FROM ZTF TO LSST | AMPEL

Mickael RIGAULT | CLERMONT | 3RD OF JUNE 2019

mickael.rigault@clermont.in2p3.fr

This project has received funding from the European Research Council (ERC) under the European Union's Horizon 2020 research and innovation programme (grant agreement n°759194 - USNAC)

“This is the most well thought out version of an event stream I've seen to date”

- AMPEL paper referee report

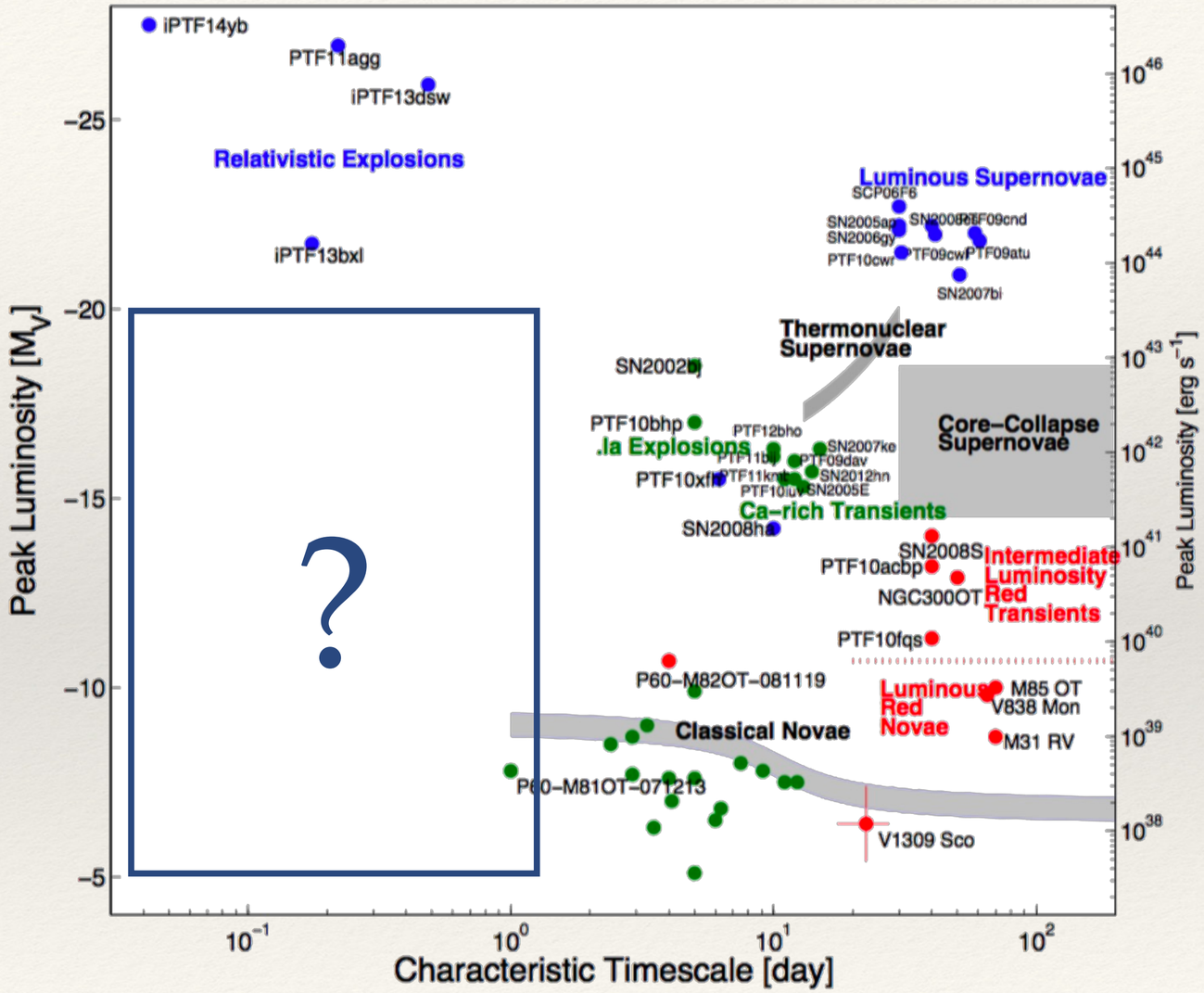
ZTF | Fast *(30s exp.)*, Large *(full visible sky)* *[Not Deep]*

We have about 10^5 events/night ; 10% of LSST

Some **ZTF Science Cases**

Transients Astro.

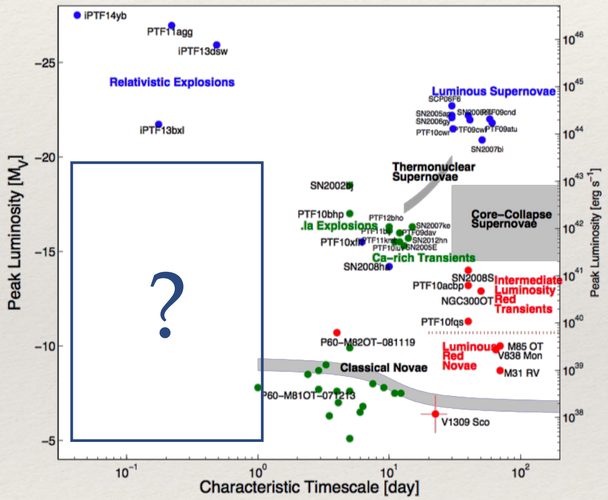
Flash Spectroscopy



Some **ZTF Science Cases**

Transients Astro.

Flash Spectroscopy

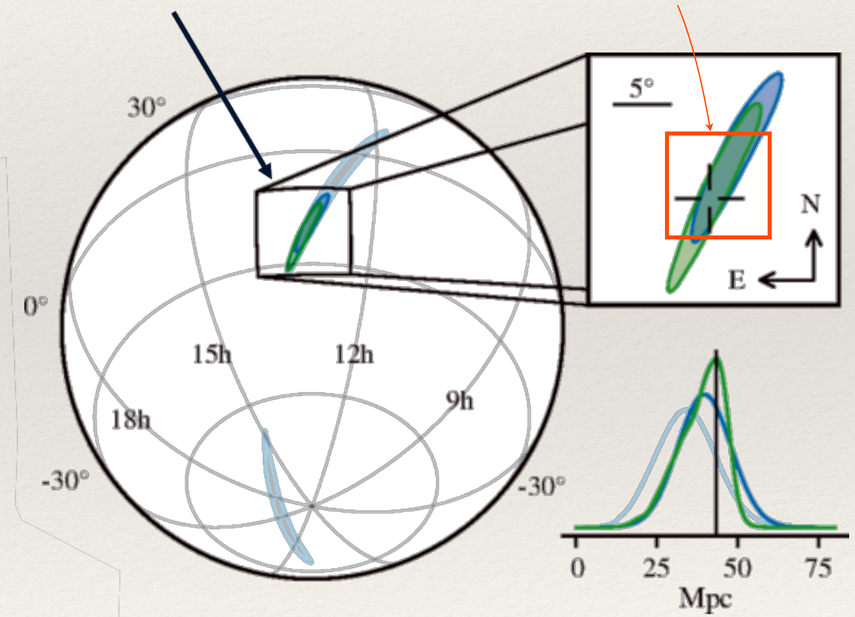


Multi-Messengers

GW & Neutrinos

Localization of GW170817 was smaller than ZTF FoV

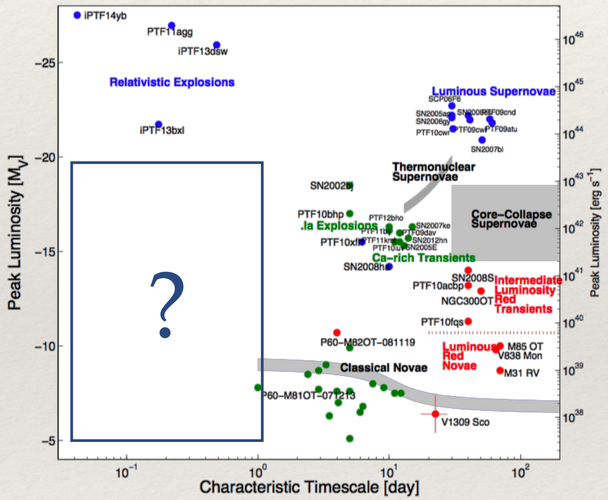
ZTF



Abbot et al. (2017), PRL 119, 161101

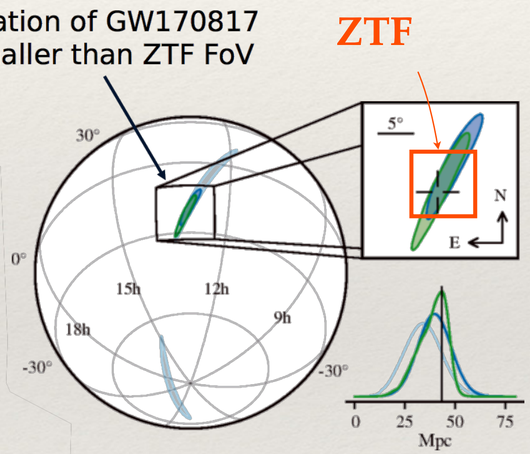
Some **ZTF Science Cases**

Transients Astro.
Flash Spectroscopy



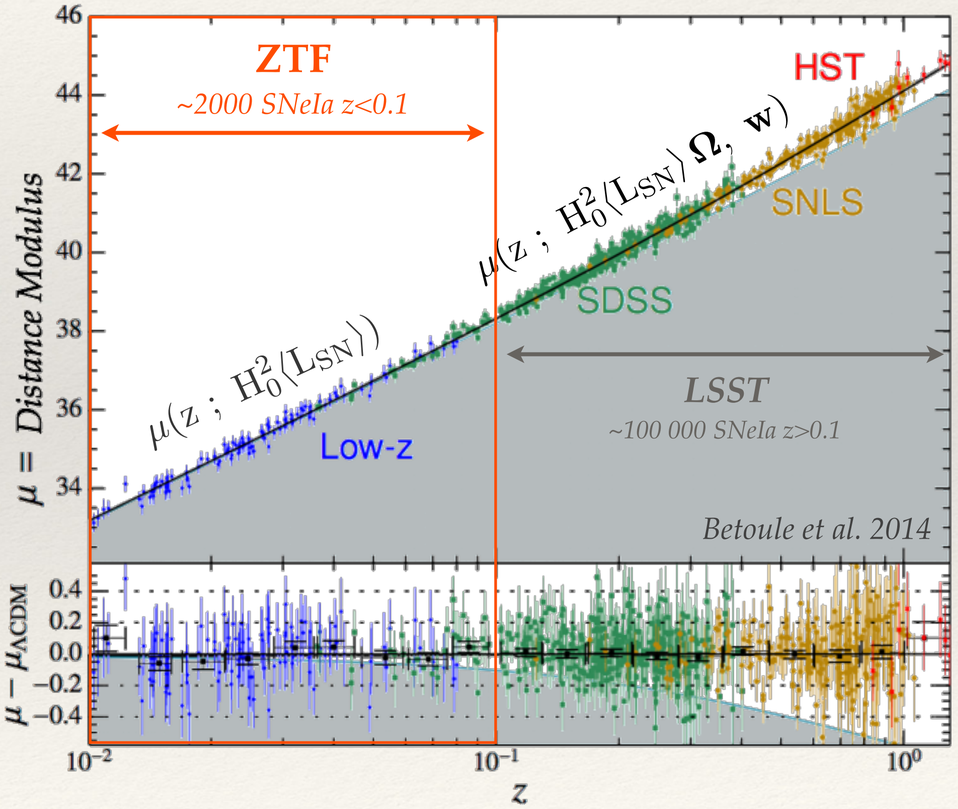
Multi-Messengers
GW & Neutrinos

Localization of GW170817 was smaller than ZTF FoV



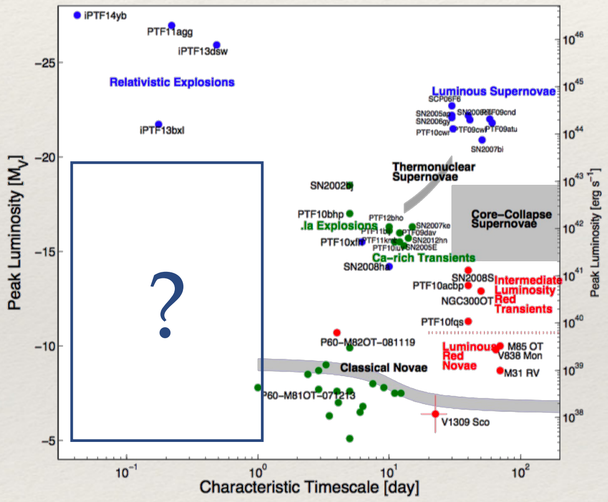
Abbot et al. (2017), PRL 119, 161101

Supernova Cosmology
Incl. Strongly lensed SNeIa

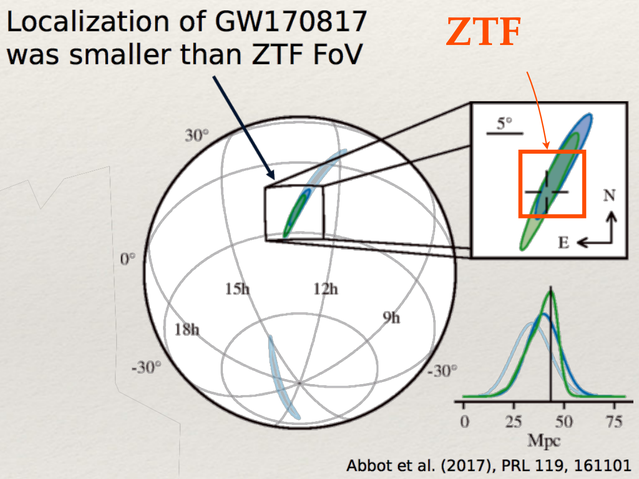


ZTF *Science Cases* ~ **LSST** *Science Cases*

Transients Astro.
Flash Spectroscopy

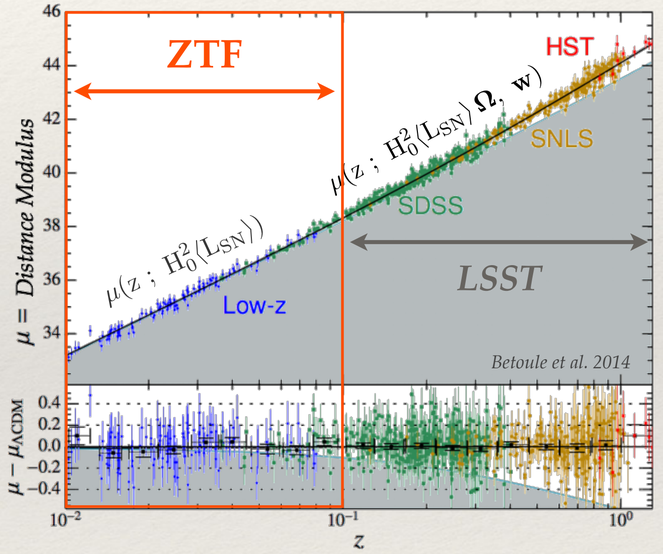


Multi-Messengers
GW & Neutrinos



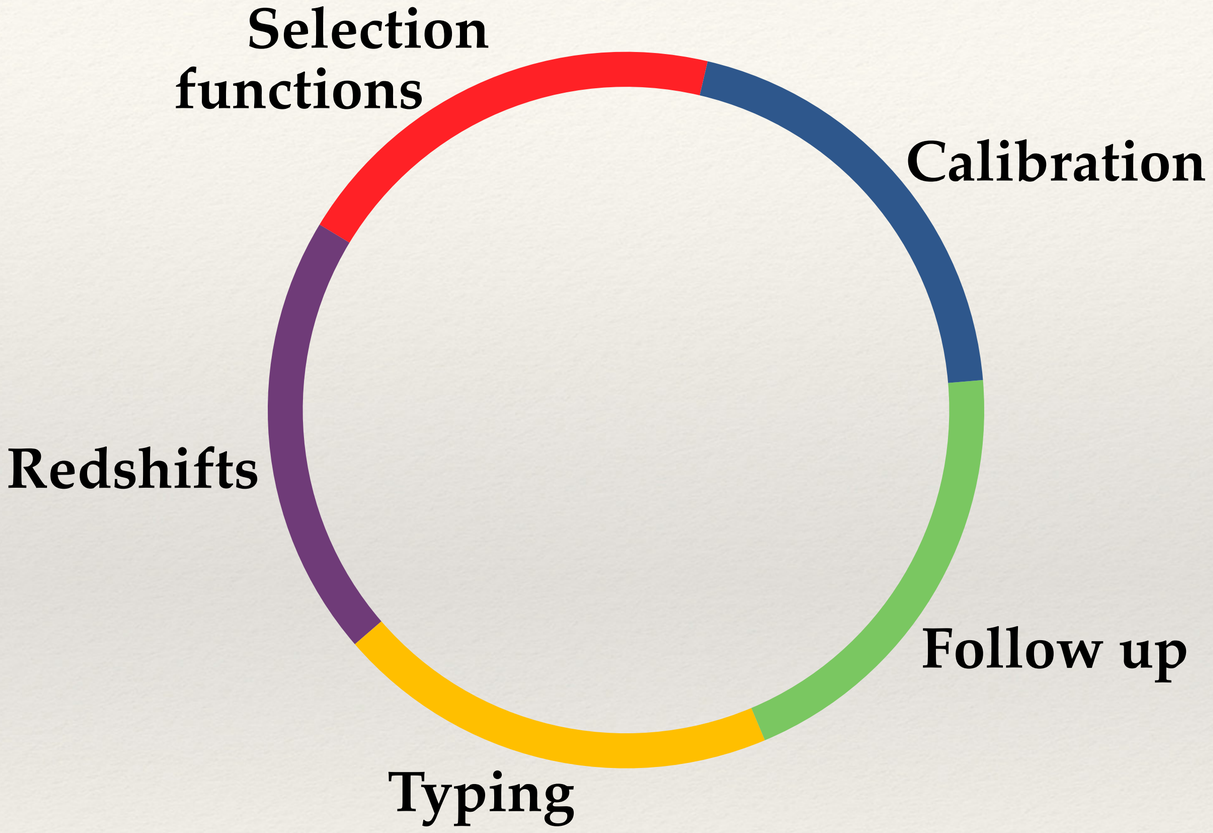
Abbot et al. (2017), PRL 119, 161101

Supernova Cosmology
Incl. Strongly lensed SNeIa



Tidal Disruption Events | Stellar Astrophysics | Solar System Bodies

Key Survey Challenges

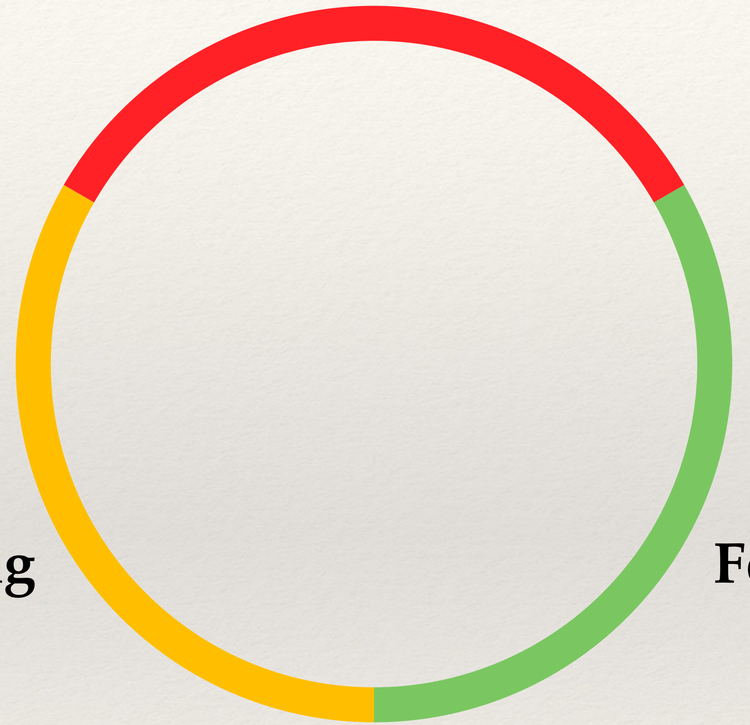


Key *Timely* Survey Challenges

~~*Calibration*~~

~~*Redshifts*~~

Selection functions



Typing

Follow up

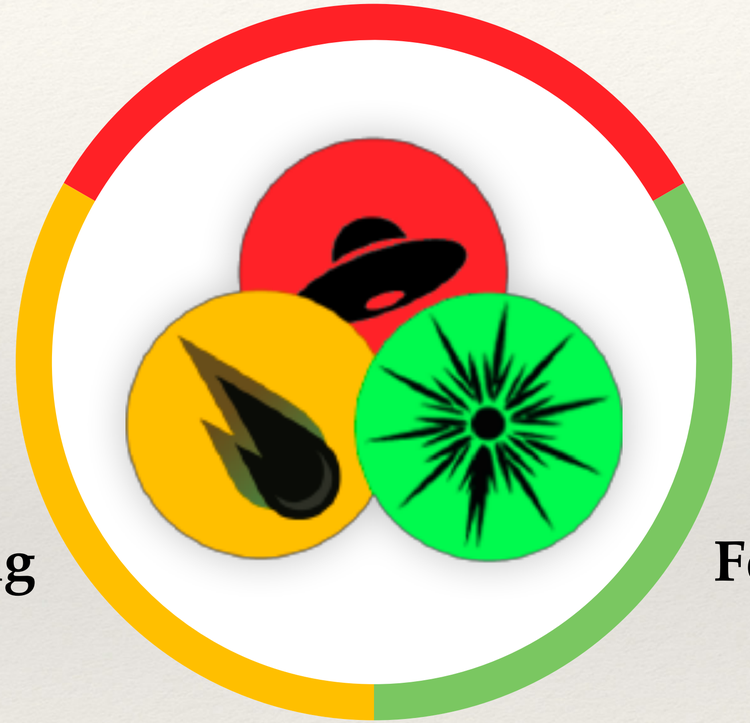
Time Sensitive Survey Challenges

Nordin et al. 2019

~~*Calibration*~~

Selection functions

~~*Redshifts*~~



Typing

Follow up

— AMPEL —

***A**lert **M**anagement, **P**hotometry and **E**valuation of **L**ightcurves*

AMPEL | Process Flow

Survey pipeline creates Alerts → *UW provides an alert stream (UW)*

Filtering
Which alerts are likely to match your interest?

MongoDB
Converts alerts into a transient

(ok for both ZTF and LSST)

Compute derived information
What do you want to know about the transient?

Make Decision
What do you want to do about it ?

AMPEL | Process Flow

Survey pipeline creates Alerts → *UW provides an alert stream (UW)*

T0

Filtering

Which alerts are likely to match your interest?

T1

MongoDB

Converts alerts into a transient

(ok for both ZTF and LSST)

T2

Compute derived information

What do you want to know about the transient?

T3

Make Decision

What do you want to do about it ?

AMPEL | Process Flow *Examples* SNeIa

Survey pipeline creates Alerts → *UW provides an alert stream (UW)*

T0

Filtering

All that have at least 2 rising points in 2 bands

T1

MongoDB

Converts alerts into a transient (already exist?)

T2

Machine learning

Compute derived information

SALT2 parameters | Host Properties (z) | Probability to be a « Ia »

T3

Active learning

Make Decision

If at max, trigger spectrograph | if odd, trigger spectrograph

*push LC on Slack | email Mickael about it | **Publish on TNS***

AMPEL | Process Flow *Examples* GW

Survey pipeline creates Alerts → *UW provides an alert stream (UW)*

T0

Filtering

All alerts in this sky-area from the last 12 hours

T1

MongoDB

Converts alerts into a transient (already exist?)

T2

Machine learning

Compute derived information

Host Properties (z) | ***Could it be a real transient ?*** | ***P(Kilonova)***

T3

Active learning

Make Decision

If real, trigger spectrograph & Photometric follow up

push LC on Slack | *email everyone !!!* | ***Publish a GCN/LVS Notice***

AMPEL

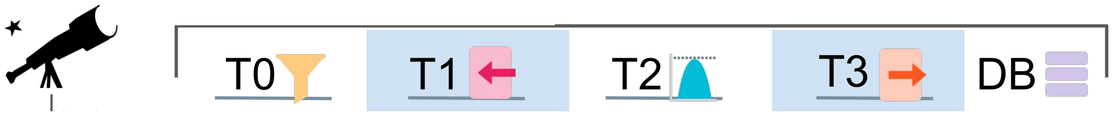
How it works for users: Channel

Channel

T0 filter(s)
Input: alerts | Output: boolean

T2 Science Modules to run
Input: T1 Transient | Output: dict

T3 Action Modules to launch
Input: T1 Transient(s) | Output: logs



AMPEL

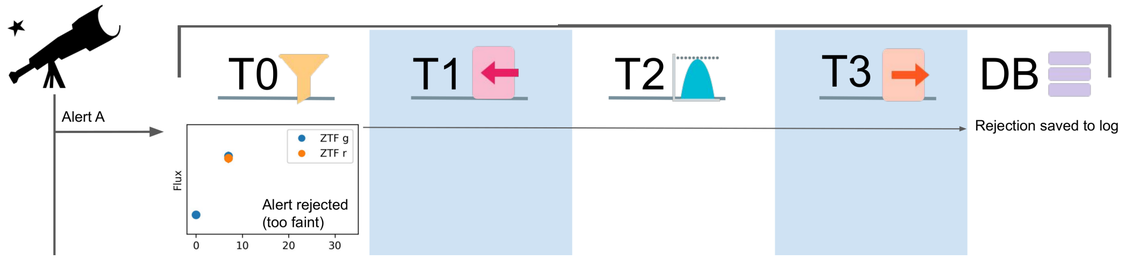
How it works for users: Channel

Channel

T0 filter(s)
Input: alerts | Output: boolean

T2 Science Modules to run
Input: T1 Transient | Output: dict

T3 Action Modules to launch
Input: T1 Transient(s) | Output: logs



Time

AMPEL

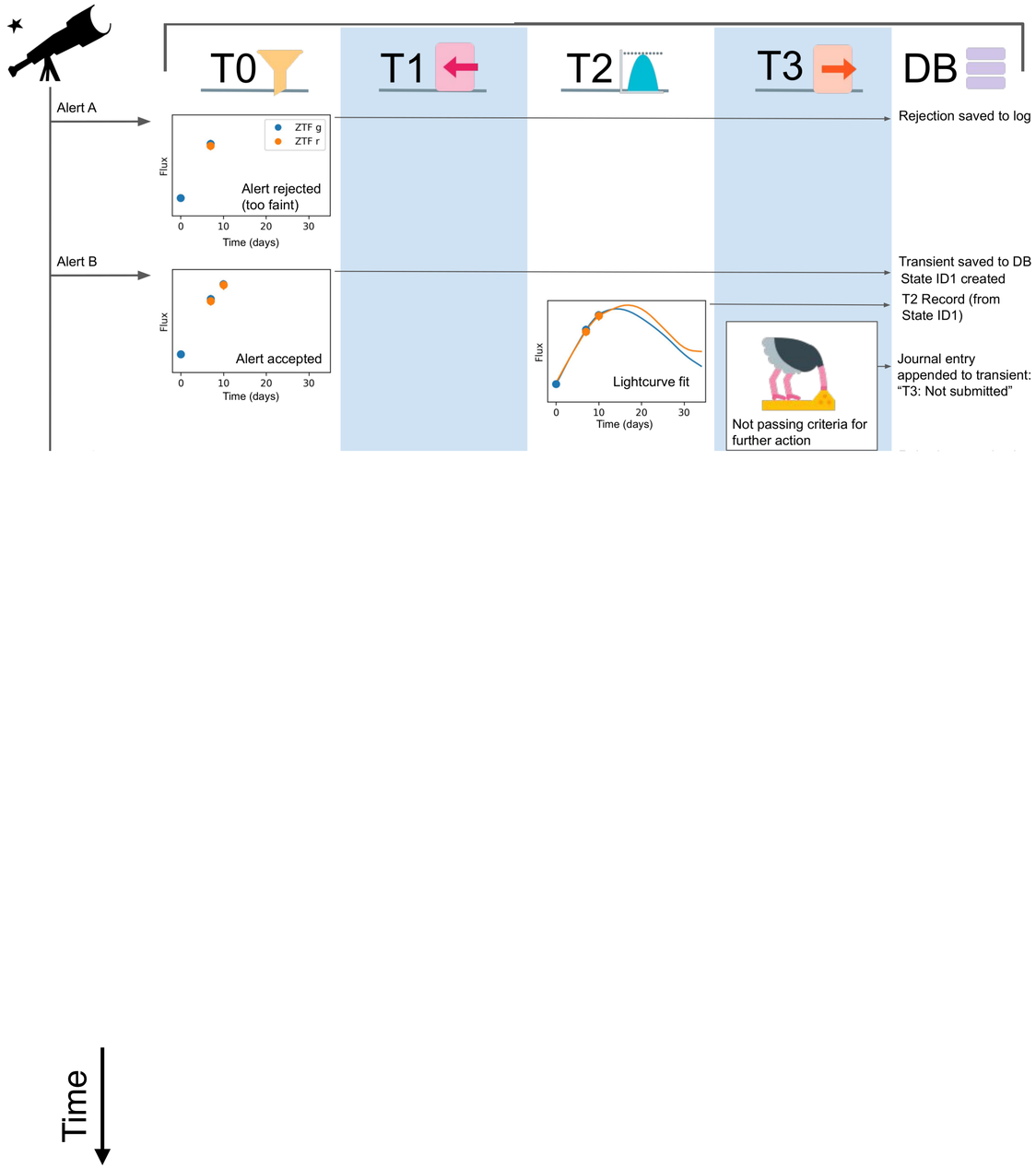
How it works for users: Channel

Channel

T0 filter(s)
Input: alerts | Output: boolean

T2 Science Modules to run
Input: T1 Transient | Output: dict

T3 Action Modules to launch
Input: T1 Transient(s) | Output: logs



AMPEL

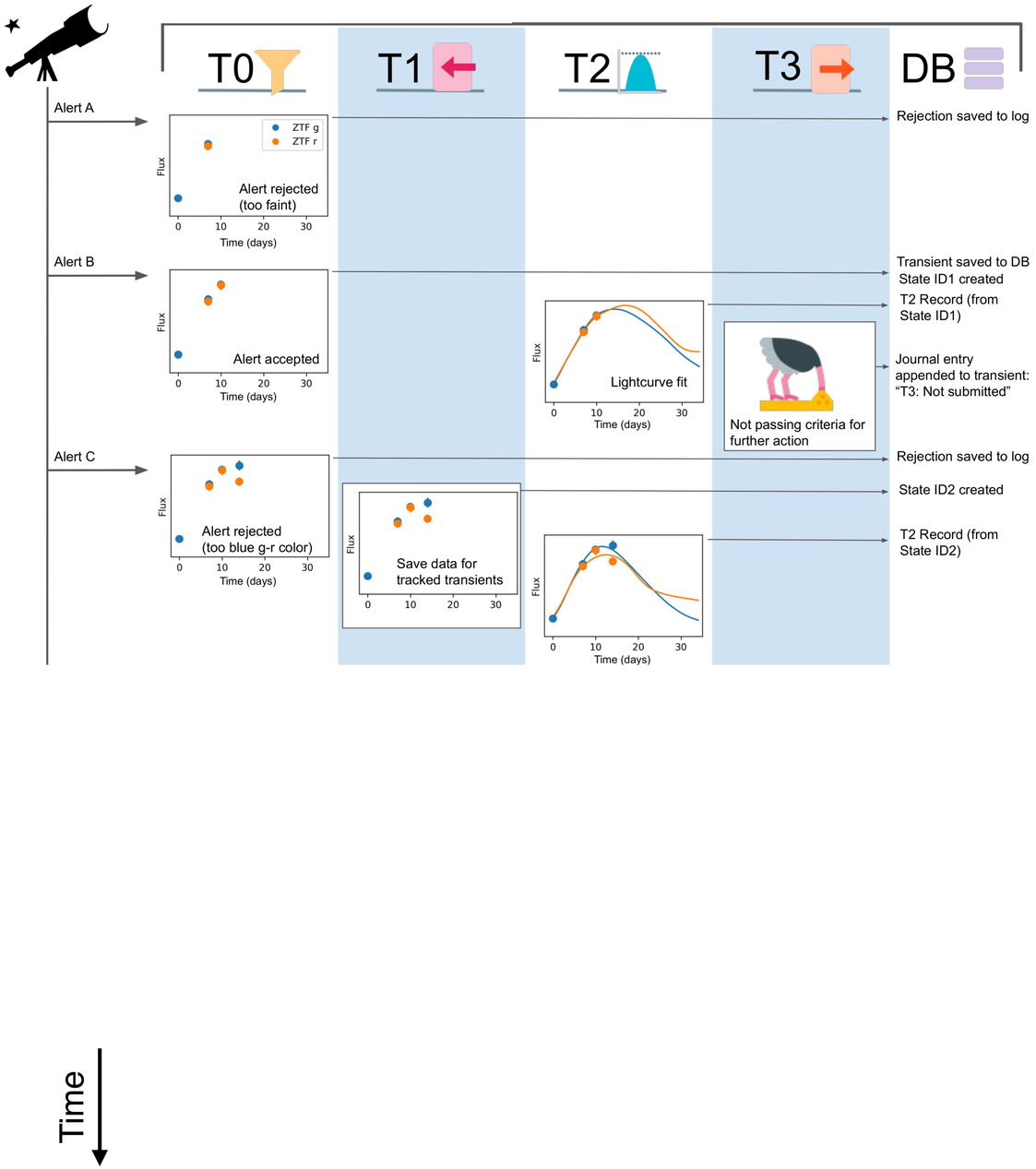
How it works for users: Channel

Channel

T0 filter(s)
Input: alerts | Output: boolean

T2 Science Modules to run
Input: T1 Transient | Output: dict

T3 Action Modules to launch
Input: T1 Transient(s) | Output: logs



AMPEL

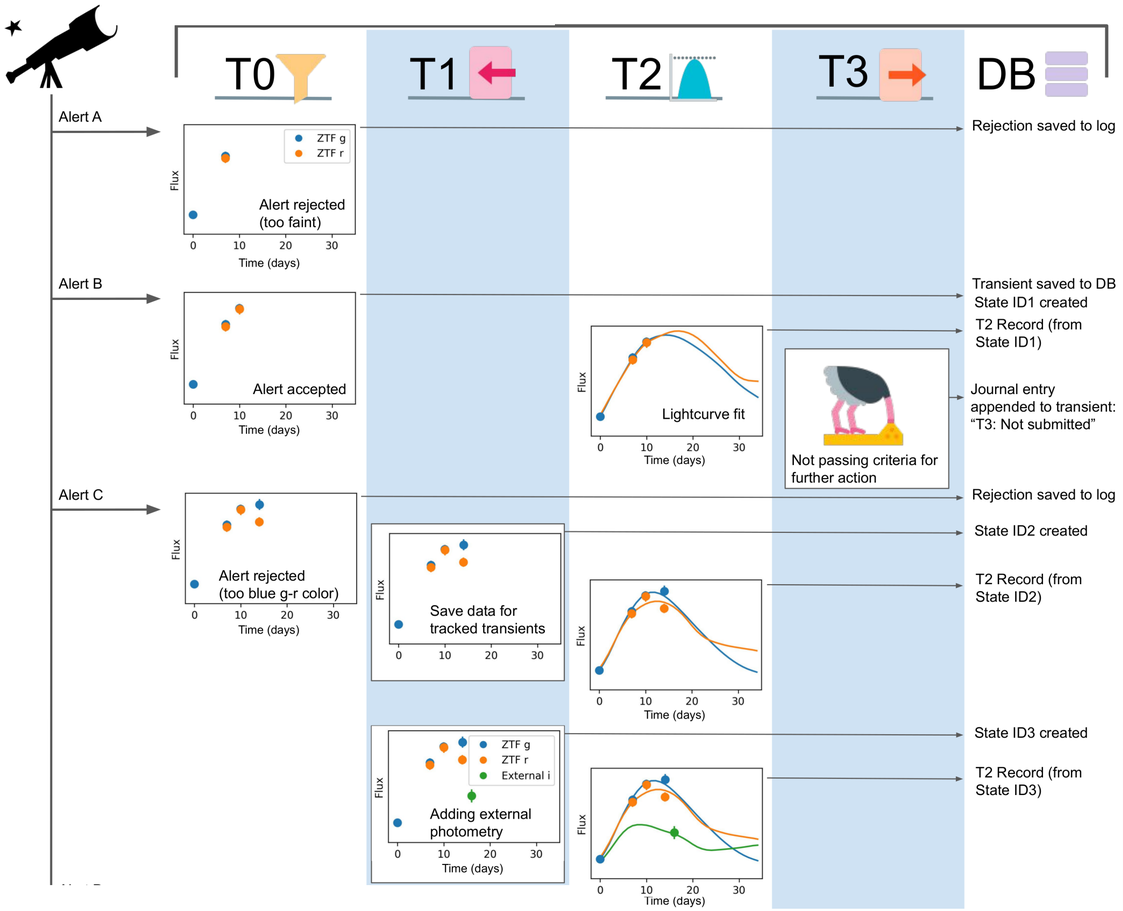
How it works for users: Channel

Channel

T0 filter(s)
Input: alerts | Output: boolean

T2 Science Modules to run
Input: T1 Transient | Output: dict

T3 Action Modules to launch
Input: T1 Transient(s) | Output: logs



AMPEL

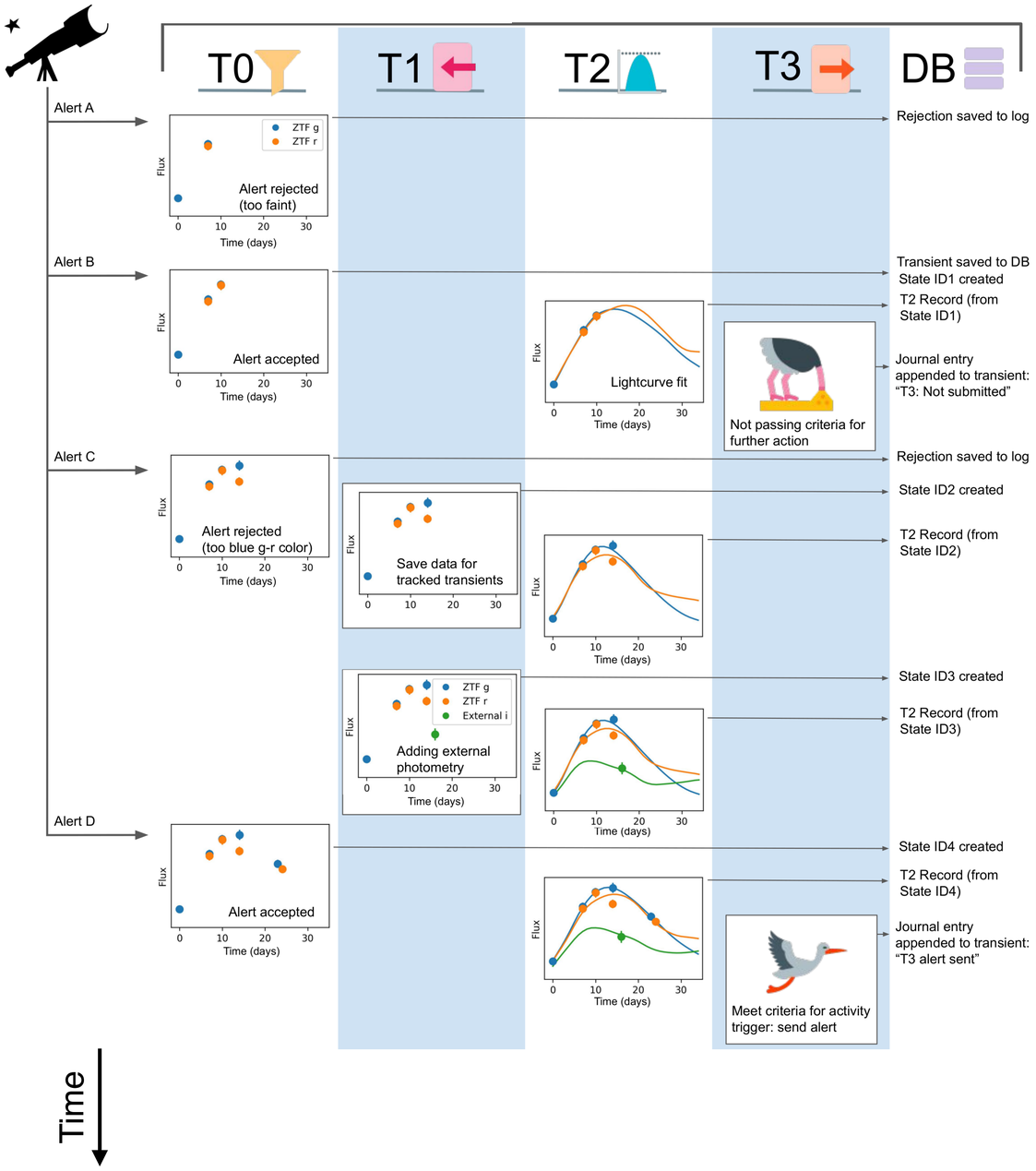
How it works for users: Channel

Channel

T0 filter(s)
Input: alerts | Output: boolean

T2 Science Modules to run
Input: T1 Transient | Output: dict

T3 Action Modules to launch
Input: T1 Transient(s) | Output: logs



AMPEL

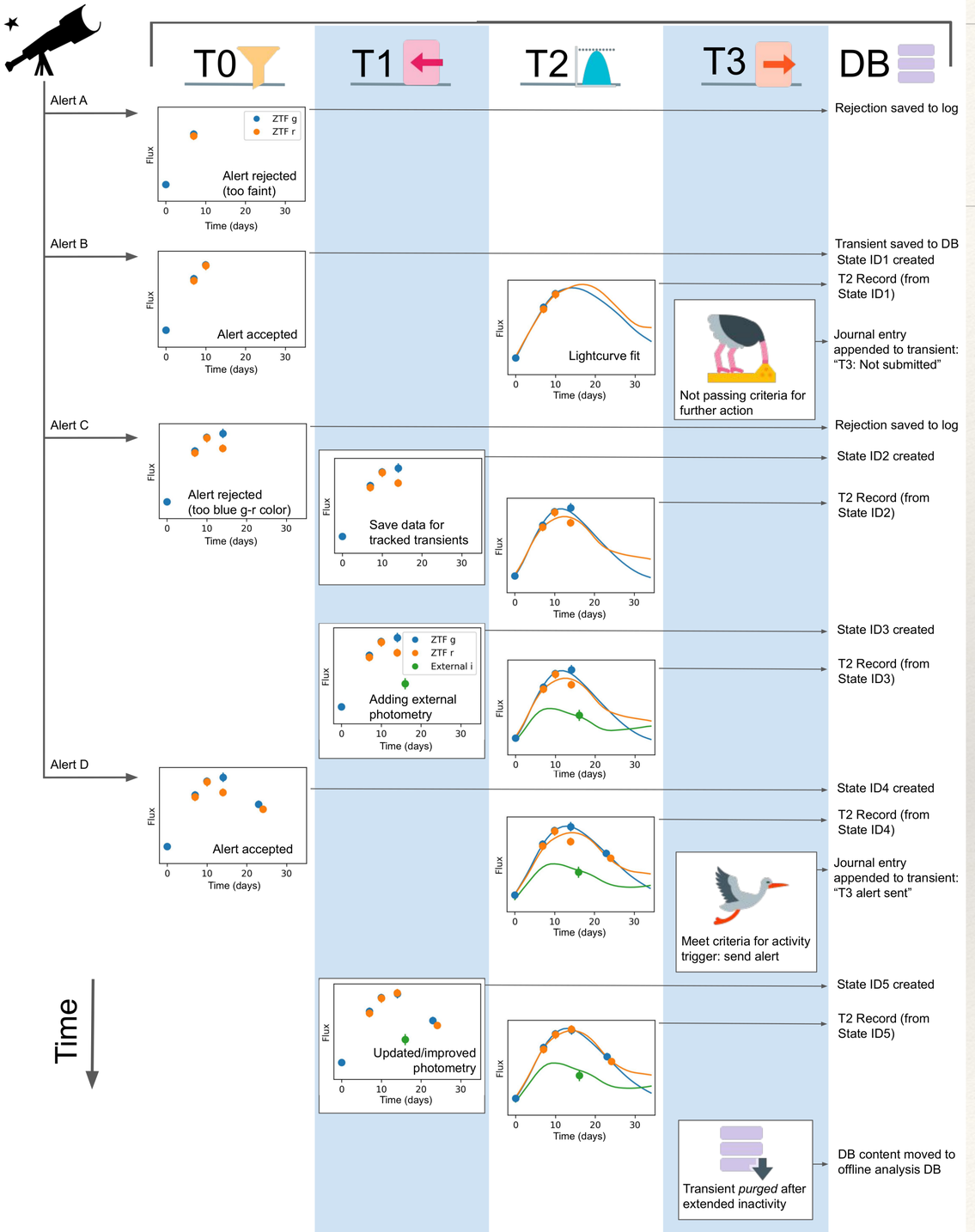
How it works for users: Channel

Channel

T0 filter(s)
Input: alerts | Output: boolean

T2 Science Modules to run
Input: T1 Transient | Output: dict

T3 Action Modules to launch
Input: T1 Transient(s) | Output: logs



AMPEL

How it works for users: Channel

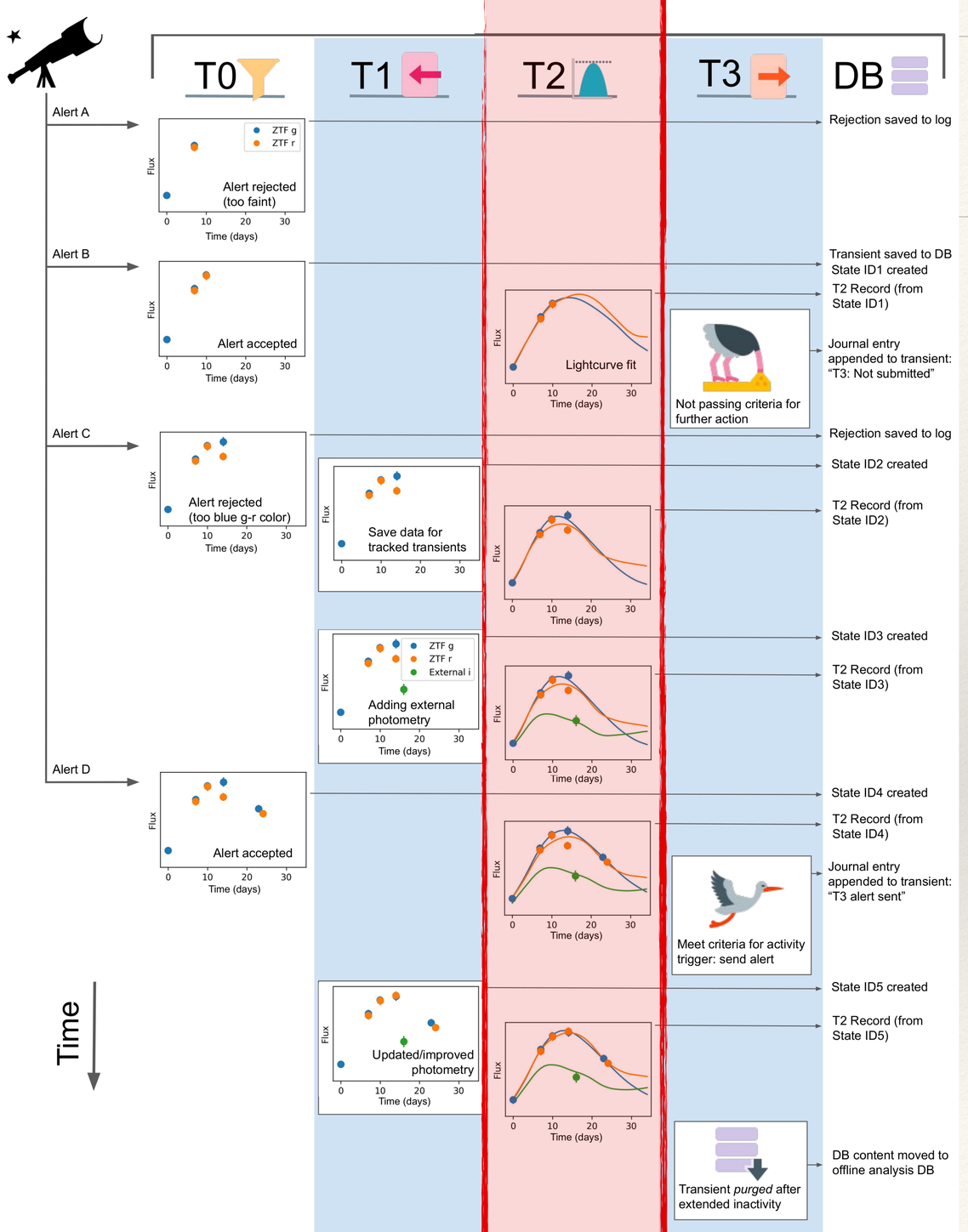
Channel

T0 filter(s)
Input: alerts | Output: boolean

T2 Science Modules to run
Input: T1 Transient | Output: dict

Host Properties

T3 Action Modules to launch
Input: T1 Transient(s) | Output: logs



Host Identification for ZTF SNe Ia

Young-Lo KIM (CNRS/IN2P3/IPNL)

Why Host Galaxy?

Host Identification:
host galaxy and host redshift (if it has)

Why Host Galaxy?

Host Identification:
host galaxy and host redshift (if it has)

To improve a photometric classification of SNe and the Hubble diagram

Why Host Galaxy?

Host Identification:
host galaxy and host redshift (if it has)

To improve a photometric classification of SNe and the Hubble diagram

host photometry data

Measuring Host Properties:
Mass and SFR of host galaxy
(which have a correlation with SN Ia luminosity)

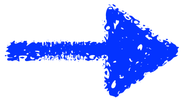
Why Host Galaxy?

Host Identification:
host galaxy and host redshift (if it has)

To improve a photometric classification of SNe and the Hubble diagram

host photometry data

Measuring Host Properties:
Mass and SFR of host galaxy
(which have a correlation with SN Ia luminosity)



To improve the SN cosmology

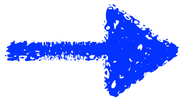
Why Host Galaxy?

Host Identification:
host galaxy and host redshift (if it has)

To improve a photometric classification of SNe and the Hubble diagram

host photometry data

Measuring Host Properties:
Mass and SFR of host galaxy
(which have a correlation with SN Ia luminosity)



To improve the SN cosmology

The reliable host identification is crucial for SN study!

Host Galaxy Identification

-DLR method-

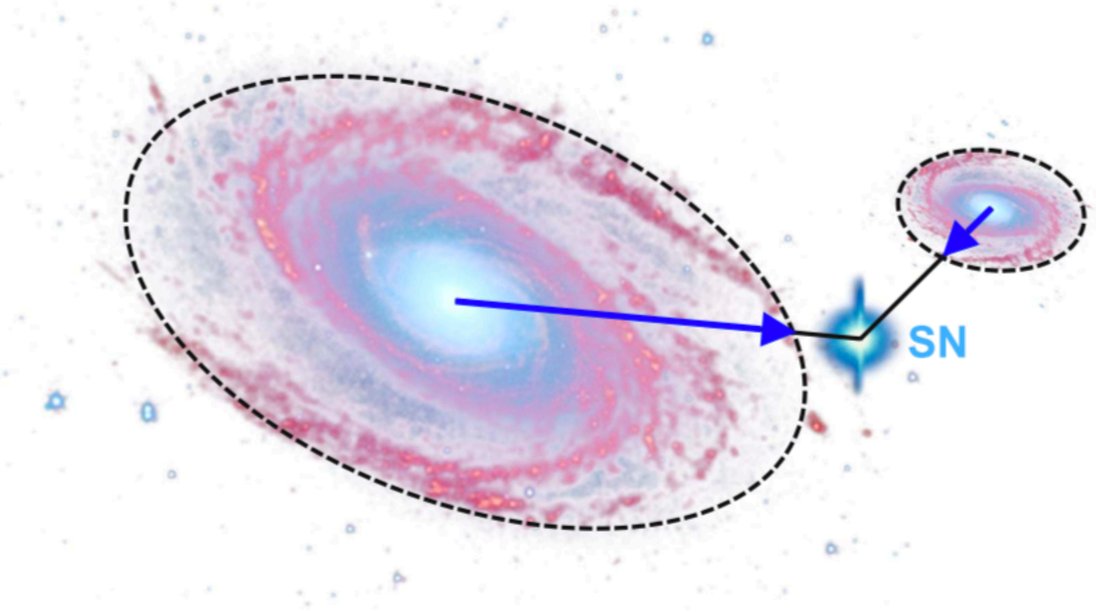


Figure 1. Illustrated example of the problem of host galaxy identification. The

Gupta+2016

DLR (Directional Light Radius):
the elliptical radius of a galaxy in the direction of the SN in units of arcsecond, roughly the galaxy size (Sullivan+2006, Sako+2014, Gupta+2016).

$$d_{\mathrm{DLR}} = \frac{\text{SN-galaxy angular separation (arcsec)}}{\text{DLR (arcsec)}}.$$

DLR Method

$$R_{\rm gal}^2 = C_{xx}(x_{\rm SN} - x_{\rm gal})^2 + C_{yy}(y_{\rm SN} - y_{\rm gal})^2 + C_{xy}(x_{\rm SN} - x_{\rm gal})(y_{\rm SN} - y_{\rm gal}), \quad (6.1)$$

$$C_{xx} = \cos^2(\theta)/r_A^2 + \sin^2(\theta)/r_B^2 \quad (6.2)$$

$$C_{yy} = \sin^2(\theta)/r_A^2 + \cos^2(\theta)/r_B^2 \quad (6.3)$$

$$C_{xy} = 2\cos(\theta)\sin(\theta)(1/r_A^2 + 1/r_B^2), \quad (6.4)$$

r_A: semimajor axis, r_B: semiminor axis, θ: position angle

Sullivan+2006, Dimitriadis-PhD Thesis.

DLR Method

$$R^2_{\rm gal} = C_{xx}(x_{\rm SN} - x_{\rm gal})^2 + C_{yy}(y_{\rm SN} - y_{\rm gal})^2 + C_{xy}(x_{\rm SN} - x_{\rm gal})(y_{\rm SN} - y_{\rm gal}), \quad (6.1)$$

$$C_{xx} = \cos^2(\theta)/r_A^2 + \sin^2(\theta)/r_B^2 \quad (6.2)$$

$$C_{yy} = \sin^2(\theta)/r_A^2 + \cos^2(\theta)/r_B^2 \quad (6.3)$$

$$C_{xy} = 2\cos(\theta)\sin(\theta)(1/r_A^2 + 1/r_B^2), \quad (6.4)$$

r_A: semimajor axis, r_B: semiminor axis, θ: position angle

Sullivan+2006, Dimitriadis-PhD Thesis.

DLR Method

SDSS D/B

$$\theta = \frac{\arctan(u/q)}{2},$$

Stokes parameters (for the ellipticity)

$Q = M_{xx} - M_{yy} = [(a-b)/(a+b)] \times \cos 2\varphi$

$U = M_{xy} = [(a-b)/(a+b)] \times \sin 2\varphi$

r_A = the Petrosian radius

2 x petroR50_r

$$r_B = r_A \left(\frac{\sin 2\theta - u}{\sin 2\theta + u} \right)$$

Dimitriadis-PhD Thesis.

Host Identification for ZTF SNe Ia

ZTF SNe Ia
586

Host Identification for ZTF SNe Ia

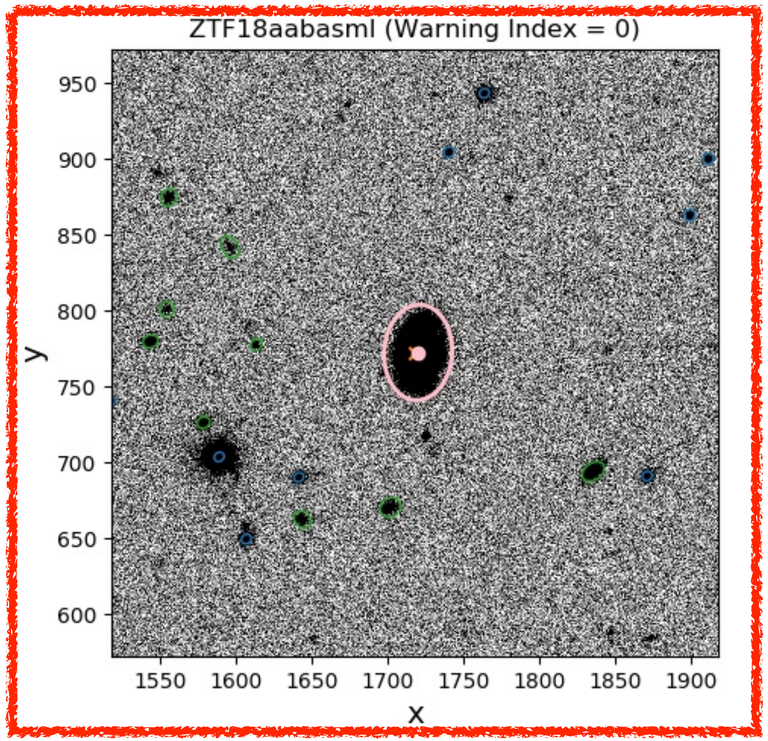
ZTF SNe Ia	In SDSS DR15
586	437

w/ 8447 host candidates

Host Identification for ZTF SNe Ia

ZTF SNe Ia	In SDSS DR15
586	437

w/ 8447 host candidates



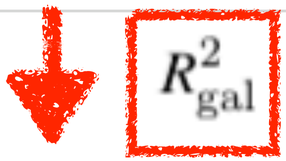
$R^2_{\rm gal}$

~ 0.31 sec / 1 SN Ia

to calculate the DLR distance for every host candidate and select a host.

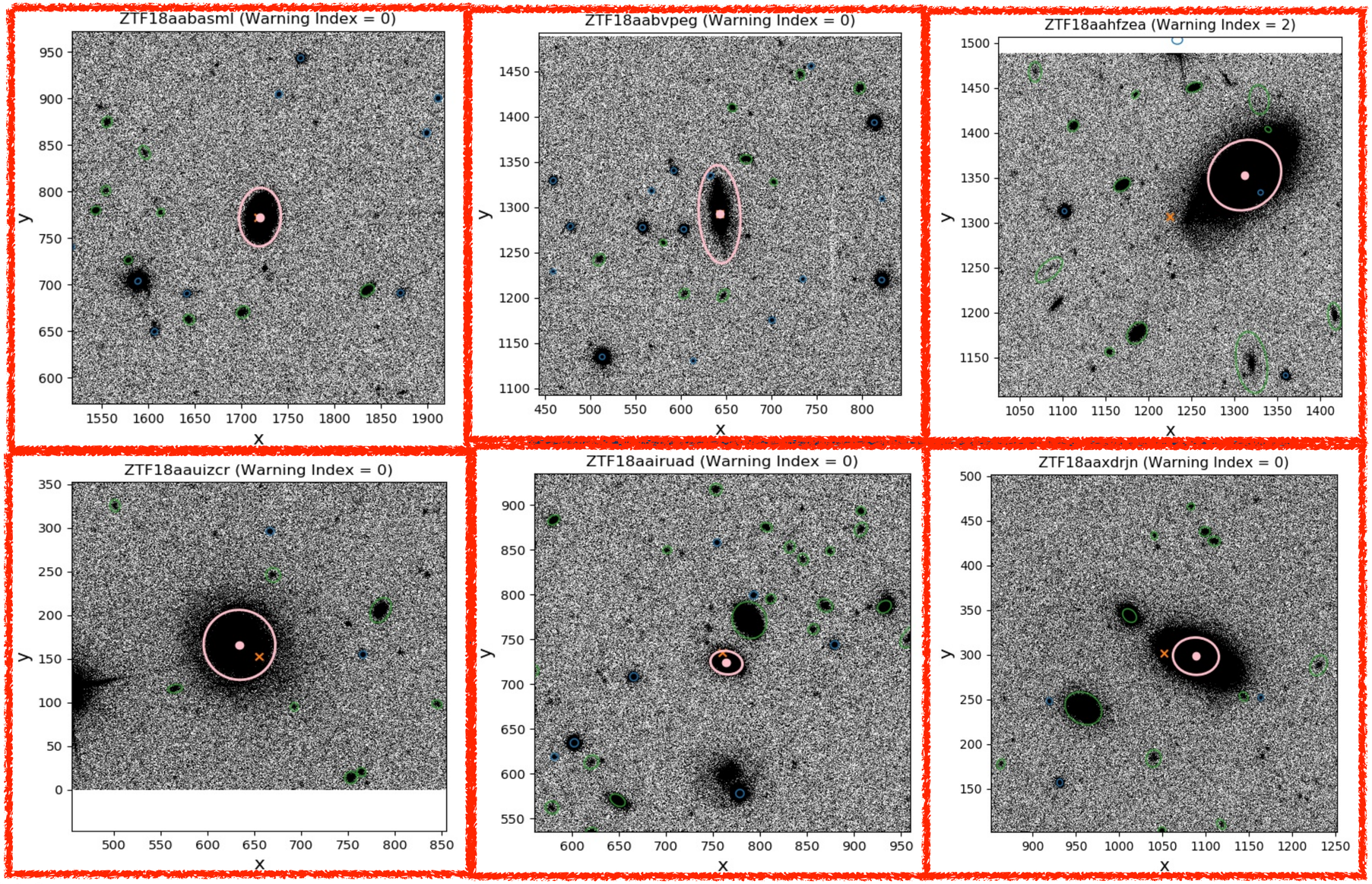
Host Identification for ZTF SNe Ia

ZTF SNe Ia	In SDSS DR15
586	437



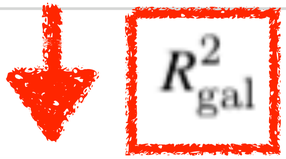
Pass	Warning
356	81

Host Identification for ZTF SNe Ia



Host Identification for ZTF SNe Ia

ZTF SNe Ia	In SDSS DR15
586	437

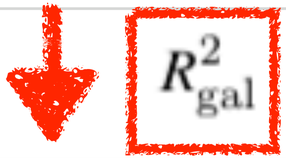


Pass	Warning
356	81

Ok	Wrong host
353	3

Host Identification for ZTF SNe Ia

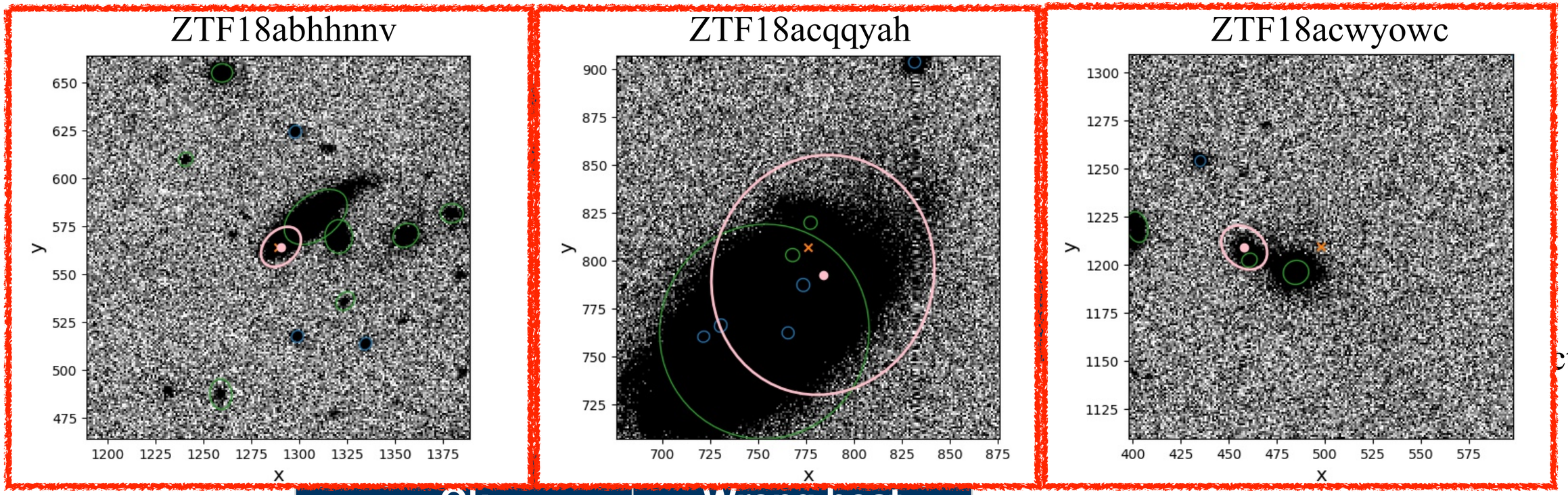
ZTF SNe Ia	In SDSS DR15
586	437



Pass	Warning
356	81

Ok	Wrong host
353	3

Host Identification for ZTF SNe Ia



ction!

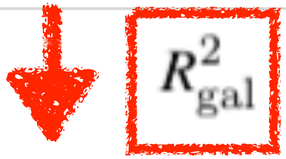
Ok | Wrong host

hosts. We then visually scan each host galaxy, using images with and without the SN present to ensure that our host galaxy association is accurate. In six cases, at low redshift, where the host is extended or resolved into multiple objects, we select by hand a more likely object as the host galaxy. Of the 379

Smith+2012

Host Identification for ZTF SNe Ia

ZTF SNe Ia	In SDSS DR15
586	437

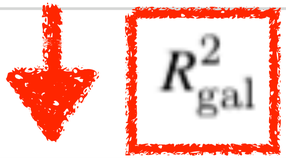


Pass	Warning
356	81

Ok	Wrong host
353	3

Host Identification for ZTF SNe Ia

ZTF SNe Ia	In SDSS DR15
586	437



Pass	Warning
356	81

Ok	Wrong host
353	3

<Warning> case requires a visual inspection!

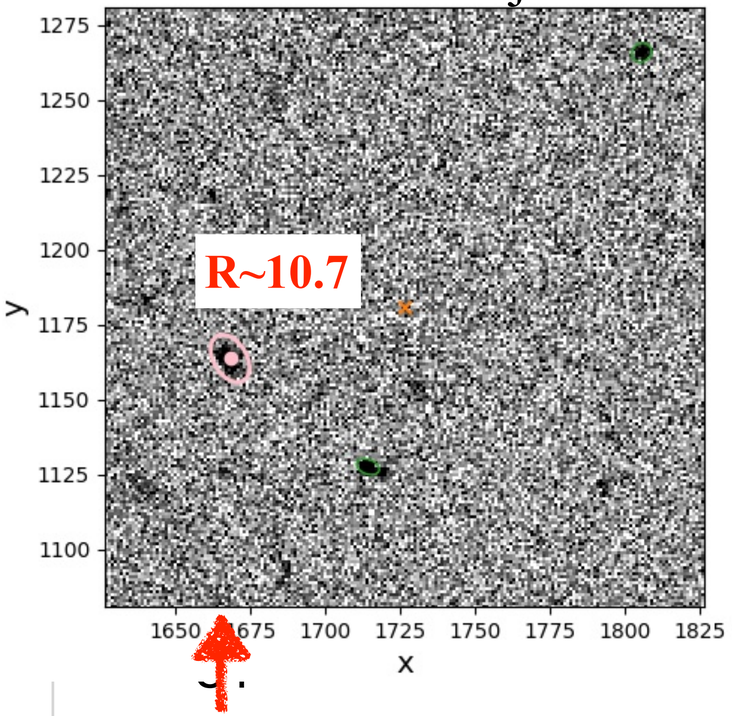
Host Identification for ZTF SNe Ia

Warning
81

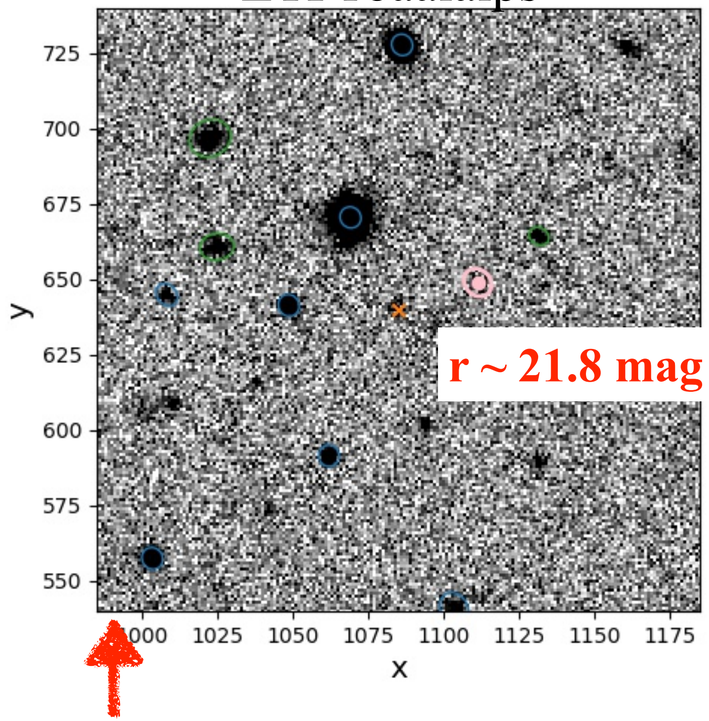
1) $R > 5$ (S06, Sako+2014) or
2) SN and host separation in arcsec > 30” (Gupta+2016) or
3) host petromag_r > 20.5 mag (faint objects to measure petrosian mag)

hostless	revised	too faint (r~22.0)	reqeury w/ host ID	reselect by visual	not in SDSS	near bright obj
15	**23**	20	**13**	**5**	1	4

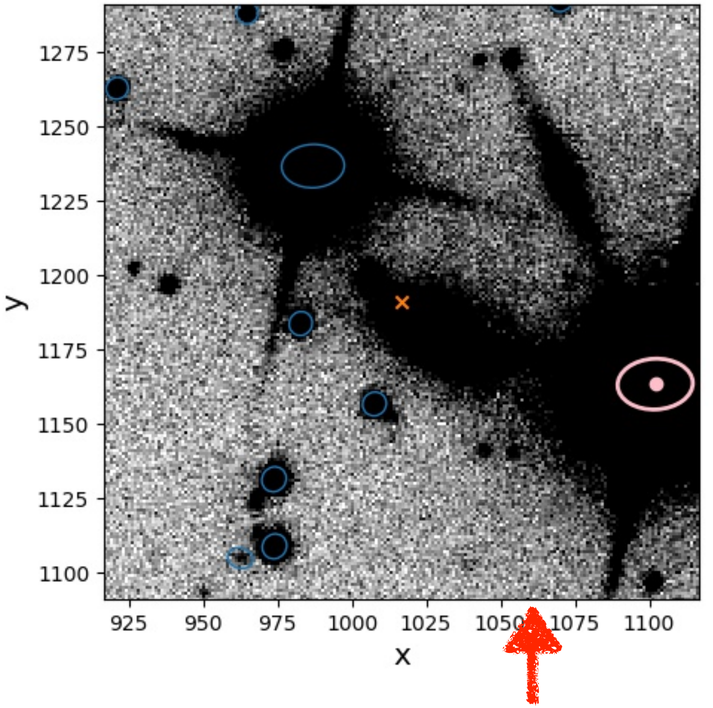
ZTF18abskzjm



ZTF18aaialps



ZTF18abebzog



hostless	revised	too faint (r~22.0)	reqeury w/ host ID	reselect by visual	not in SDSS	near bright obj
15	**23**	20	**13**	**5**	1	4

Host Identification for ZTF SNe Ia

ZTF SNe Ia	w/ Host
586	397

Host Identification for ZTF SNe Ia

ZTF SNe Ia	w/ Host
586	397

Host z_spec in SDSS DR15
178

GALEX Data

ZTF SNe Ia	In SDSS DR15	ZTF in SDSS
586	437	397

GALEX
274

FUV+NUV	FUV	NUV
208	211	271

Measurements of Host Properties

Le PHARE

PHotometric Analysis for
Redshift Estimations

Stéphane ARNOUTS & Olivier ILBERT

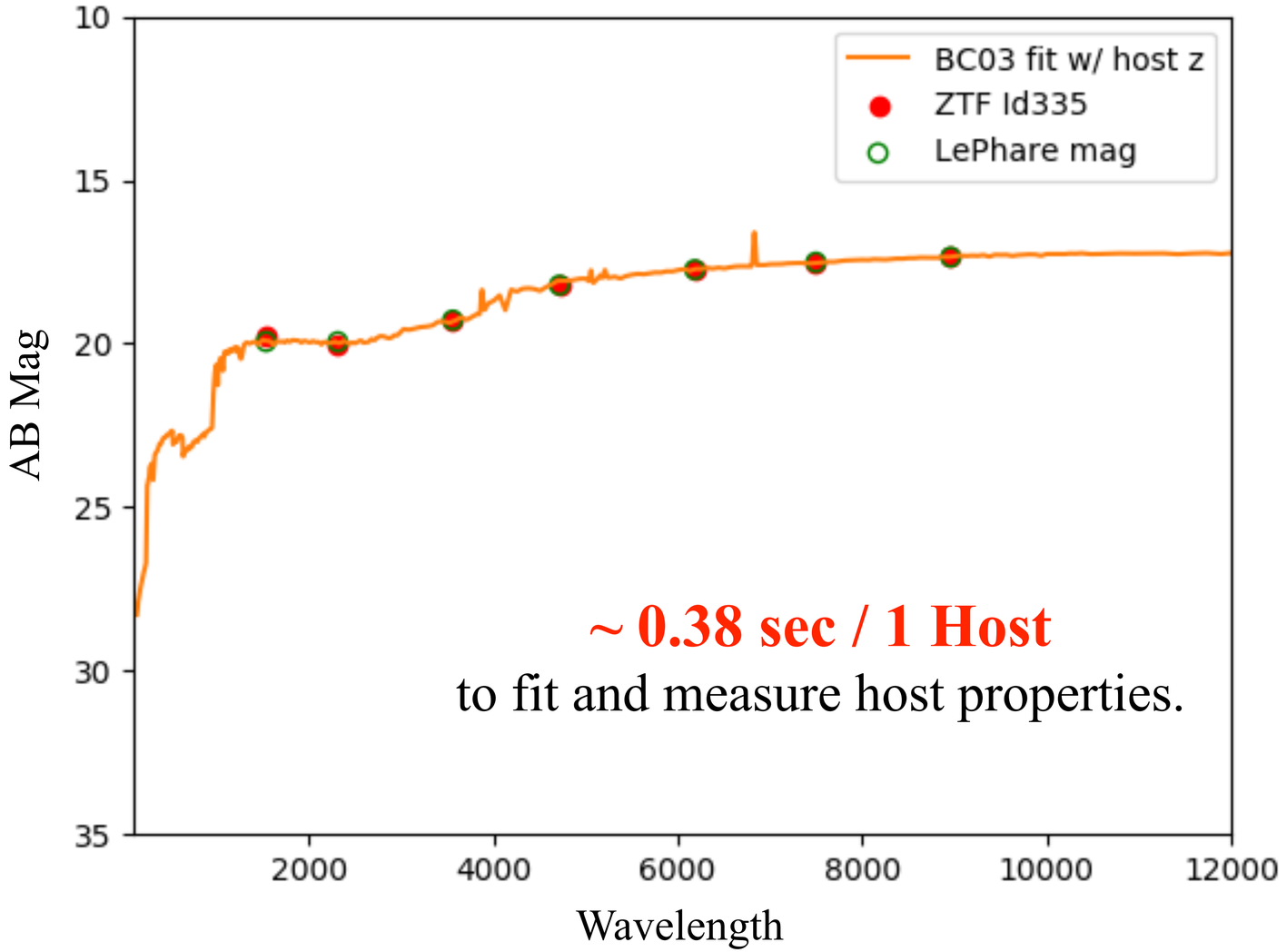
+

GALAXEV (version 2003)

G. Bruzual[1⋆] and S. Charlot[2,3⋆]

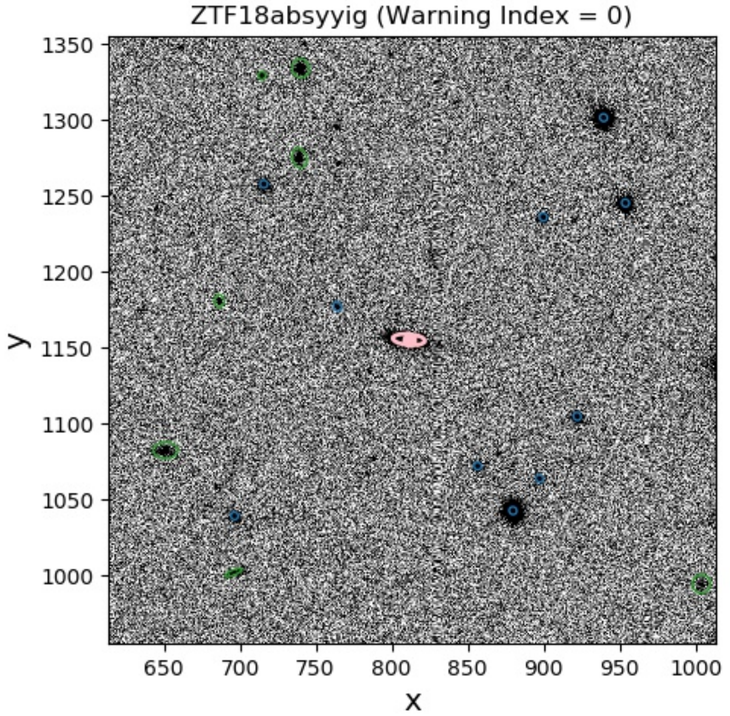
We made 883,477 templates with a combination of various ages, metallicities, and extinction values.

Measurements of Host Properties



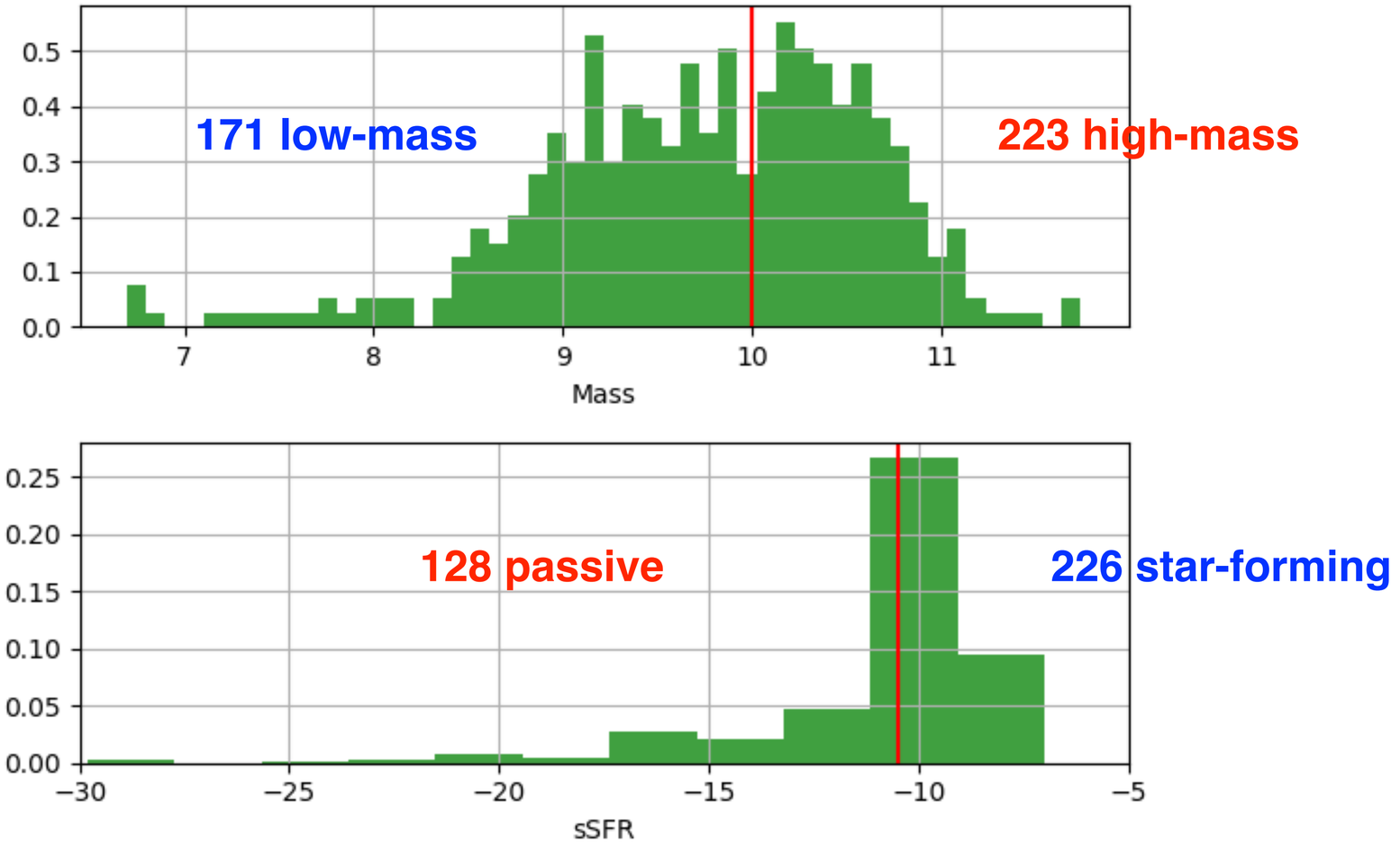
~ 0.38 sec / 1 Host

to fit and measure host properties.



Measurements of Host Properties

Mass and SFR, which have a correlation with SN luminosity



Why Host Galaxy?

Host Identification:
host galaxy and host redshift (if it has)

DLR method **~ 0.31 sec / 1 SN Ia**

host photometry data

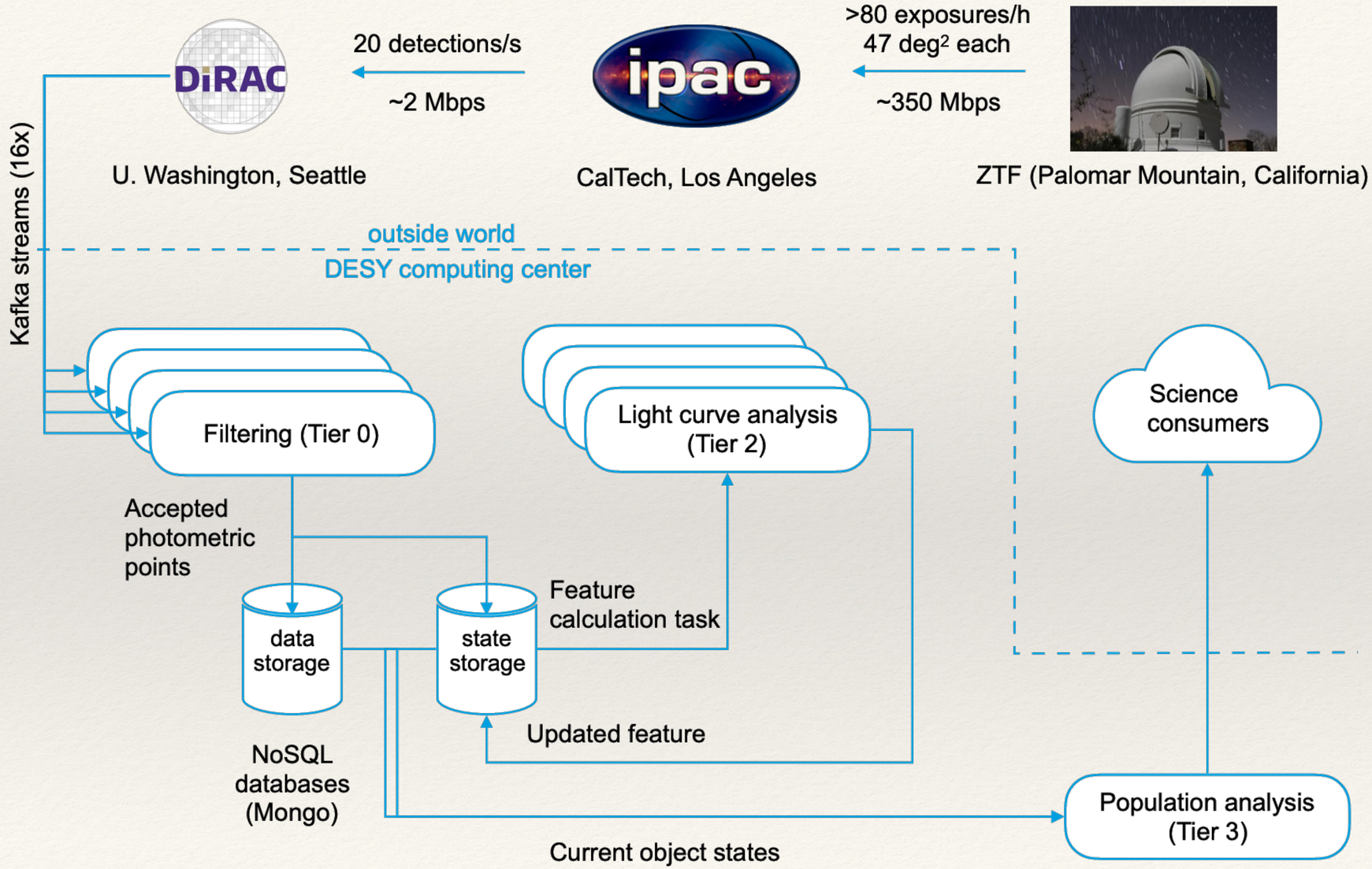
Measuring Host Properties:
Mass and SFR of host galaxy
(which have a correlation with SN Ia luminosity)

Le PHARE+BC03 templates **~ 0.38 sec / 1 Host**

The host identification would provide useful information to improve photometric classification of SNe and SN cosmology for both ZTF and LSST SN surveys.

AMPEL | *Scales Horizontally*

Nordin et al. 2019



AMPEL | *Some* Facts & Numbers

Nordin et al. 2019

Able to rerun the entire stream while changing any of your AMPEL configurations
-> THE unique way to understand your selection fonction

Can ingest ~1250 alerts per second (T0) ~3x more than what LSST will provide
AMPEL is already LSST ready !

T0 (filters) and T2 (science) can use more than 24 already available catalogs (SDSS/Gaia/PS)
Be as smart as you want when filtering your alerts

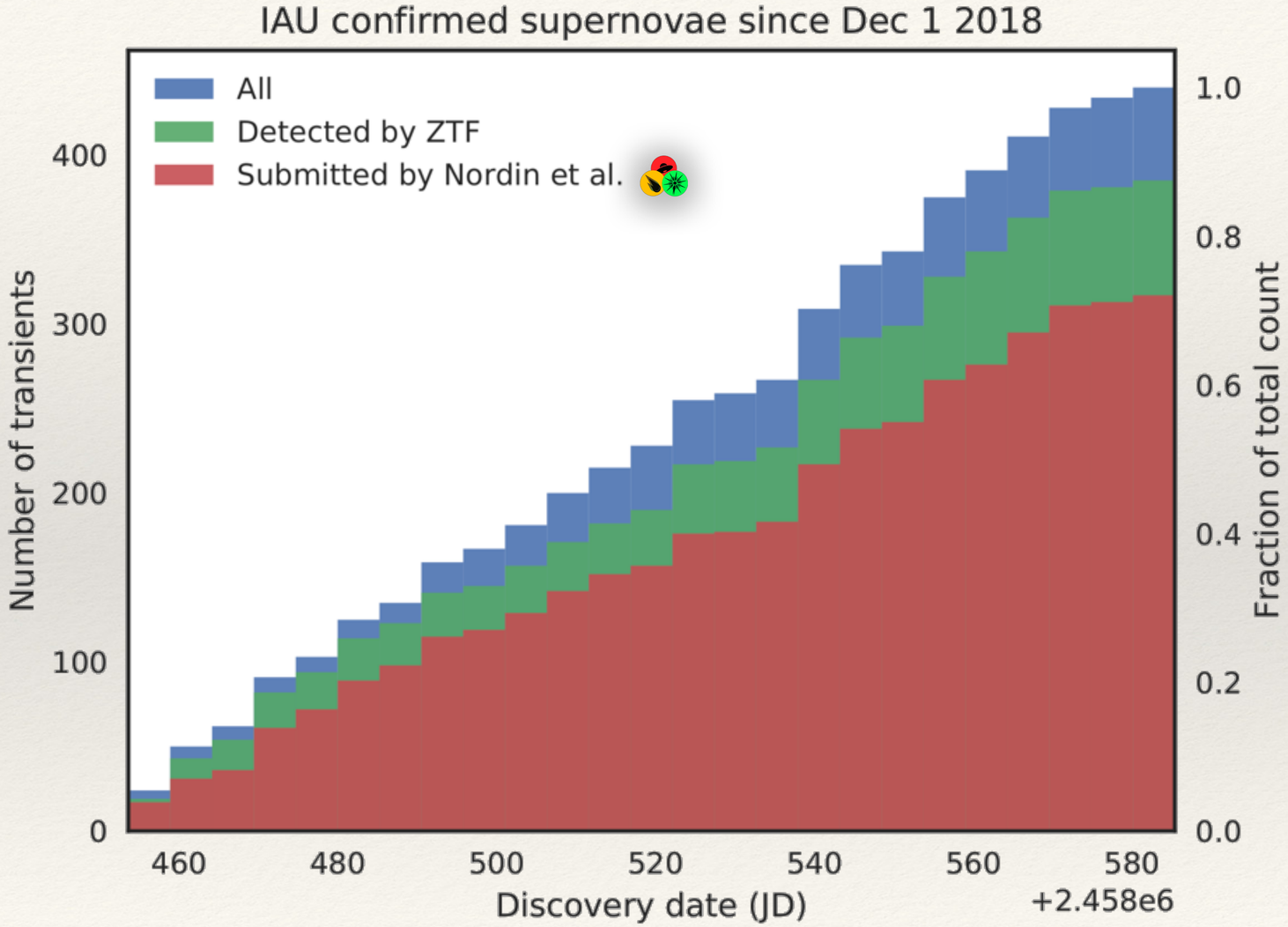
AMPEL is fully "containerised"
Takes ~20min to install and run anywhere

AMPEL can automatically trigger a spectrograph (tested on SEDM)
Get a Spectra few minutes after your alters has been issued

AMPEL is currently ~16k lines of code
2 years of brainstorming development by 5 scientists (incl myself)

AMPEL | *Already the largest Supernova reporter*

Nordin et al. 2019



“This is the most well thought out version of an event stream I've seen to date”

- AMPEL paper referee report

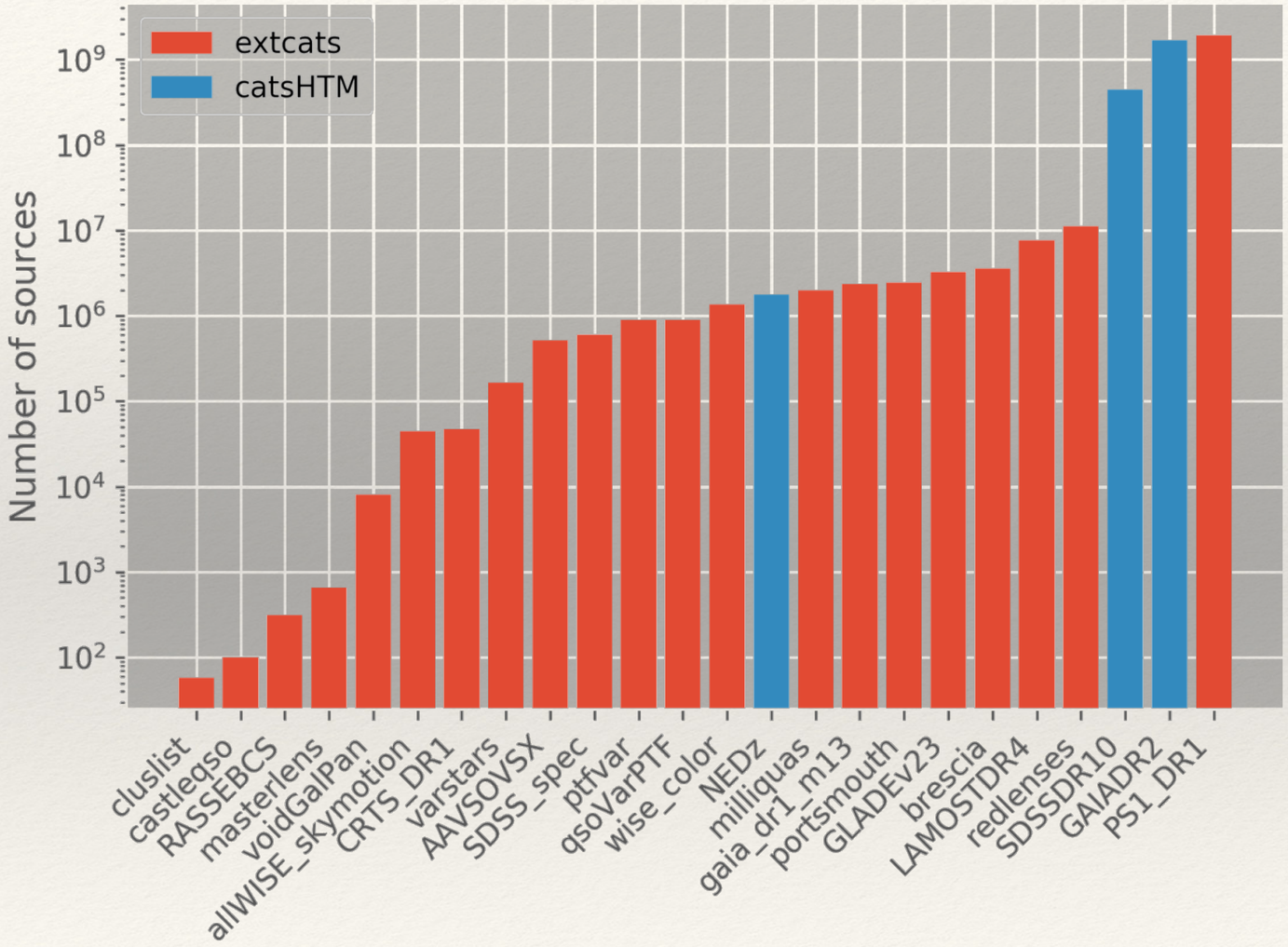
Join us | Thanks

Start instructions at:
https://github.com/AmpelProject/Ampel-contrib-sample

Contact us:
J. Nordin (PI, jnordin@hu-berlin.de) or myself

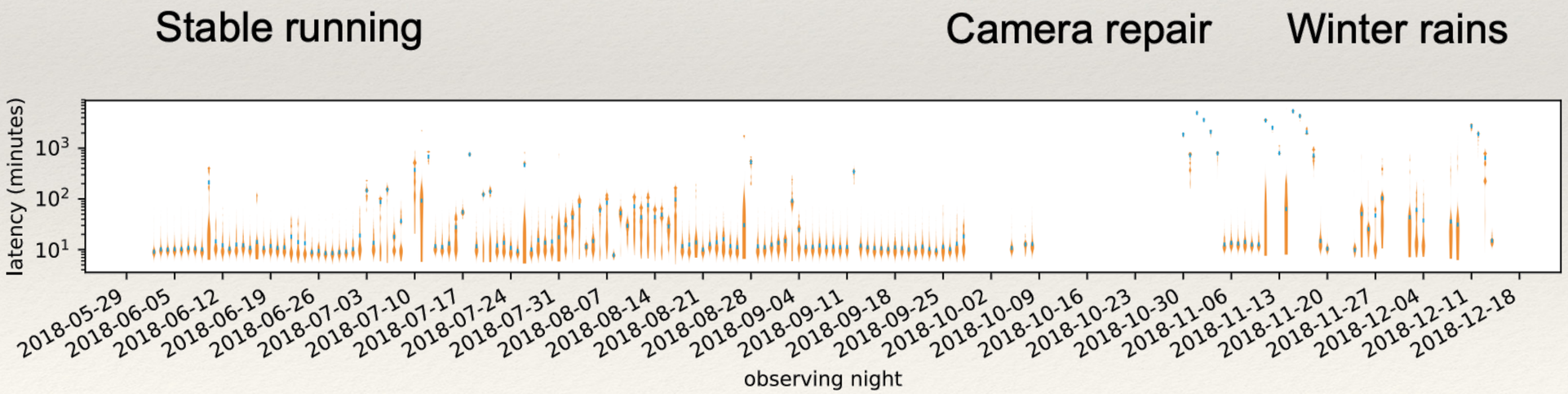
Catalogs

hdf5 & geoJson/healpix



Latency

- ZTF alert distribution began in June 2018
- Performance as of 1.1.2019:
  - 64M alerts (one Kafka message each)
  - 4.9 TB (2.9 TB de-duplicated)
  - Latency from shutter close at Palomar to alert ingestion at DESY typically < 10 min



Current System *(DESY)*

Fully sufficient for ZTF

Burst Hardware:

- Dell PowerEdge R740 Server
- 16 Xeon Gold 6130 cores
- 96Gb RAM
- RAID 10 - 4x460GB “read intensive” SSDs
- 8TB spinning disks