open mind

# The beauty of an observational science

*“... telescopes that merely achieve their stated science goals have probably failed to capture the most important scientific discoveries available to them.”*

*Norris, R. (2017). Discovering the Unexpected in Astronomical Survey Data. Publications of the Astronomical Society of Australia, 34, E007. doi:10.1017/pasa.2016.63*

## Supervised



Training sample:

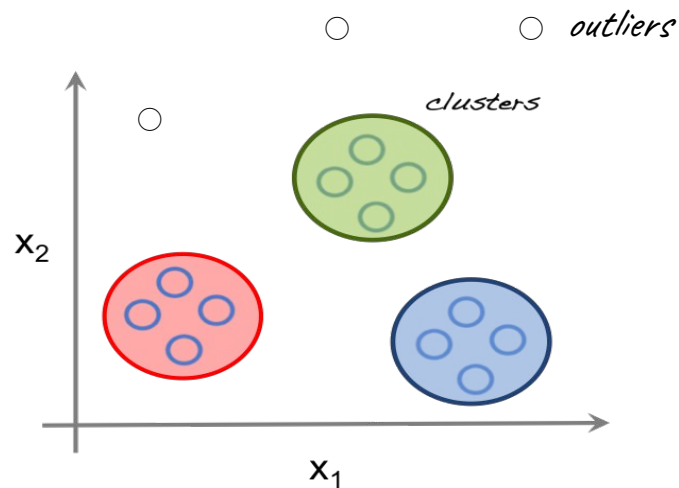
*features + labels*

Target sample:

*features*

x

## Unsupervised

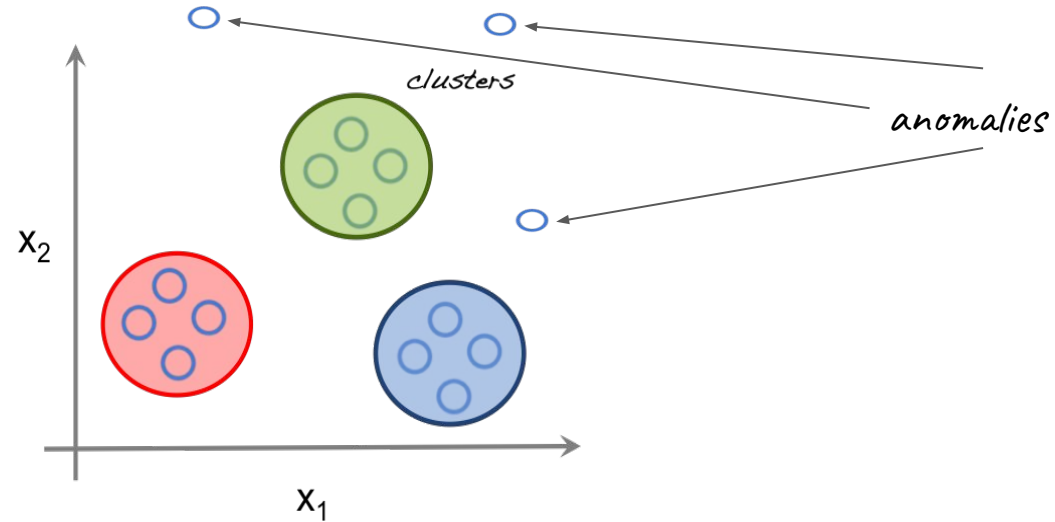


Data sample:

*features*

*Statistically,*

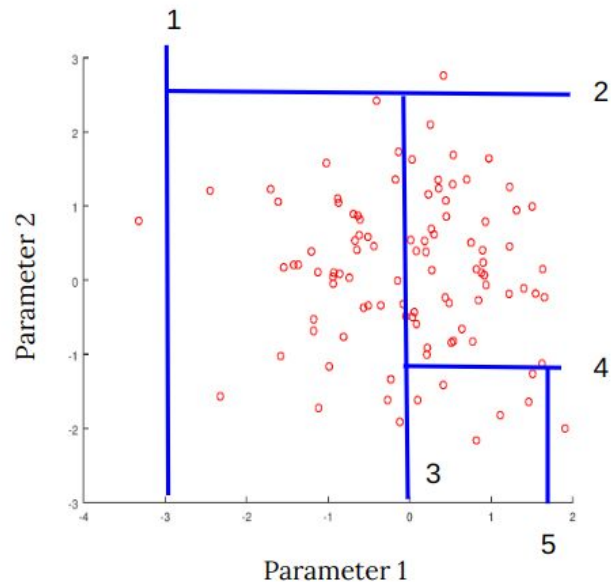
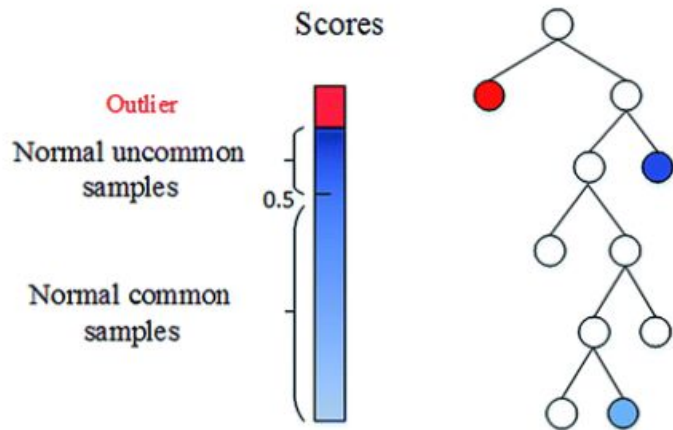
# Anomaly Detection



"An anomaly is an observation which deviates so much from the other observations as to arouse suspicions that it was generated by a different mechanism"

Example of an automatic search for anomalies,

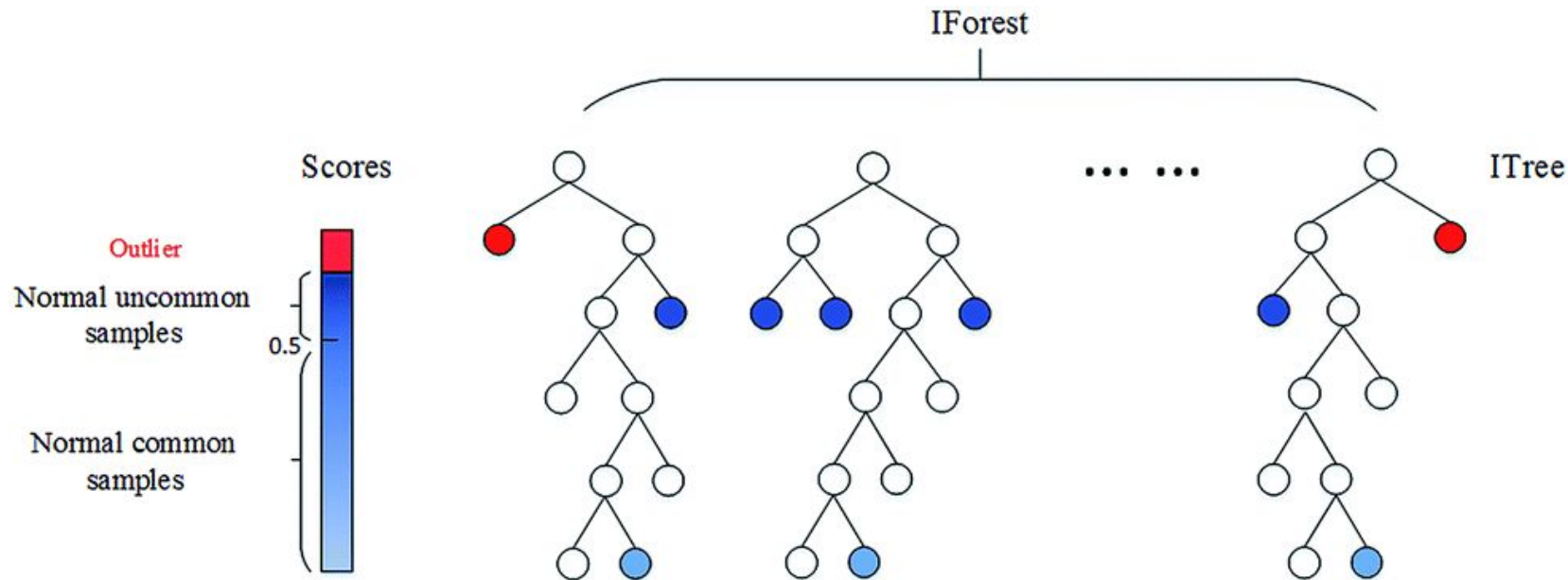
# Isolation tree



Plot from <https://donghwa-kim.github.io/iforest.html>

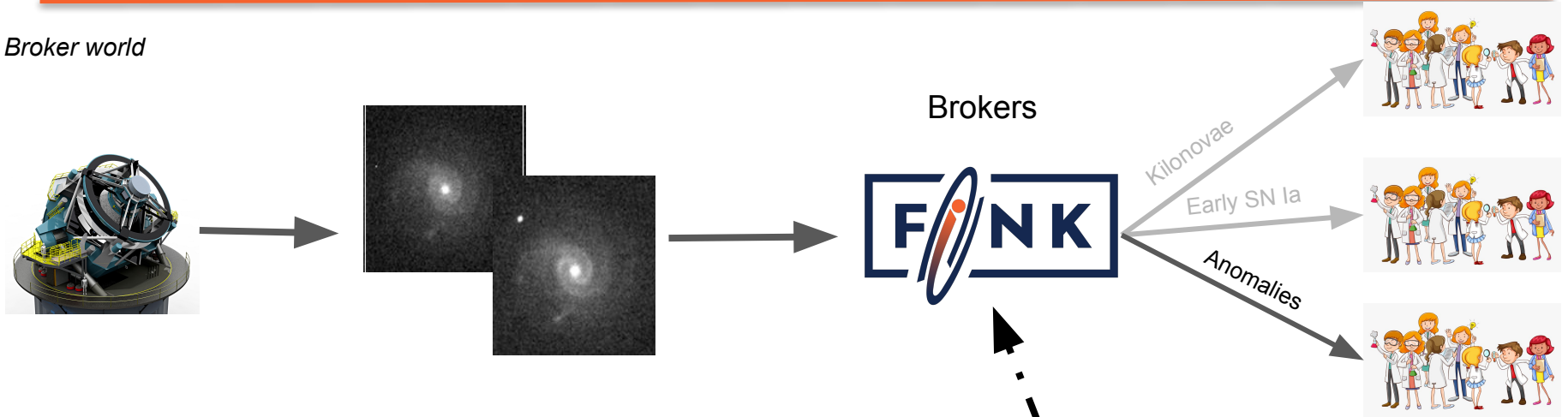
Example of an automatic search for anomalies,

# Isolation forest

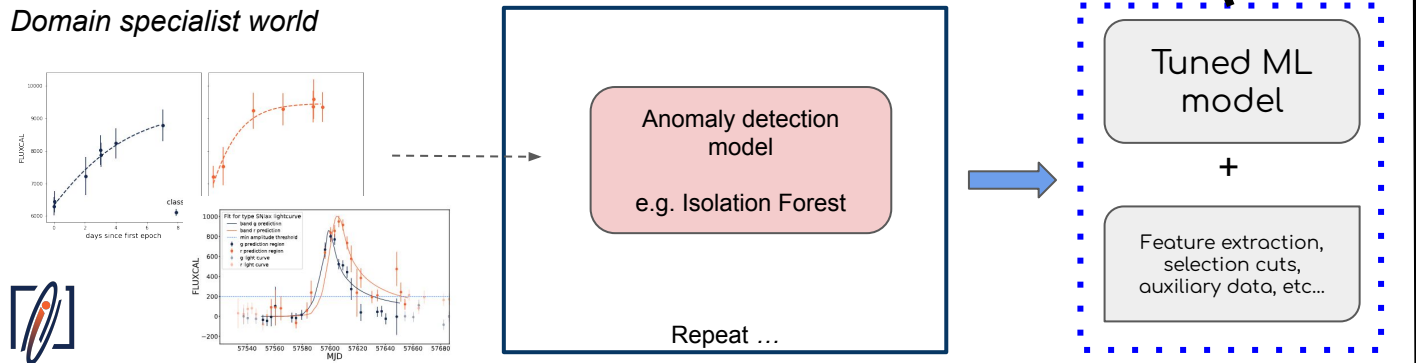


# Back to the broker ...

Broker world

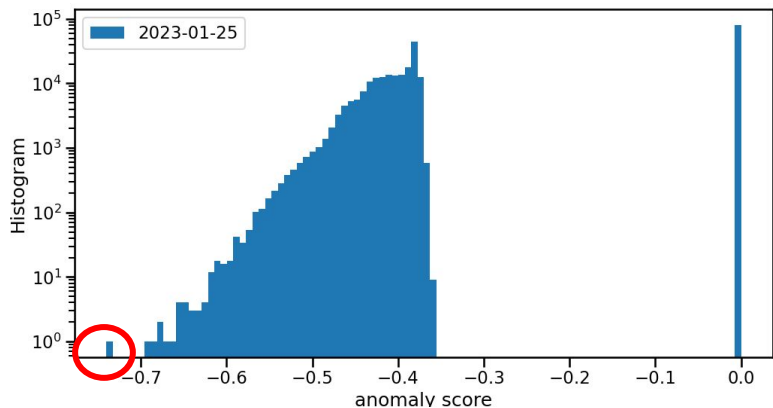


Domain specialist world

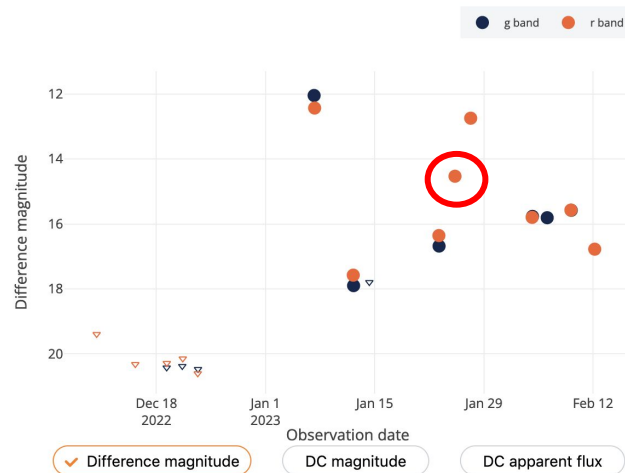


# Anomaly detection in Fink

Small modifications to isolation forest  
1st processing night



Plot by Julien Peloton, algorithm implementation by Igor Beschastnov



<https://fink-portal.org/ZTF23aaaatwl>

Spectroscopic follow-up with multiple telescopes in a matter of a few days. Spectra changes very quickly!

Classification: *AM CVn*, *WZ Sge*-type (?)



# Anomaly Bot



Slack Connect  
More

Channels

- # active-learning
- # adacs-fink
- # agn
- # announcements
- # anomaly\_bot
- # anomaly-detection
- # classifier\_references
- # conferences\_events
- # dashboard
- # deployment
- # dev
- # elastic
- # everyone
- # fast-transients-module
- # fink-general
- # fink-hackathon-2022
- # grb-filter
- # gsoc2019

**anomaly\_bot** APP 4:08 PM  
Median anomaly score overnight: -0.39

ID: ZTF23aamcbjv  
DR OID (<1"): None  
GAL coordinates: 13.066223, 8.144619  
UTC: 2023-05-30 09:01:38.997  
Real bogus: 0.87  
Anomaly score: -0.61

4:08 ID: ZTF18aaynswy  
DR OID (<1"): 539101400007596  
GAL coordinates: 42.964791, -1.053742  
UTC: 2023-05-30 09:41:07.998  
Real bogus: 0.84  
Anomaly score: -0.64

ID: ZTF18abijuhx  
DR OID (<1"): 538102100079556  
GAL coordinates: 39.870803, 7.074541  
UTC: 2023-05-30 09:43:52.003  
Real bogus: 0.9  
Anomaly score: -0.64

ID: ZTF18abecmdq  
DR OID (<1"): 385116100152594  
GAL coordinates: 28.384657, -4.849832  
UTC: 2023-05-30 09:34:17.996  
Real bogus: 0.74  
Anomaly score: -0.61

The screenshot shows the ZTF23aamcbjv alert page. It includes a header with the object name and classification (Kilonova candidate, SN candidate, Unknown). Below this is a discovery date, last detection, and number of detections. A central plot shows the difference magnitude over time from April 30 to May 28, 2023. The plot has two data series: g band (blue dots) and r band (red dots). The y-axis ranges from 17 to 21, and the x-axis shows observation dates. A legend indicates the individual alert classification: Kilonova candidate: 14%, SN candidate: 43%, Unknown: 43%. On the right side, there are several interactive elements: 'Last alert cutouts' with three circular thumbnails, 'Coordinates', 'Last alert content', 'Download data', 'Other brokers', 'Neighbourhood', and 'Share'.

# It is about Discovery

“An anomaly is an observation which deviates so much from the other observations as to arouse suspicions that it was generated by a different mechanism”

Stages of discovery in astronomy:

- Detection
- Interpretation
- Understanding
- Acceptance

Which mechanism?  
Is it something we are familiar with but fail to proper model or recognise?  
Is it something we have never seen before?  
*Is there something new for us to Learn?*

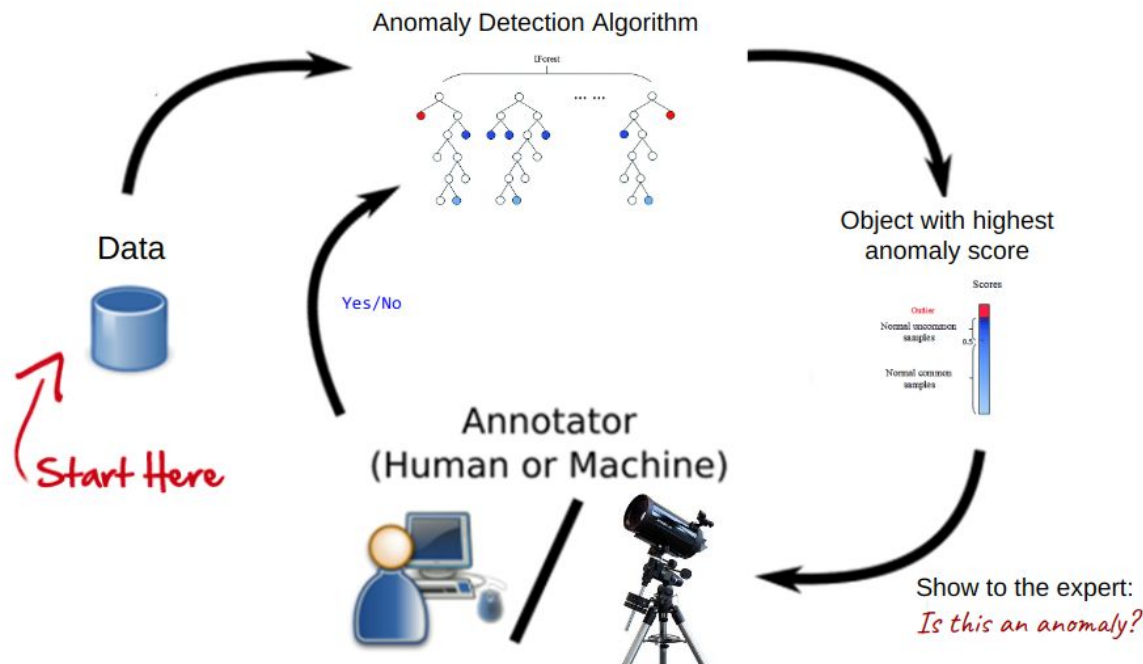


*In order to identify the unusual we need to have a clear ideal of what is usual ...*

*.. and that is a social construct. It changes and adapts with time!*



# Active Anomaly Detection



Plot modified from [Chowdhury et al., 2021, SPIE Medical Imaging](#)

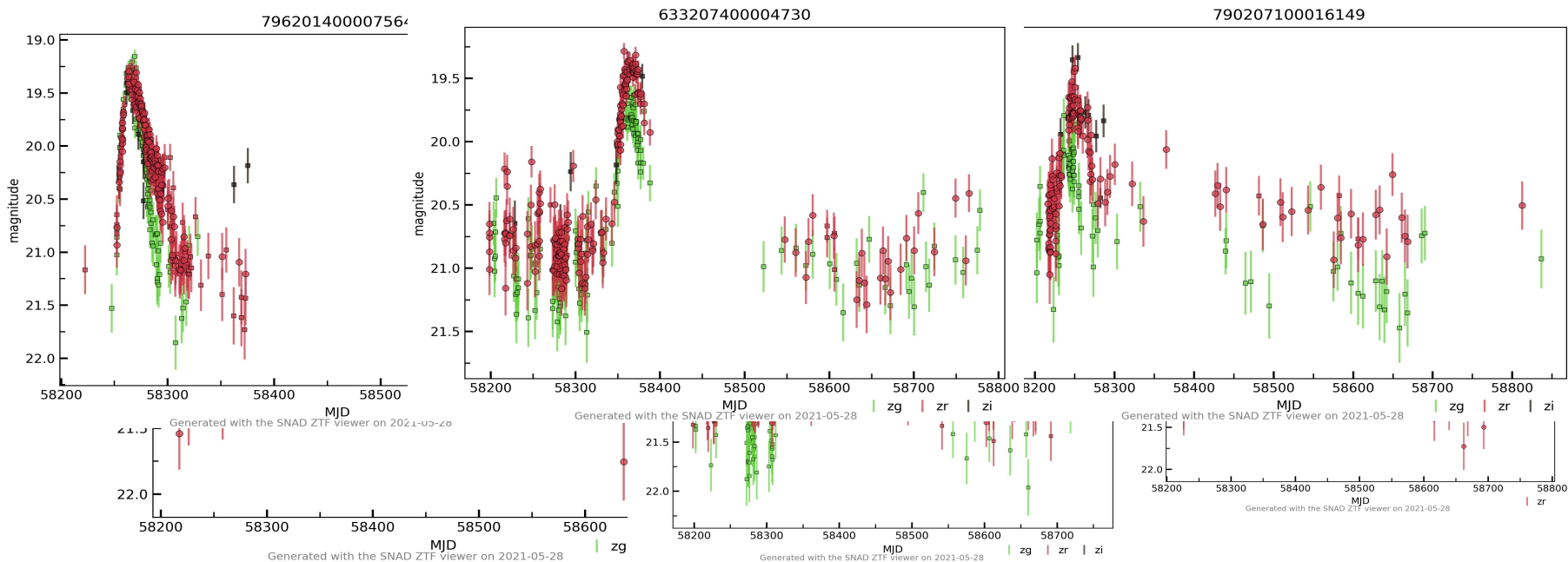
Algorithm from Das, S., et al., 2017, in Workshop on Interactive Data Exploration and Analytics (IDEA'17), KDD workshop, [arXiv:cs.LG/1708.09441](#)

Try the SNAD implementation: <https://coniferest.readthedocs.io/en/latest/quickstart.html>

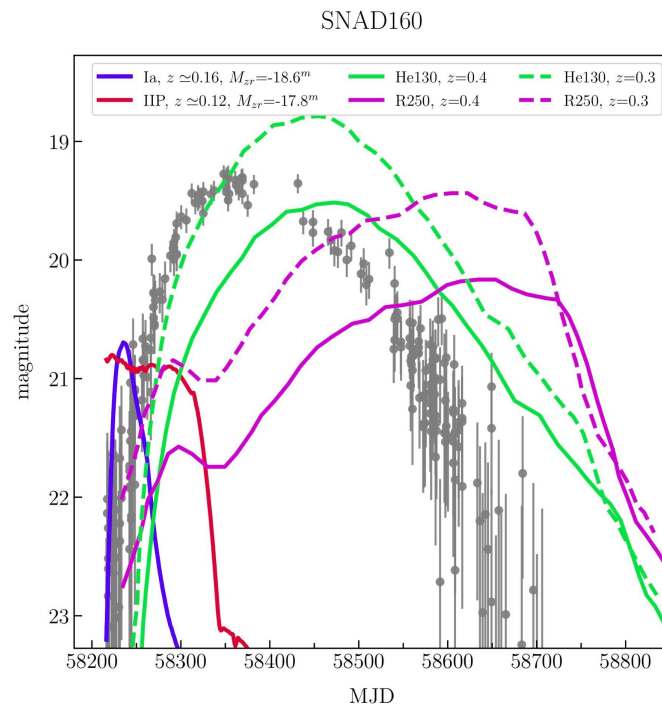
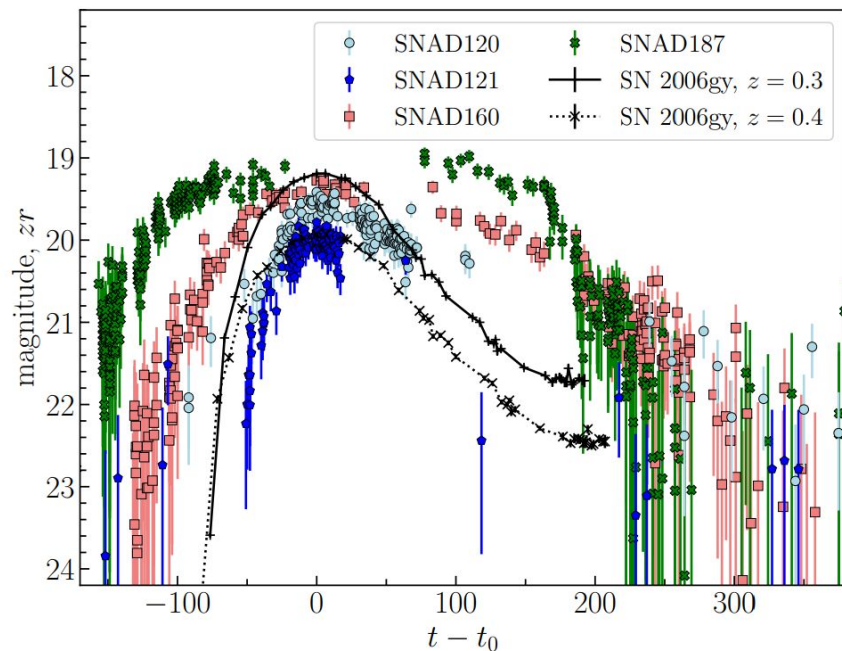
# AAD on real data: ZTF data releases

*“There should be no supernova-like objects in ZTF DR”*

*Basically everyone to whom we mentioned we were looking for them.*



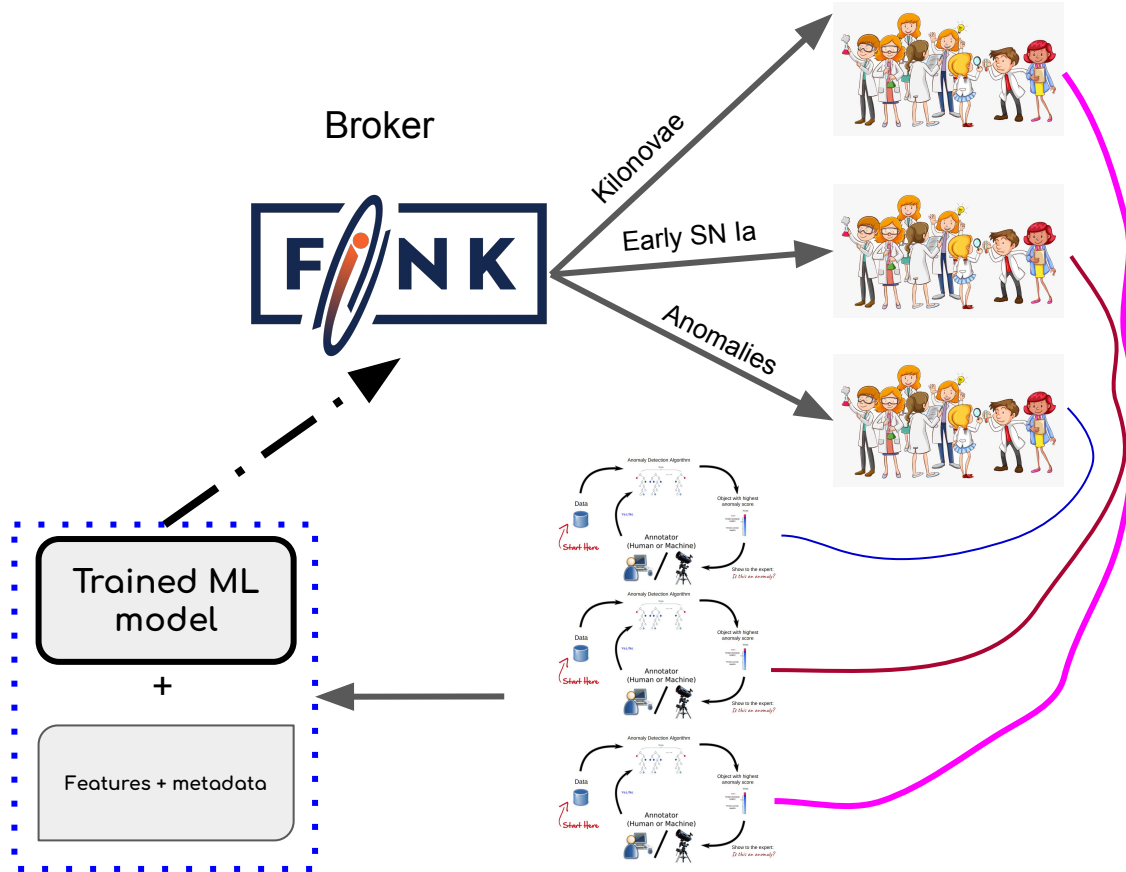
# Interesting SLSN candidates



# The dream ...

**Active anomaly  
discovery**  
*in the alert stream*

**For *personalized*  
anomaly detection models**



# Explore the boundaries of your knowledge

- In the era of Rubin, serendipitous discoveries will not happen
- Domain experts **must be included** in the development of new techniques **from the first stages**. They should supervise the first prototypes.

It is crucial to know what you want

# Explore the boundaries of your knowledge

- In the era of Rubin, serendipitous discoveries will not happen
- Domain experts **must be included** in the development of new techniques **from the first stages**. They should supervise the first prototypes.

It is crucial to know what you want

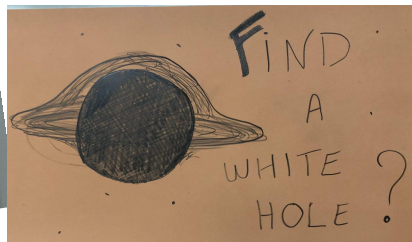
**FinkBR** -- collaboration meeting at CBPF, Rio - May/2024 !





# #FinkDreamShots

Build a catalogue  
of interstellar asteroids



A classifier  
for tidal disruption  
events

I WANT TO  
FIND A  
DYSON  
SPHERE



I WANT TO  
FIND A LIVE  
PISN

~~I wish astronomers~~  
~~use REAL units!~~  
A switch between  
mag. and Lum.

What do you want  
to see?

**THANK**

**YOU**

