Alert management in optical surveys

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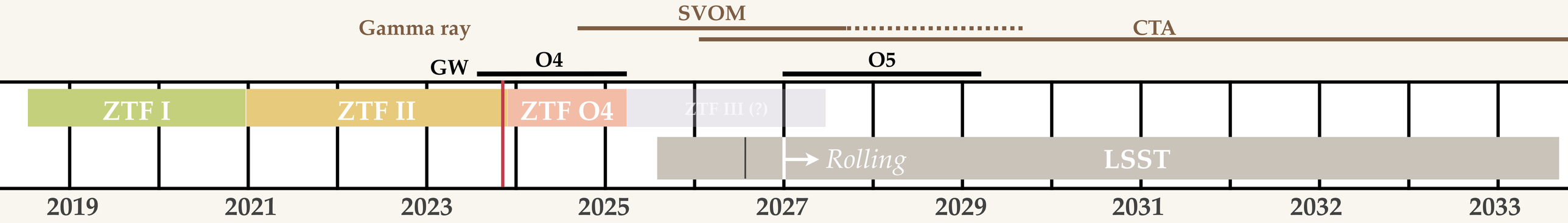
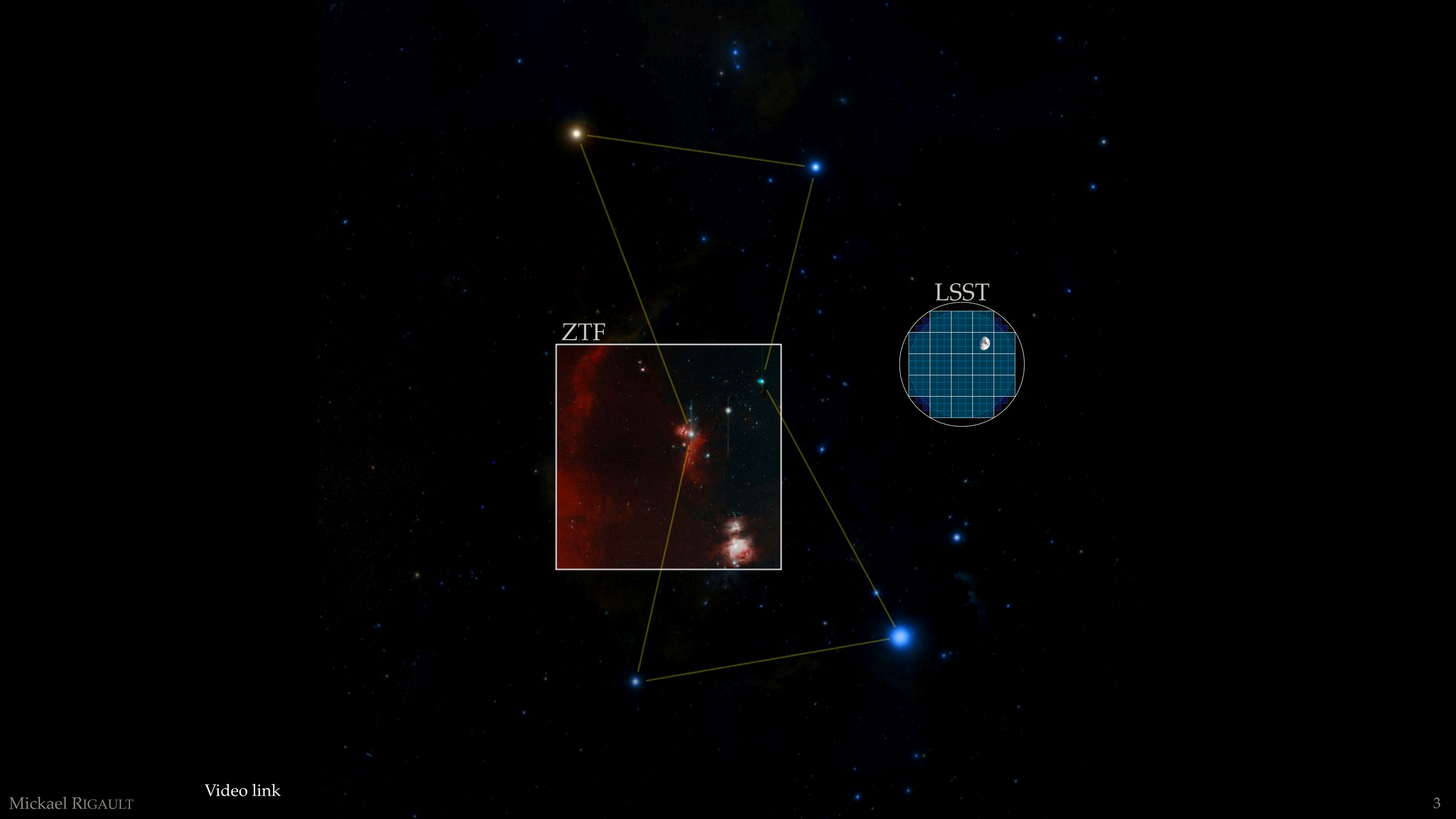
Optical Surveys | *ZTF & LSST*

ZTF | 47deg² | 5σ depth 20.5 mag | g, r, i
full sky every night | High-cadence fields | dedicated spectroscopy

LSST | 9 deg² | 5σ depth ~24 mag | (u),g , r, i, z, y
few-days cadence | deep fields to 26 mag | "flagship" survey



See also: **ASAS-SN** | <18.5 mag 1 day cadence • **ATLAS** | <19.5 mag 2 day cadence

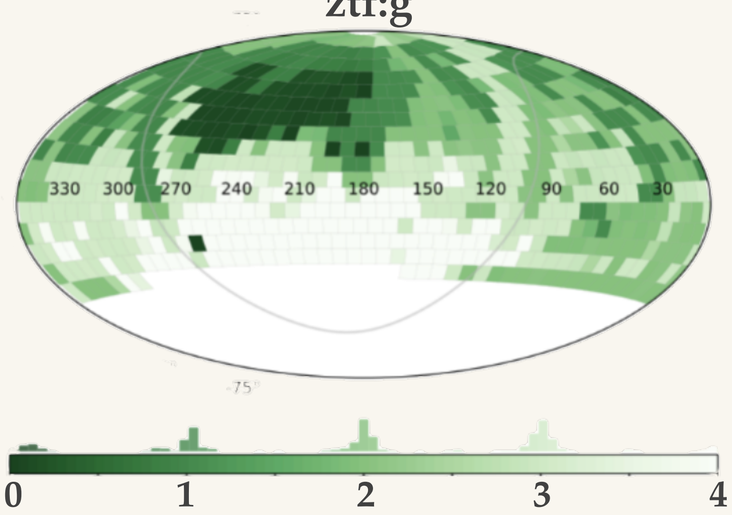


Video link

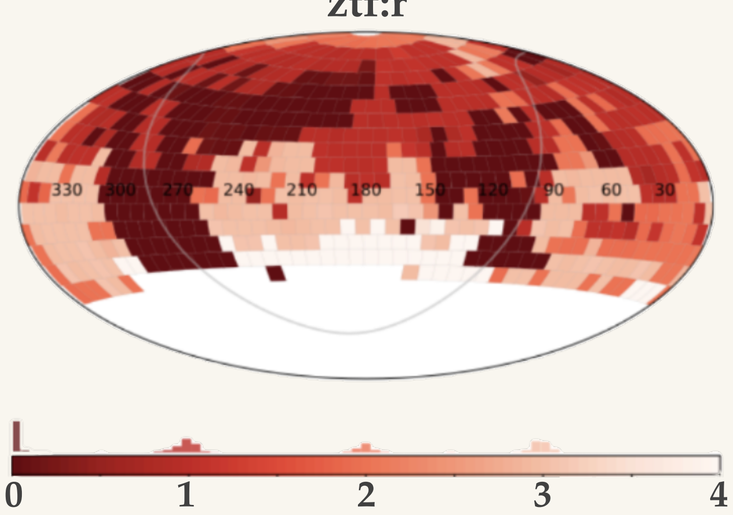
ZTF | full sky & high cadence

Stats from 03/2018-12/2020 | Cosmo DR2 | Rigault et al. in prep

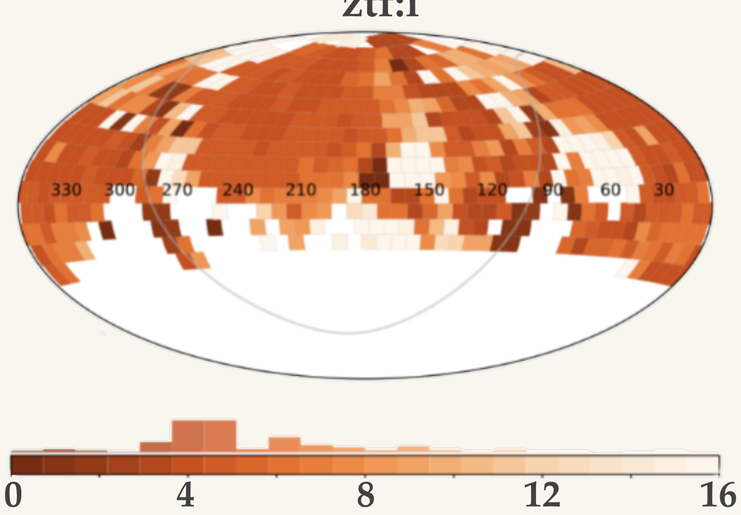
ztf:g



ztf:r



ztf:i

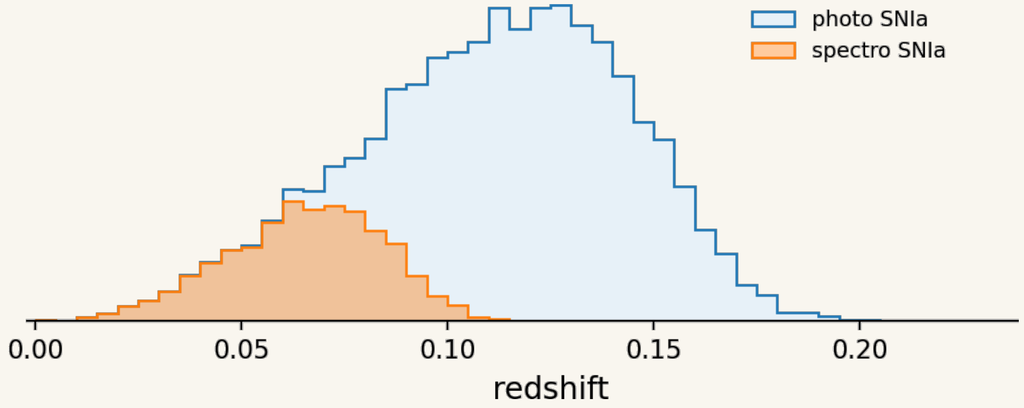


Next observation [days]

Rigault et al. in prep

ZTF Ia Sample

simplistic simulations



48 000

40 000

36 000

DR3

24 000

Cosmo photo

12 000

6 000

DR2

Cosmo spectro

3 000

Current SNeIa Data (20 years)

ZTF III

ZTF

LSST

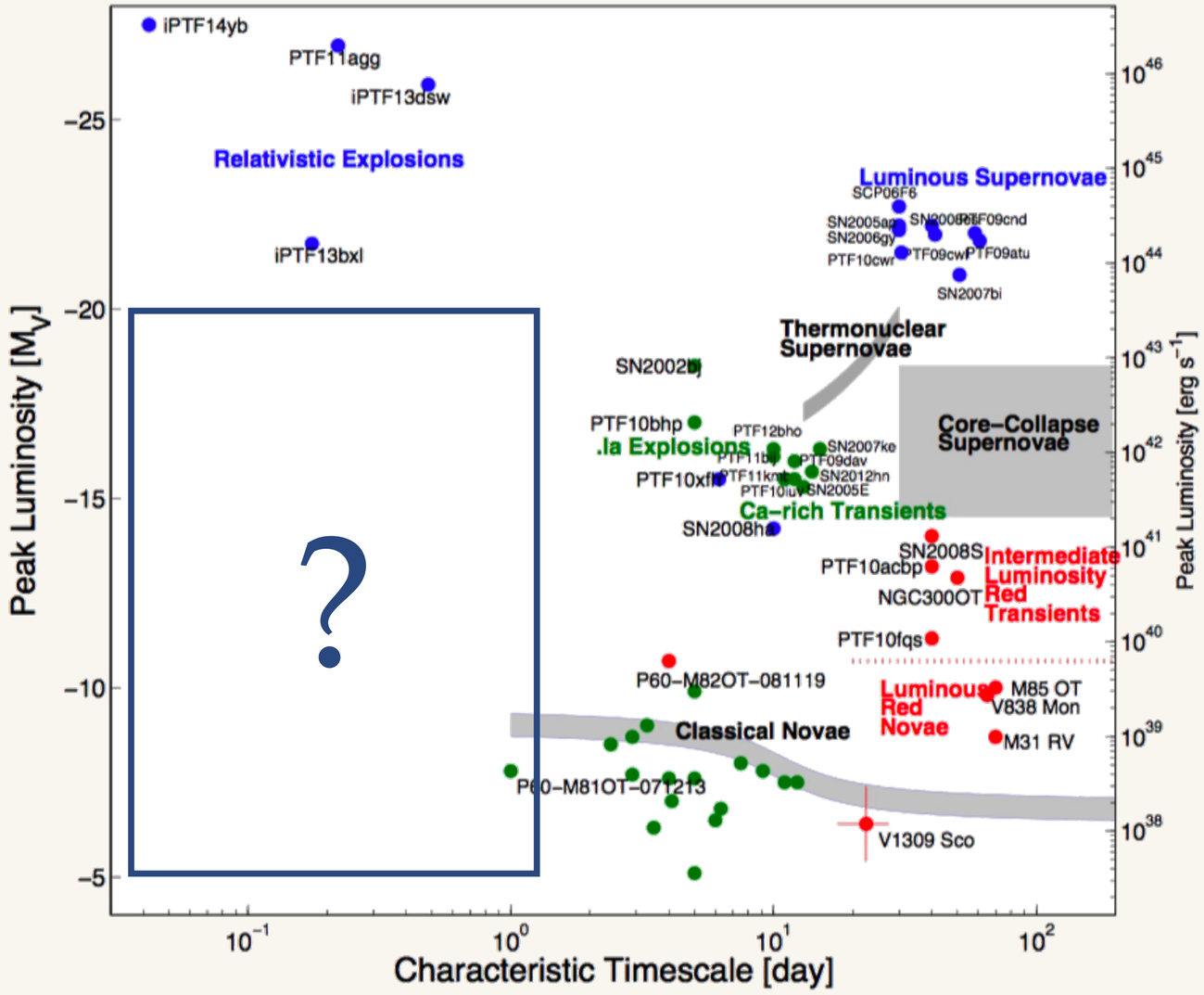
→Rolling

2019 2020 2021 2022 2023 2024 2025 2026 2027

Some Science Cases

Transients Astro.

Flash Spectroscopy



Some Science Cases

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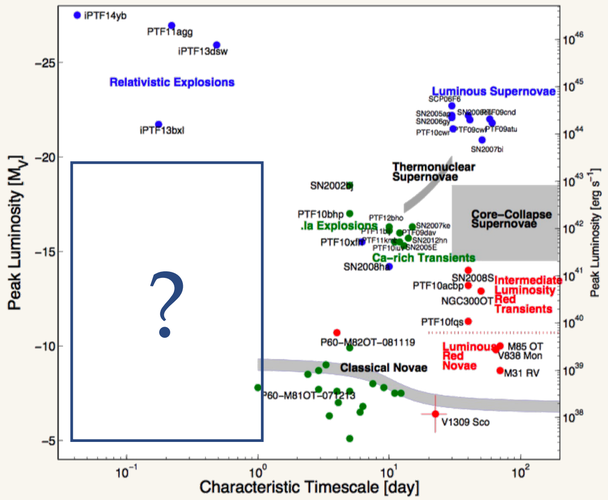
Flash Spectroscopy

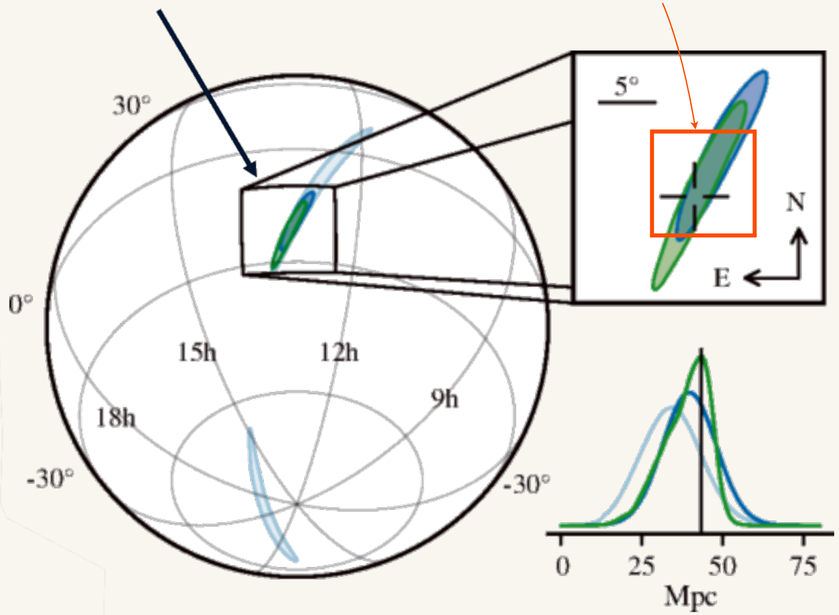


Multi-Messengers

GW & Neutrinos & GRB

Localization of GW170817 was smaller than ZTF FoV

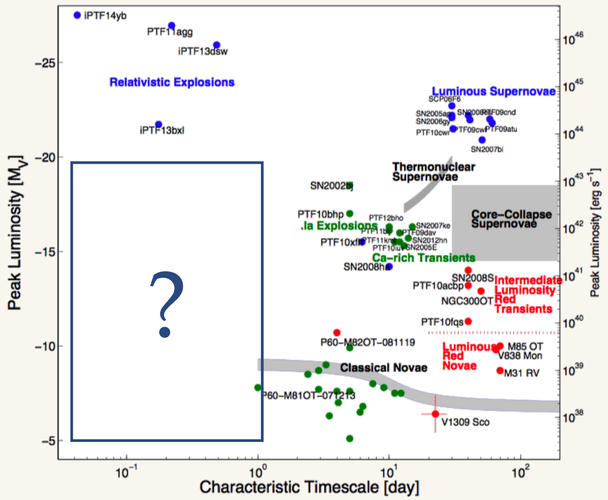
ZTF



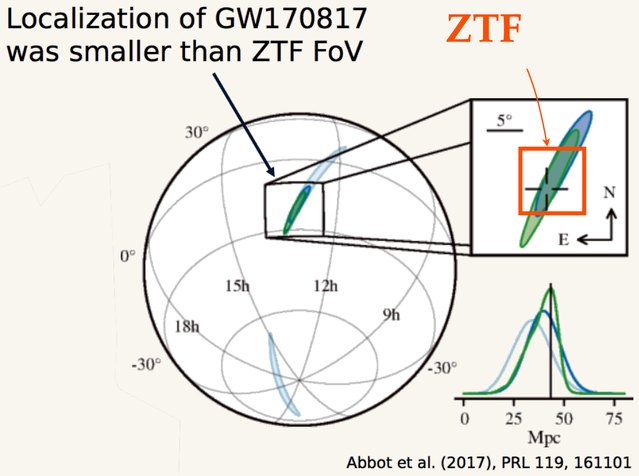
Abbot et al. (2017), PRL 119, 161101

Some Science Cases

Transients Astro.
Flash Spectroscopy

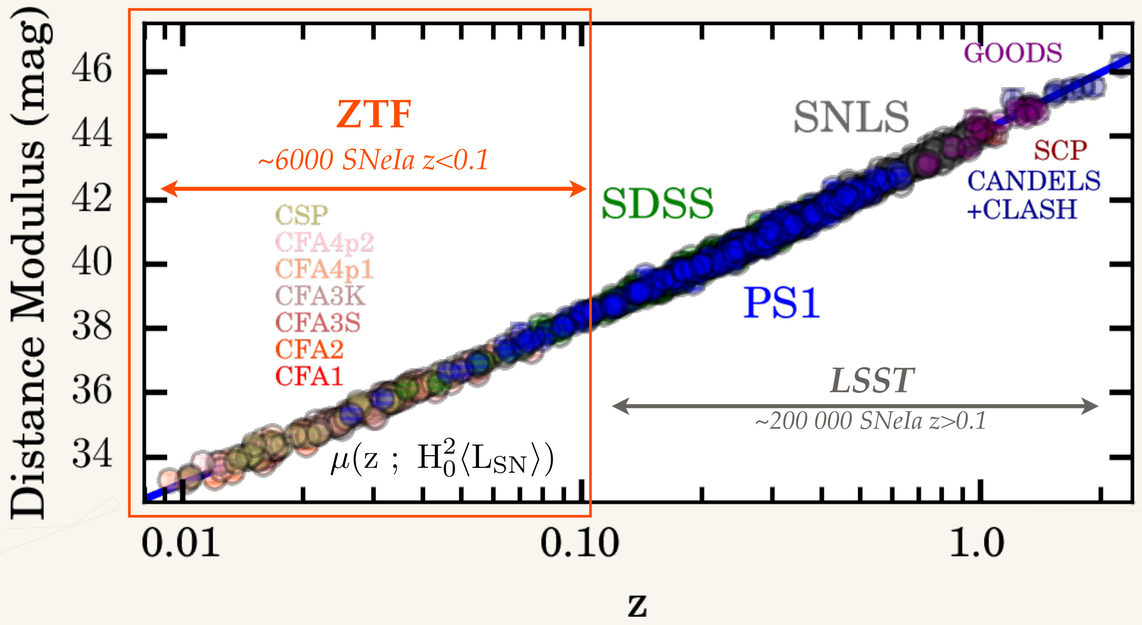


Multi-Messengers
GW & Neutrinos & GRB



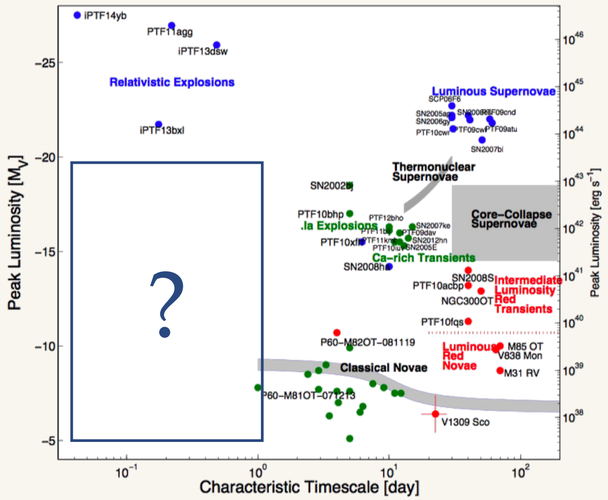
Abbot et al. (2017), PRL 119, 161101

Supernova Cosmology
Incl. Strongly lensed SNeIa

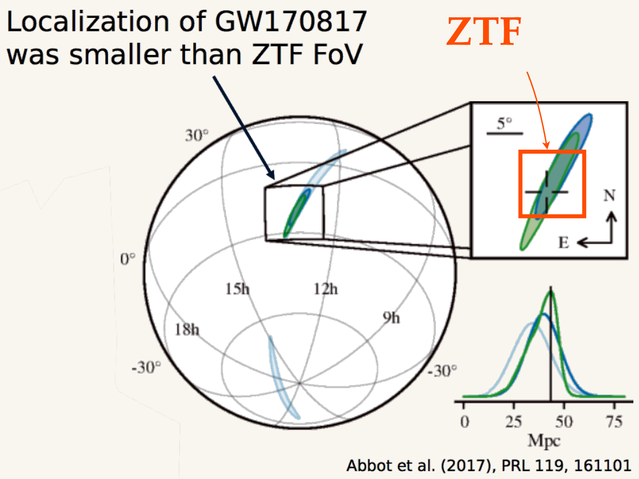


ZTF *Science Cases* ~ LSST *Science Cases*

Transients Astro.
Flash Spectroscopy



Multi-Messengers
GW & Neutrinos



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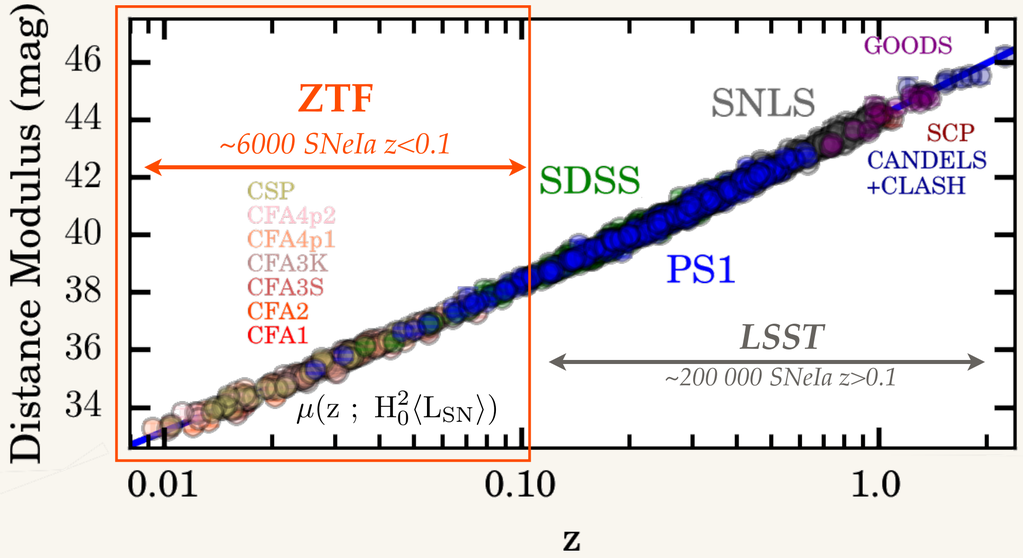
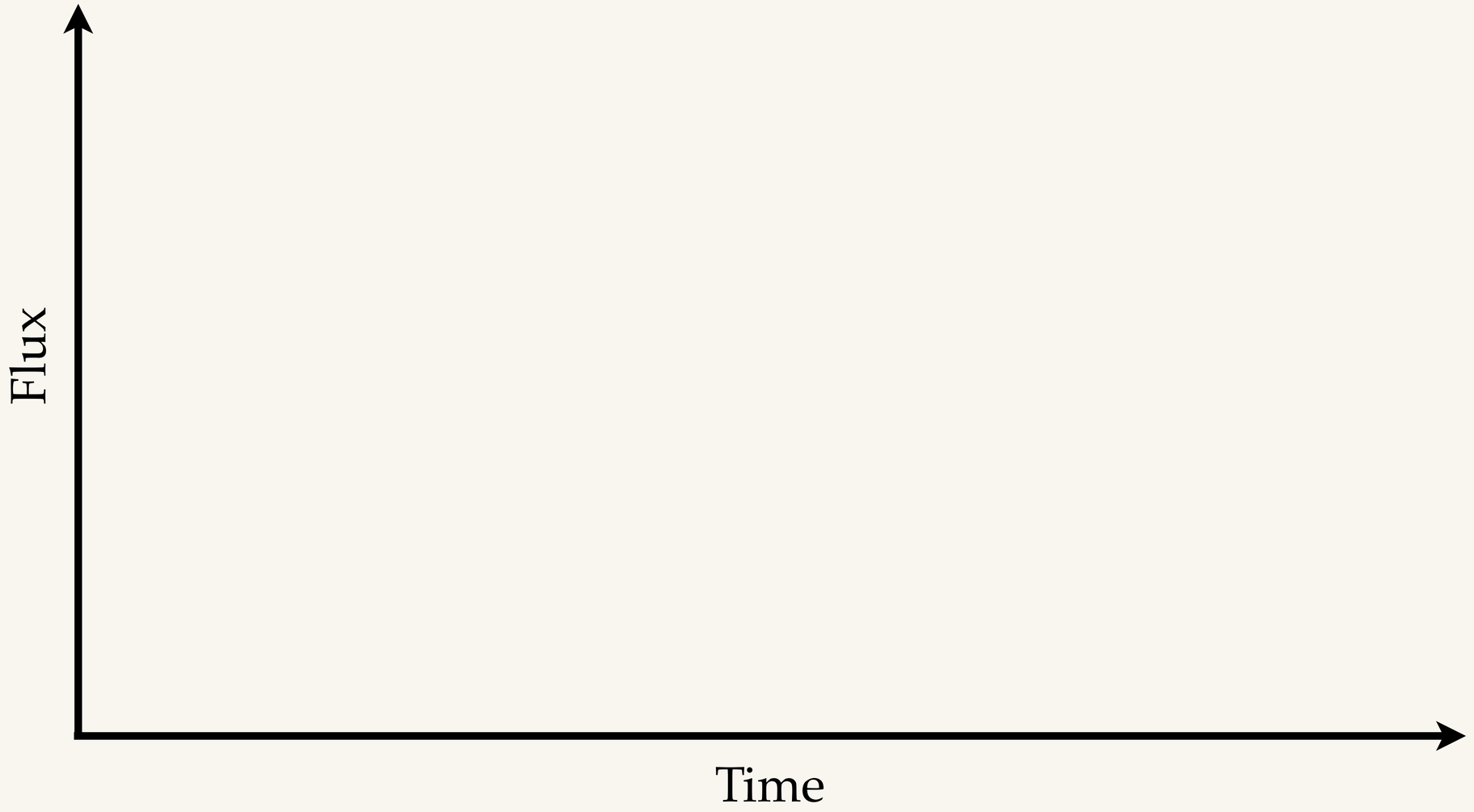
Supernova Cosmology
Incl. Strongly lensed SNeIa



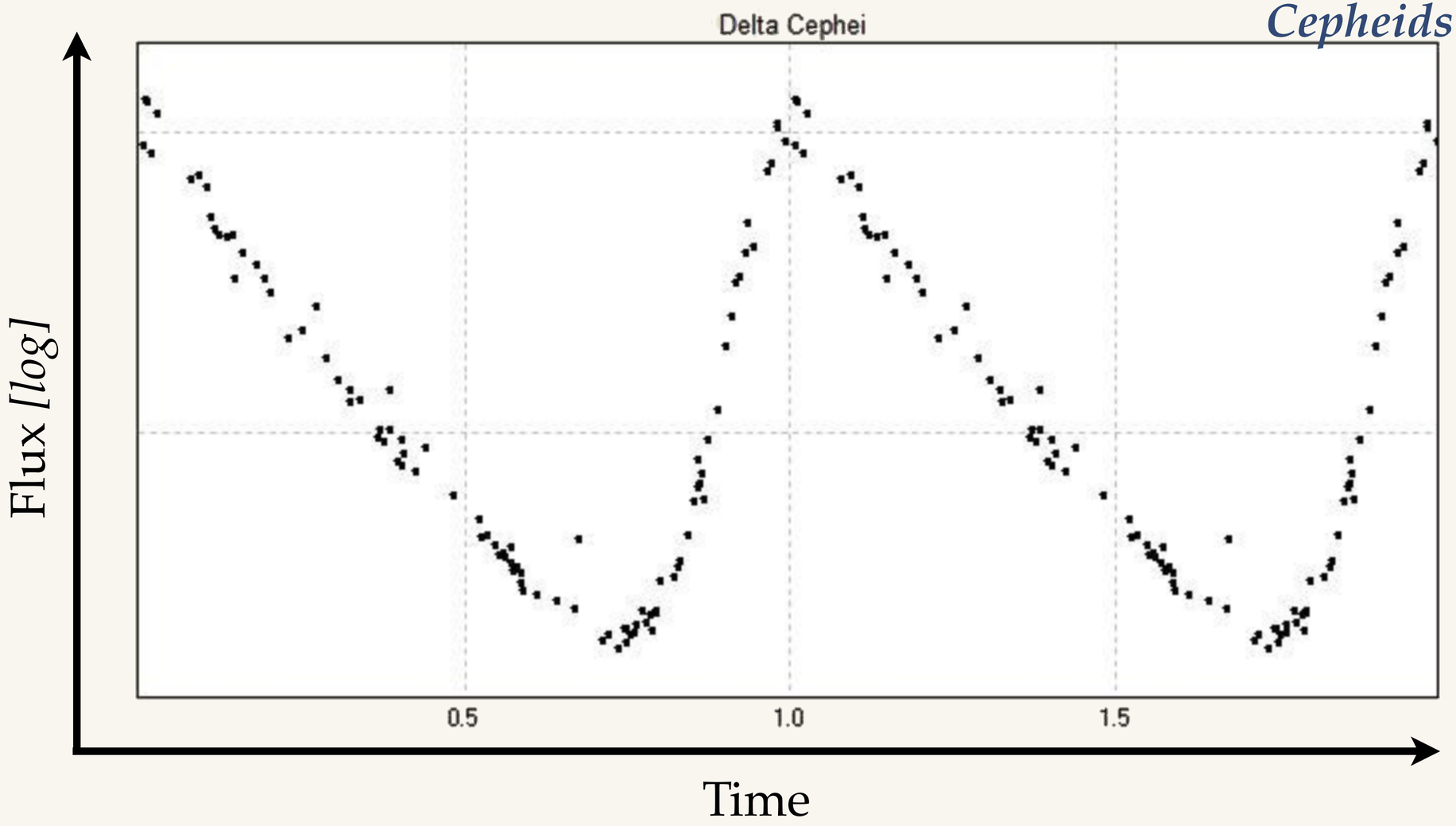
Tidal Disruption Events | Stellar Astrophysics | Solar System Bodies | …

Optical Transient | *Lightcurves*

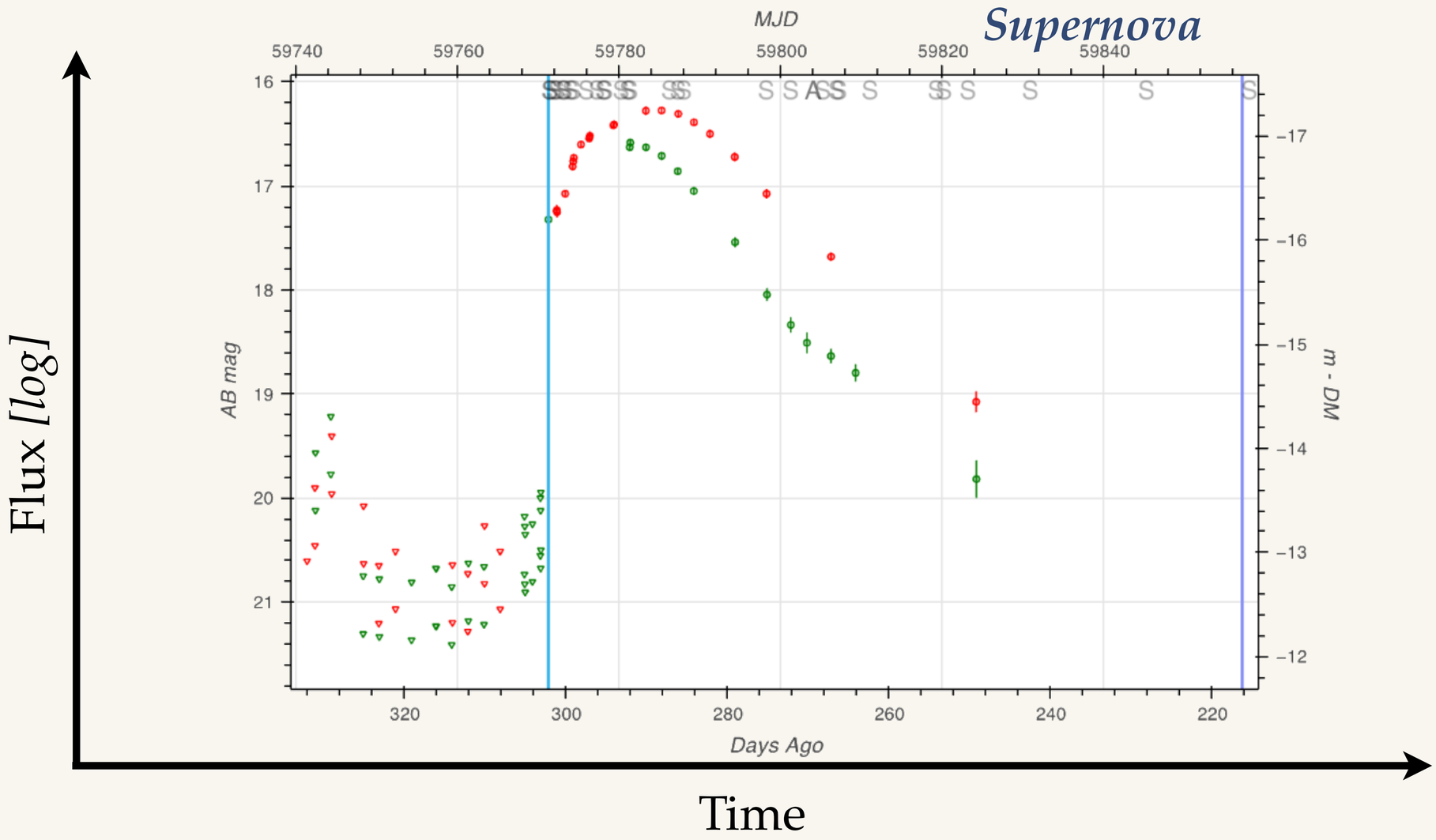


Transients | *Non-exploding stars*

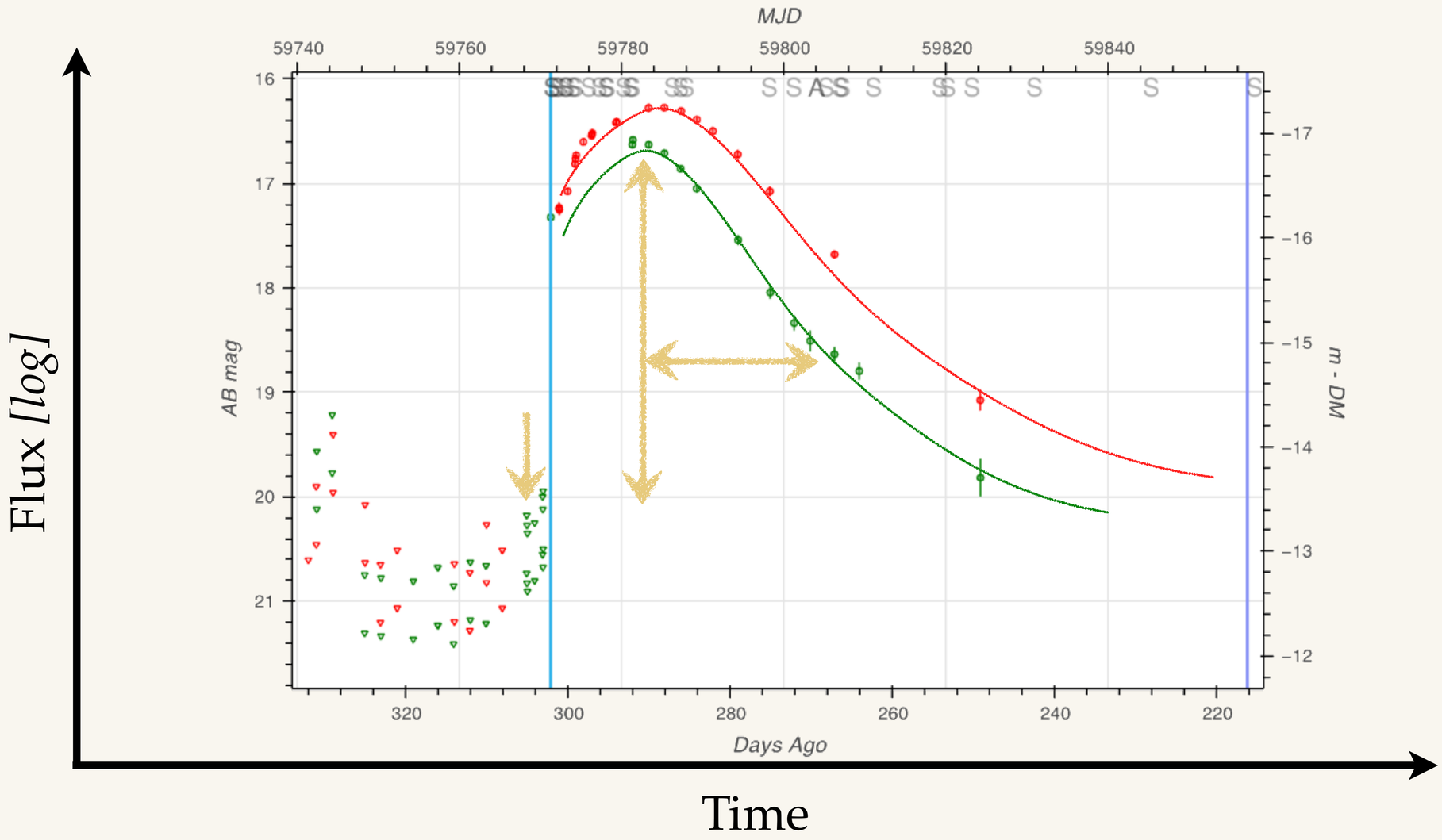
Cepheids



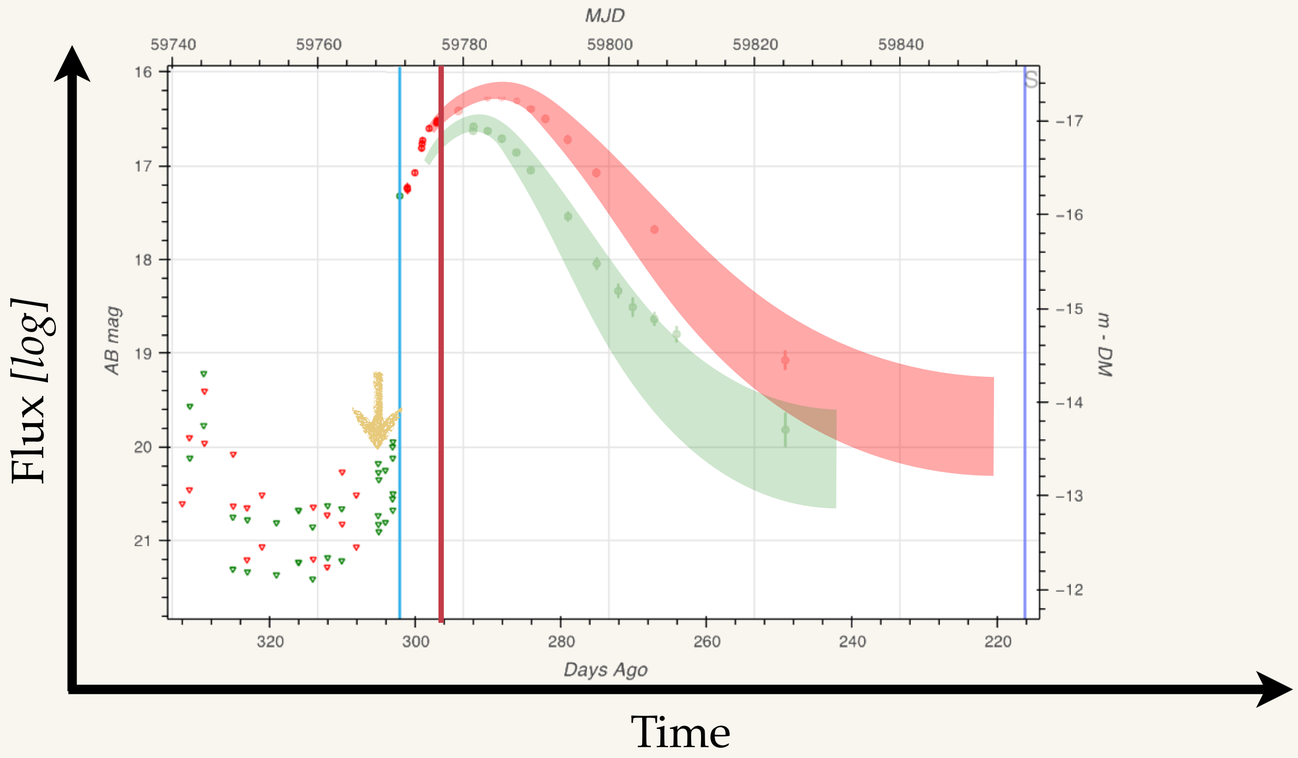
Transients | *Exploding stars*



Features users are looking for



Should we trigger ? When ? What ?



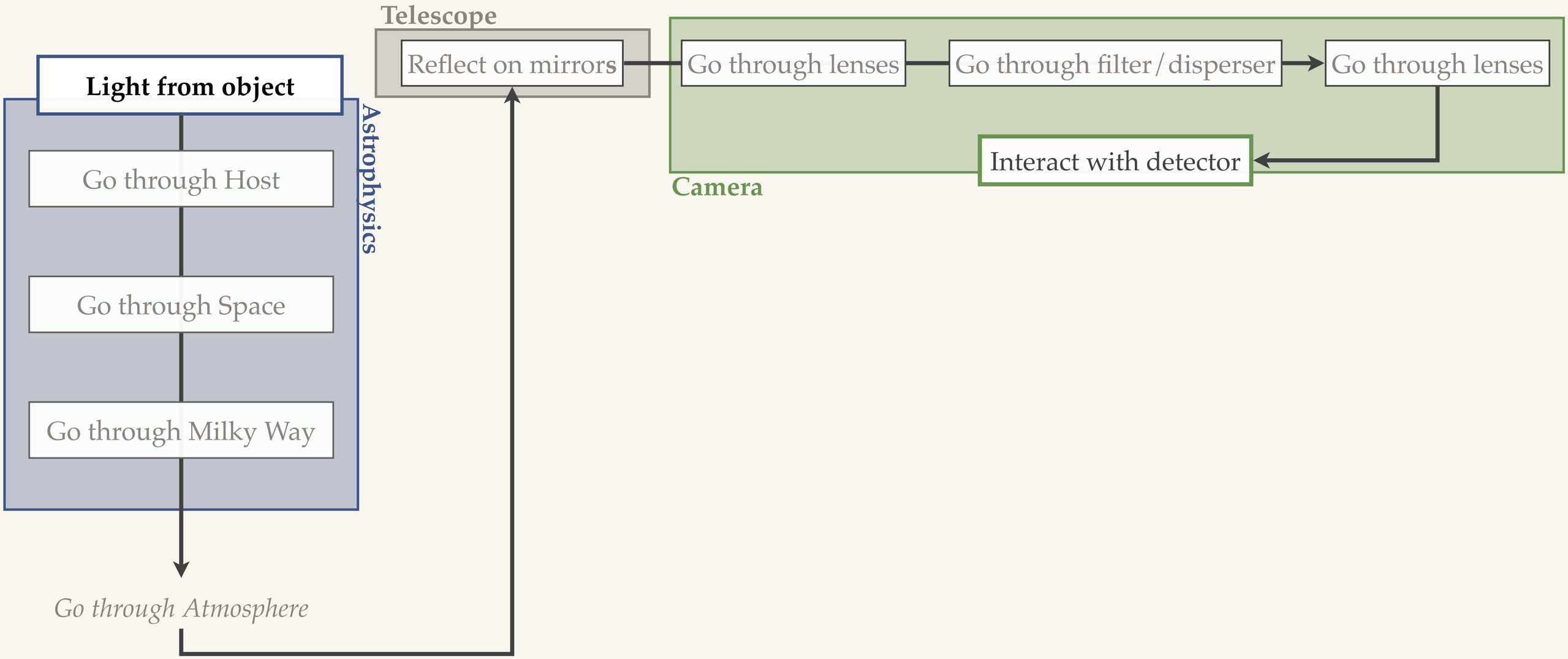
Spectroscopy, *which ?*

Additional photometry

Higher resolution image

Only a “tracker”

Transient alert | *What is happening ?*



Transient alert | *What is happening ?*

Telescope

Reflect on mirrors → Go through lenses → Go through filter / disperser → Go through lenses

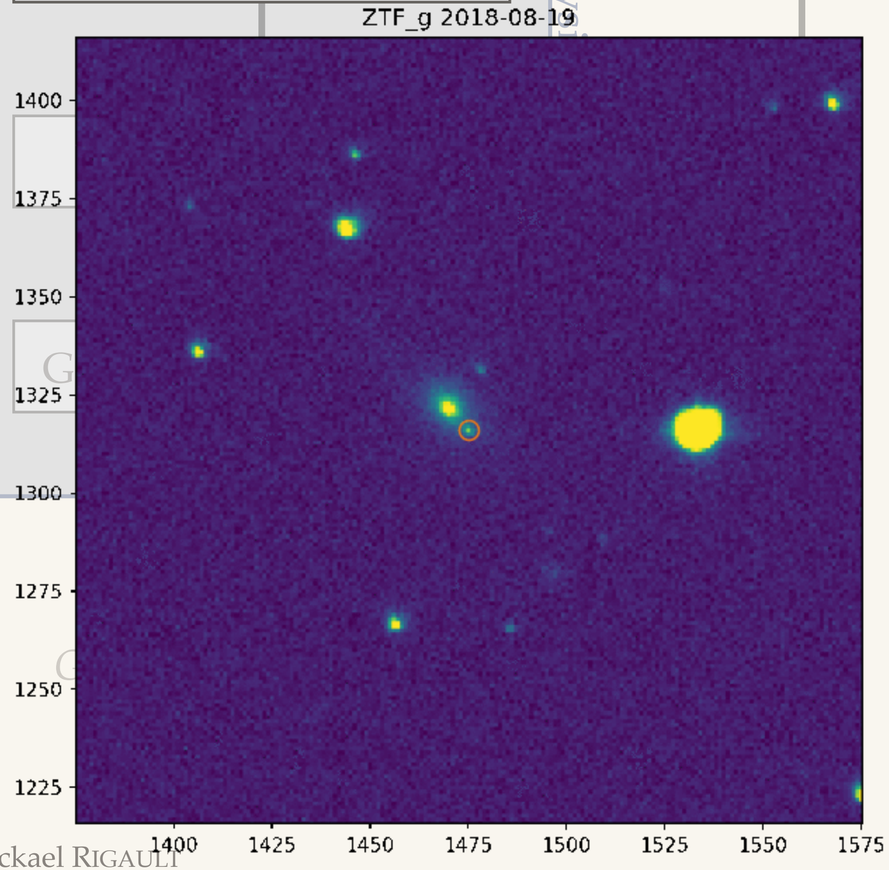
Camera

Interact with detector

Light from object

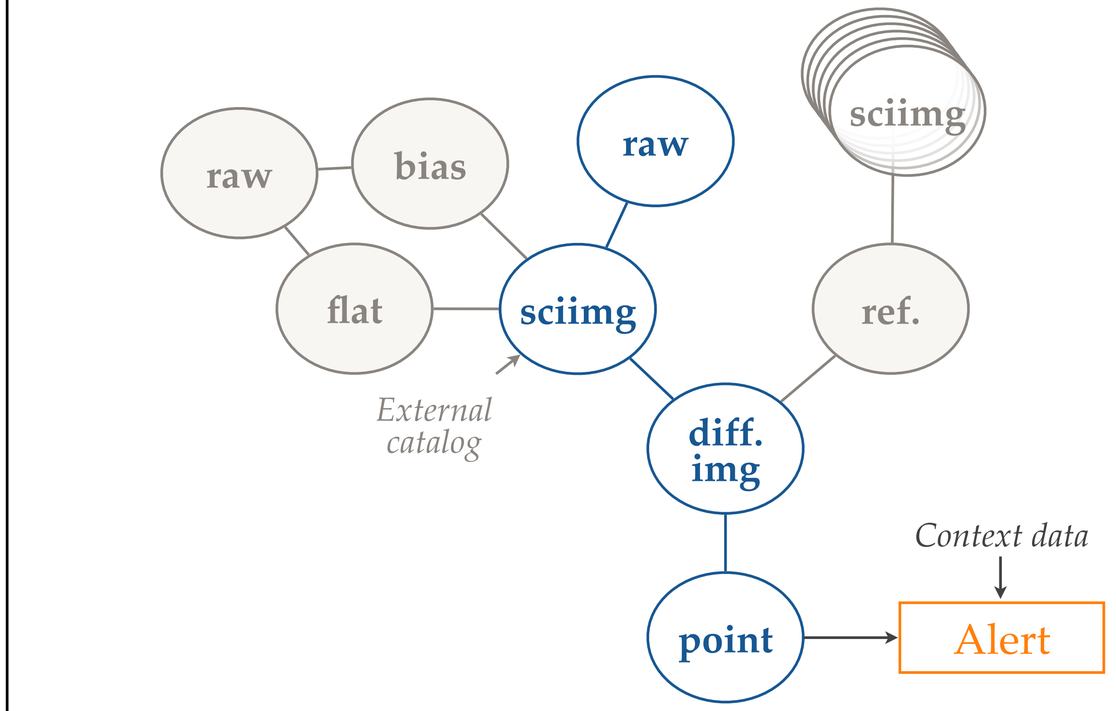
Go through Host

Astrophysi



Calibration

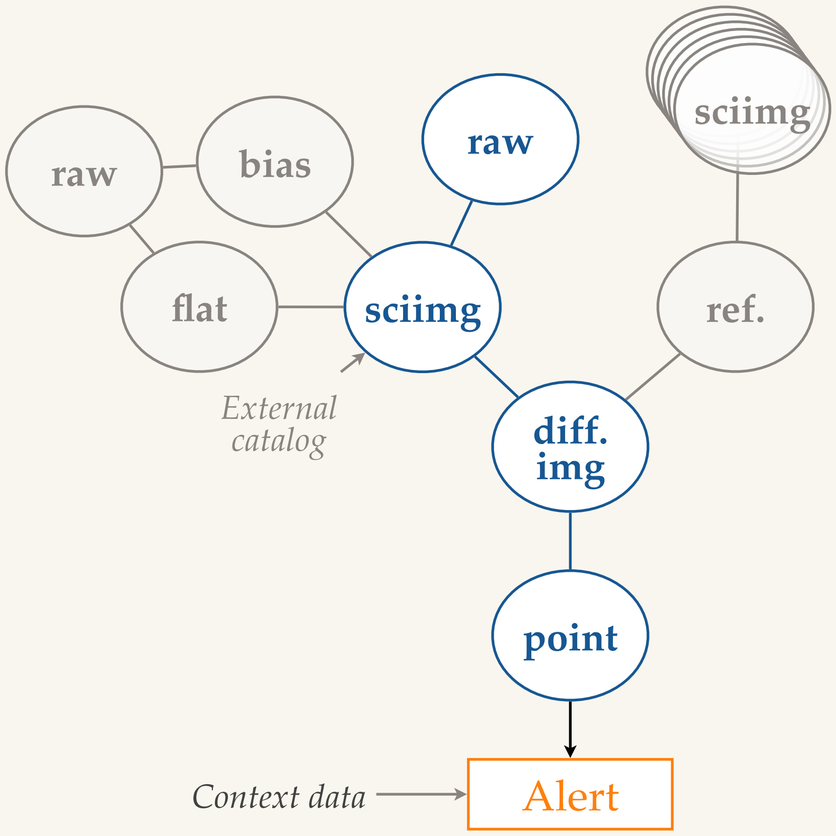
- Flat Fielding
- PSF model
- Astrometry
- Linearity
- …



ZTF / LSST Alerts

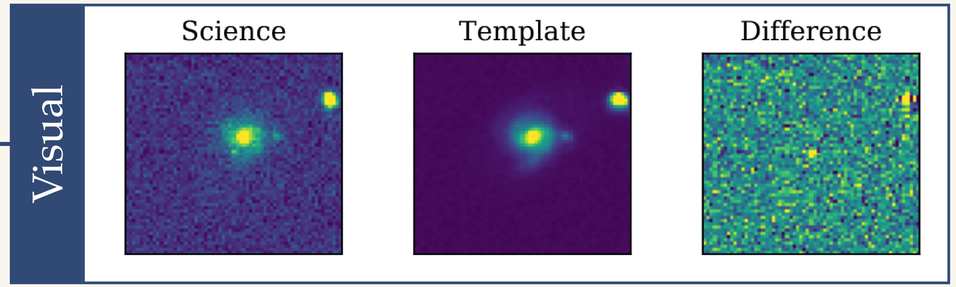
Data Processing to alert issuing

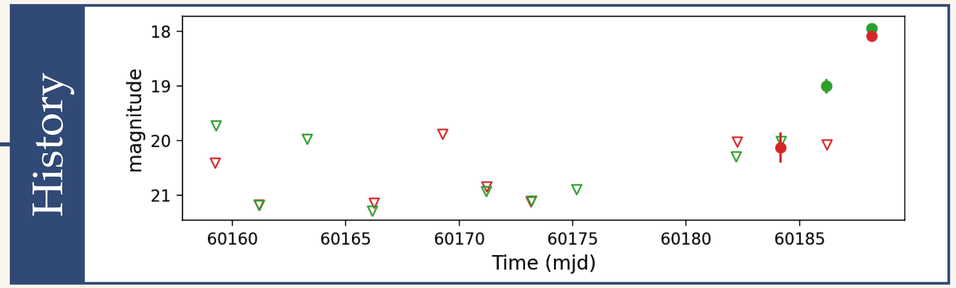
(~10min in ZTF)



Alert

Avro (kafka stream)



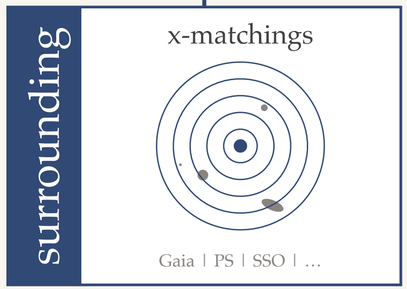


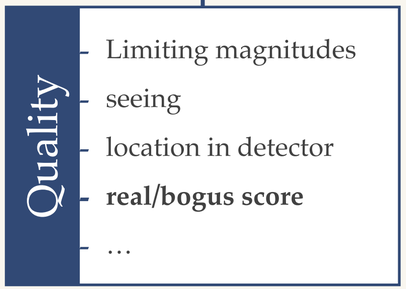
30 days alert in ZTF | few months force-photometry LSST

x10^5 / night

x10^6 / night

Big stream ! not for individual users





Broker | *Process the alert flow*

AMPEL | Nordin et al. 2019
Fink | Möller et al. 2020

ZTF | $O(10^5)$/day

LSST | $O(10^6)$/day

T0

FILTER
Which alerts are likely to match your interest?

T1

DB MANAGEMENT
Converts alerts into a transient

T2

SCIENCE ADDED VALUES
What do you want to know about the transient?

T3

DECISION MAKING
What do you want to do about it ?

French Broker
website | Doc
contact

German Broker
website | Doc
contact

LASAIR | UK
+4 "non-European"

Example | *Flash Spectroscopy*

ZTF | $O(10^5)$/day

LSST | $O(10^6)$/day

T0

FILTER

All that have at least 2 rising points in 2 bands
no detection yesterday & off the core & nearby

T1

DB MANAGEMENT

Converts alerts into a transient (already exist?)

T2

SCIENCE ADDED VALUES

None

T3

DECISION MAKING

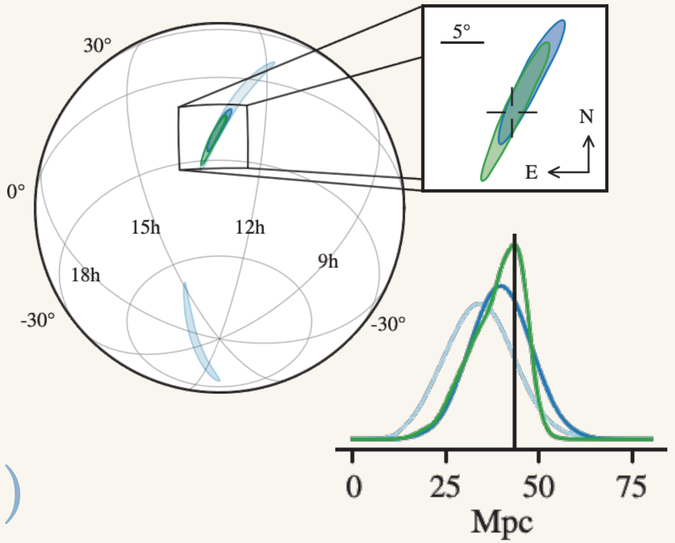
send emails arounds | Push to Slack/telegram

Trigger Spectrograph

Takes ~ 1 minute

Example | *Flash Spectroscopy*

ZTF | $O(10^5)$/day — Alerts — LSST | $O(10^6)$/day



T0

FILTER

Rewind the stream by 12h & give anything within a sky area

T1

DB MANAGEMENT

Converts alerts into a transient (already exist?)

T2

SCIENCE ADDED VALUES

Host Properties (z) | Could it be a real transient ? | "kilonovaness" score

T3

DECISION MAKING

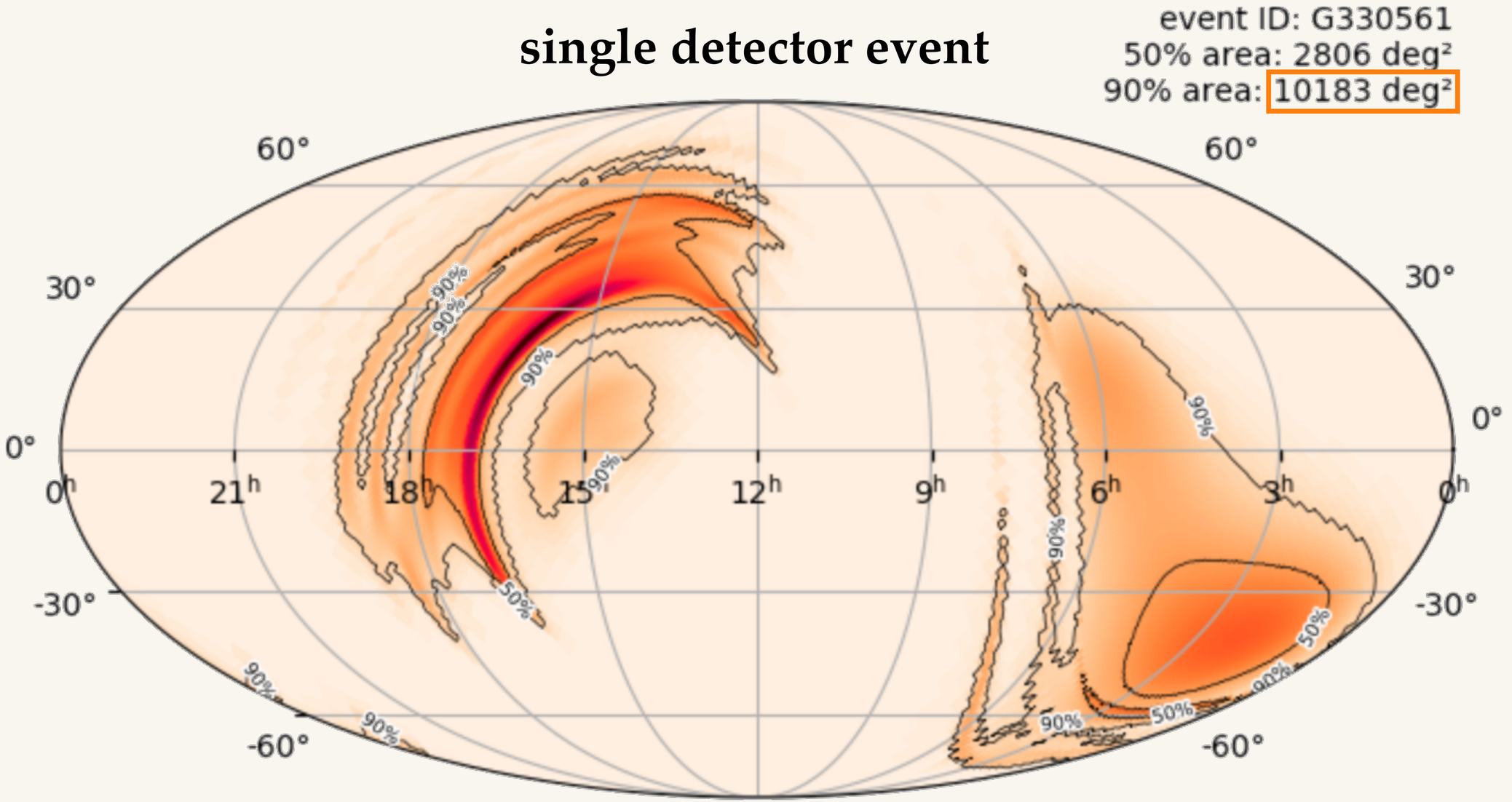
Notify user to trigger follow up

Push to slack | email | Publish a GCN/LVS Notice

Binary Neutron Star Event | *GW190425z*

Ligo/Virgo O3

single detector event



GW search | *BNS*

Ligo/Virgo O3

Found 22 output matching the criteria

too APPLI 11 h 24
Summary: 2019-09-07

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  ,_id,DESY_TOO_TEST
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3 0,ZTF19abaeiub,342.7762513,7.9168824,18.1737766265869,0.876688003540039,0.46000000834465,2458653.9415972,2458653.
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4 0,ZTF19abaejff,343.2315487,8.1177775,18.5571346282959,1.0,0.381428569555283,2458653.9420486,2458653.9420486,1,12.
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5 0,ZTF19abaejgs,340.5133117,10.8542407,18.3296947479248,0.00166666996665299,0.392857134342194,2458653.9420486,2458
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Full Photometry: 2019-09-07

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  ,jd,jdendhist,jdendref,jdstarthist,jdstartref,magap,magapbig,magdiff,magfromlim,maggaia,maggaiabright,magnr,magps
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  ,scorr,seeratio,sgmag1,sgmag2,sgmag3,sgscore1,sgscore2,sgscore3,sharpnr,sigmagap,sigmagapbig,sigmagnr,sigmapsf,si
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  oflag,tranId,xpos,ypos,zpclrcov,zpmed,ztf_name,most_recent_detection,first_detection,n_detections,DESY_TOO_TEST
2 0,715128695315015000,0.9819999933242798,0.41965800523757935,"[1, 2, 19,
  23]",0.6800000071525574,0.2905980050563812,0.4909...
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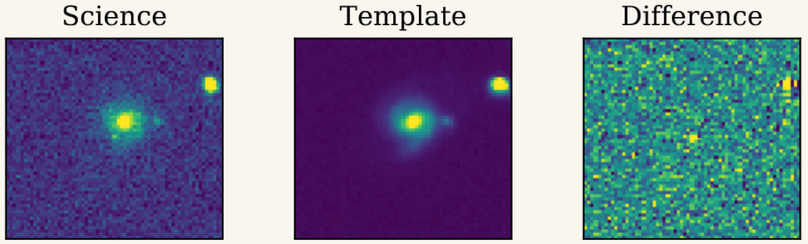
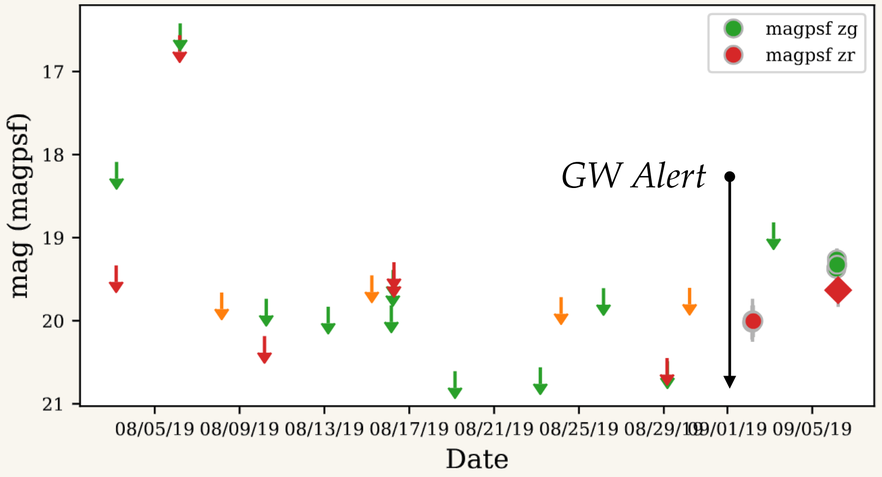
— Looking at potential candidate —

alert: ID: 978220762815015009 (RA: 220.34974 | Dec: 54.15111 | Filter: zr)





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nbad : 0.000
elong : 1.176
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sgscore3 : 0.5
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distpsnr3 : 13.6035718917847
srmag1 : 18.1639003753662
srmag2 : -999.0
srmag3 : 19.6291999816895

Robert Stein (DESY), Harsh Kumar (IITB), Michael Coughlin (Caltech), Varun Bhalerao (IITB), Shreya Anand (Caltech), Igor Andreoni (Caltech), Maitreya Khandagale (IITB), Kunal Deshmukh (IITB), Pradip Gatkine (UMD), Viraj Karambelkar (Caltech), Yashvi Sharma (Caltech), Mansi Kasliwal (Caltech), Tomas Ahumada (UMD), Leo P. Singer (NASA GSFC), Eric Bellm (UW):

On behalf of the Zwicky Transient Facility (ZTF) and Global Relay of Observatories Watching Transients Happen (GROWTH) collaborations:

We have continued observing the localization region of the gravitational wave trigger S190910d (LVC et al. GCN 25707) with the Palomar 48-inch telescope equipped with the 47 square degree ZTF camera (Bellm et al. 2019, Graham et al. 2019). In addition to the target-of opportunity observations beginning at UT 2019-09-04 10:18 UT which were already reported by us (Ananad et. al, GCN 25706), we have continued serendipitous observations of the localisation region. Each exposure was 30s, with a typical median depth of 20.6 mag. In total, we have now observed 34.6% of the enclosed probability map at least twice since merger, accounting for chip gaps.

The images were processed in real-time through the ZTF reduction and image subtraction pipelines at IPAC to search for potential counterparts (Masci et al. 2019). **AMPEL (Nordin et al. 2019) was used to search the alerts database for candidates**. We rejected stellar sources (Tachibana and Miller 2018) and moving objects, applied machine learning algorithms (Mahabal et al. 2019), and removed candidates with history of variability prior to the merger time. Four additional candidates were found by our pipeline, lying within the 95% probability region.

ZTF Name | IAU Name | RA (deg) | DEC (deg) | Filter | Mag | Magerr

GW search | *BNS*

Ligo/Virgo O3

Found 22 output matching the criteria

too APPLI 11 h 24
Summary: 2019-09-07

```
1 ,ztf_name,ra,dec,magpsf,sgscore1,rb,first_detection,most_recent_detection,n_detections,distnr,distpsnr1,isdiffpos
  ,_id,DESY_TOO_TEST
2 0,ZTF18abolwbb,344.7107927,8.2407861,19.883899688720703,MISSING,0.6666669845581055,2458469.6286921,2458733.815601
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3 0,ZTF19abaeiub,342.7762513,7.9168824,18.1737766265869,0.876688003540039,0.46000000834465,2458653.9415972,2458653.
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4 0,ZTF19abaejff,343.2315487,8.1177775,18.5571346282959,1.0,0.381428569555283,2458653.9420486,2458653.9420486,1,12.
  5434093475342,12.6535234451294,t,899442040215015007,True
5 0,ZTF19abaejgs,340.5133117,10.8542407,18.3296947479248,0.00166666996665299,0.392857134342194,2458653.9420486,2458
  653.9420486,1,4.49421834945679,16.6980838775635,t,899442042415015005,True
```

Full Photometry: 2019-09-07

```
1 ,_id,aimage,aimagerat,alFlags,bimage,bimagerat,chinr,chipsf,classtar,clrcoeff,clrcounc,clrmed,clrrms,dec,decnr,di
  ffmaglim,distnr,distpsnr1,distpsnr2,distpsnr3,drb,drbversion,dsdiff,dsnrms,elong,exptime,fid,field,fwhm,isdiffpos
  ,jd,jdendhist,jdendref,jdstarthist,jdstartref,magap,magapbig,magdiff,magfromlim,maggaia,maggaiabright,magnr,magps
  f,magzpsci,magzpscirms,magzpsciunc,mindtoedge,nbad,ncovhist,ndethist,neargaia,neargaiabright,nframesref,nid,nmatc
  hes,nmtchps,nneg,objectidps1,objectidps2,objectidps3,pdiffimfilename,pid,programid,ra,ranr,rb,rbversion,rcid,rfid
  ,scorr,seeratio,sgmag1,sgmag2,sgmag3,sgscore1,sgscore2,sgscore3,sharpnr,sigmagap,sigmagapbig,sigmagnr,sigmapsf,si
  mag1,simag2,simag3,sky,srmag1,srmag2,srmag3,ssdistnr,ssmagnr,ssnamenr,ssnrms,sumrat,szmag1,szmag2,szmag3,tblid,to
  oflag,tranId,xpos,ypos,zpclrcov,zpmed,ztf_name,most_recent_detection,first_detection,n_detections,DESY_TOO_TEST
2 0,715128695315015000,0.9819999933242798,0.41965800523757935,"[1, 2, 19,
  23]",0.6800000071525574,0.2905980050563812,0.4909...
```

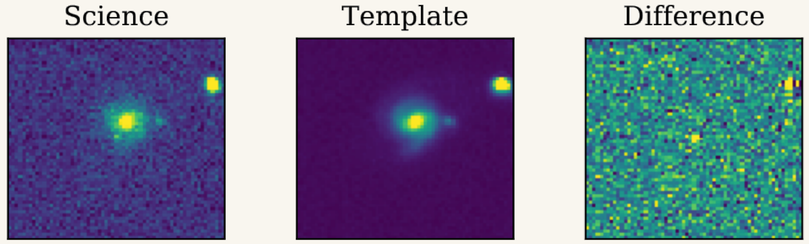
4h later….

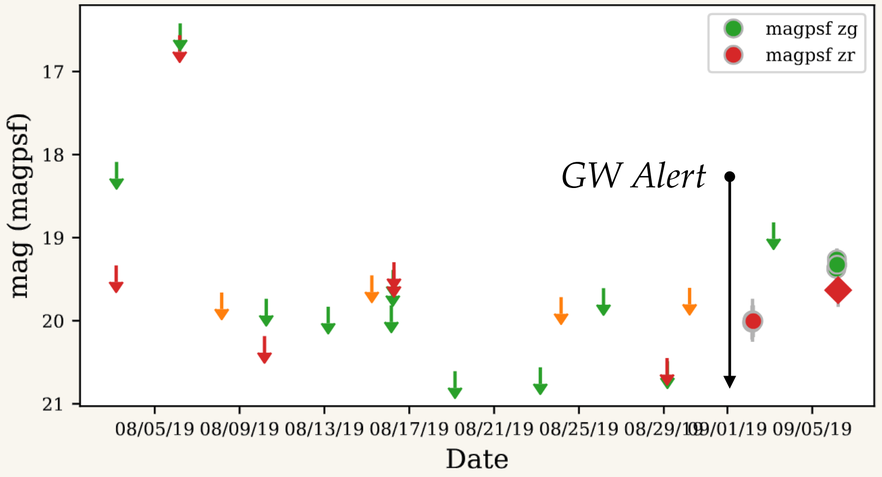
ZTF19abwvals has been classified as Ia btw:
https://gcn.gsfc.nasa.gov/gcn3/25675.gcn3

robertstein 15 h 56
Yes, I saw 😞

— Looking at potential candidate —

alert: ID: 978220762815015009 (RA: 220.34974 | Dec: 54.15111 | Filter: zr)



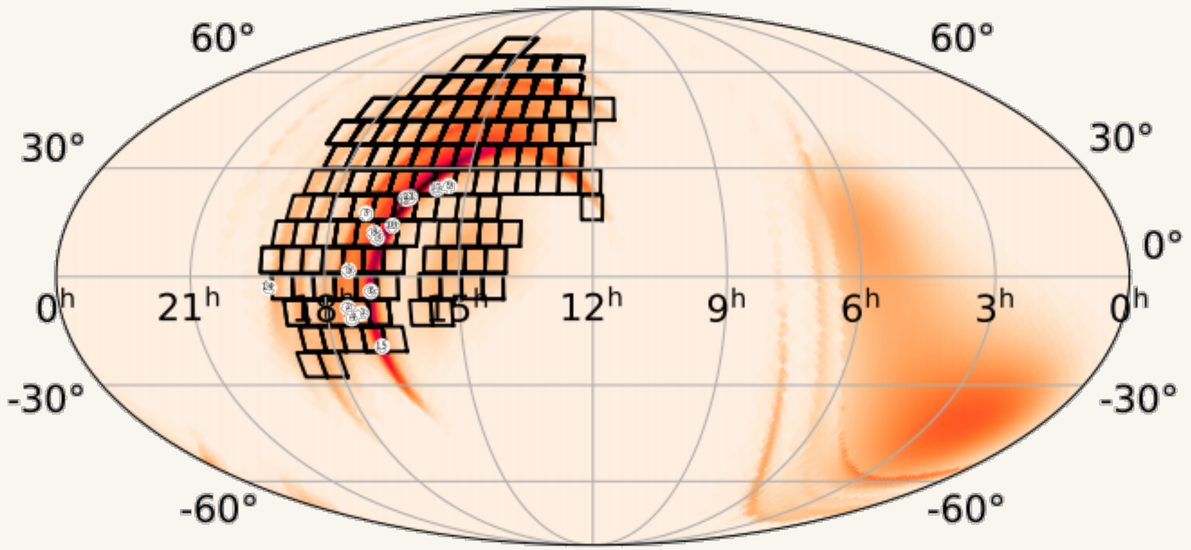


rb : 0.869
fwhm : 2.270
nbad : 0.000
elong : 1.176
isdiffpos : t
objectidps1 : 172982203482633712
objectidps2 : 172982203465482689
objectidps3 : 172982203437013557
sgscore1 : 0.0811963975429535
sgscore2 : 0.401762008666992
sgscore3 : 0.5
distpsnr1 : 5.93016958236694
distpsnr2 : 7.15922927856445
distpsnr3 : 13.6035718917847
srmag1 : 18.1639003753662
srmag2 : -999.0
srmag3 : 19.6291999816895

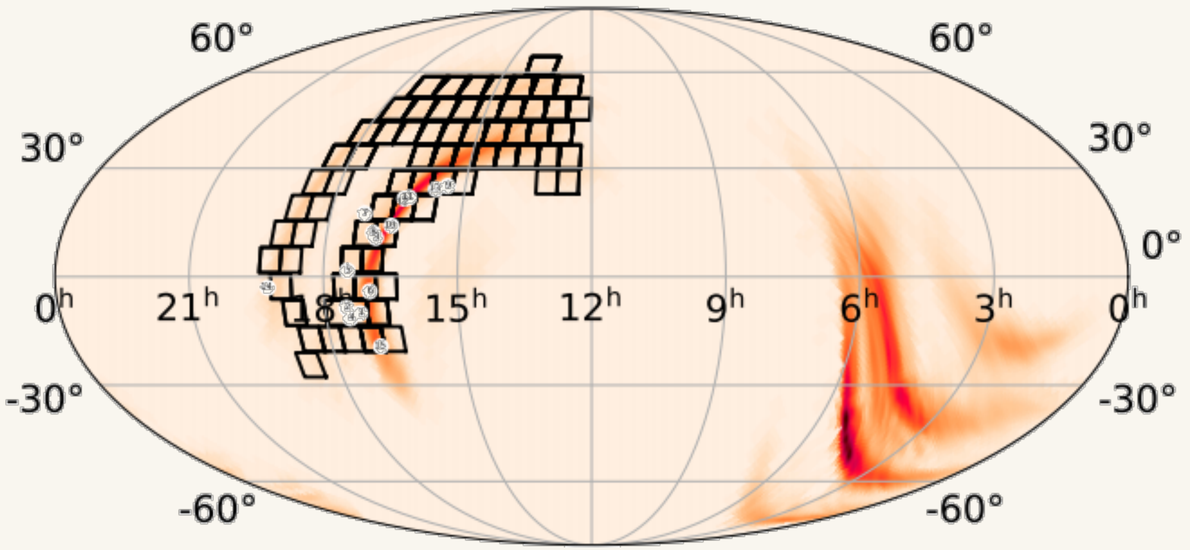
ZTF follow-up GW | *GW190425z*

Ligo/Virgo O3 | **single detector event** | **Coughlin et al. 2019**

Quick pipeline contours | **8000 deg²**



Final contours



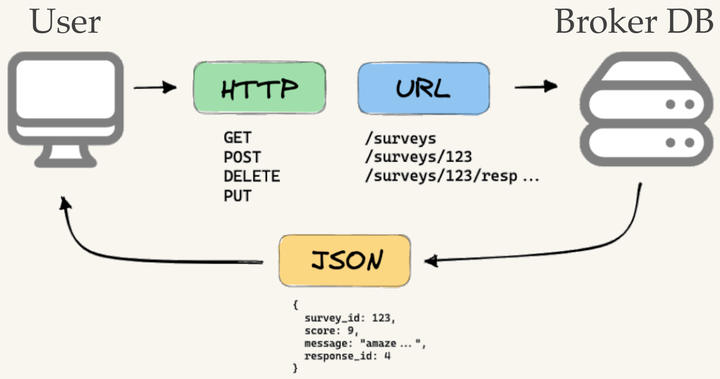
ZTF scanned 46% of confidence area in *3 hours in 2 bands* *(25% observing time used)*

338 646 alerts → **15 candidates counterparts** → **2 particularly interesting** → **All Supernovae…**

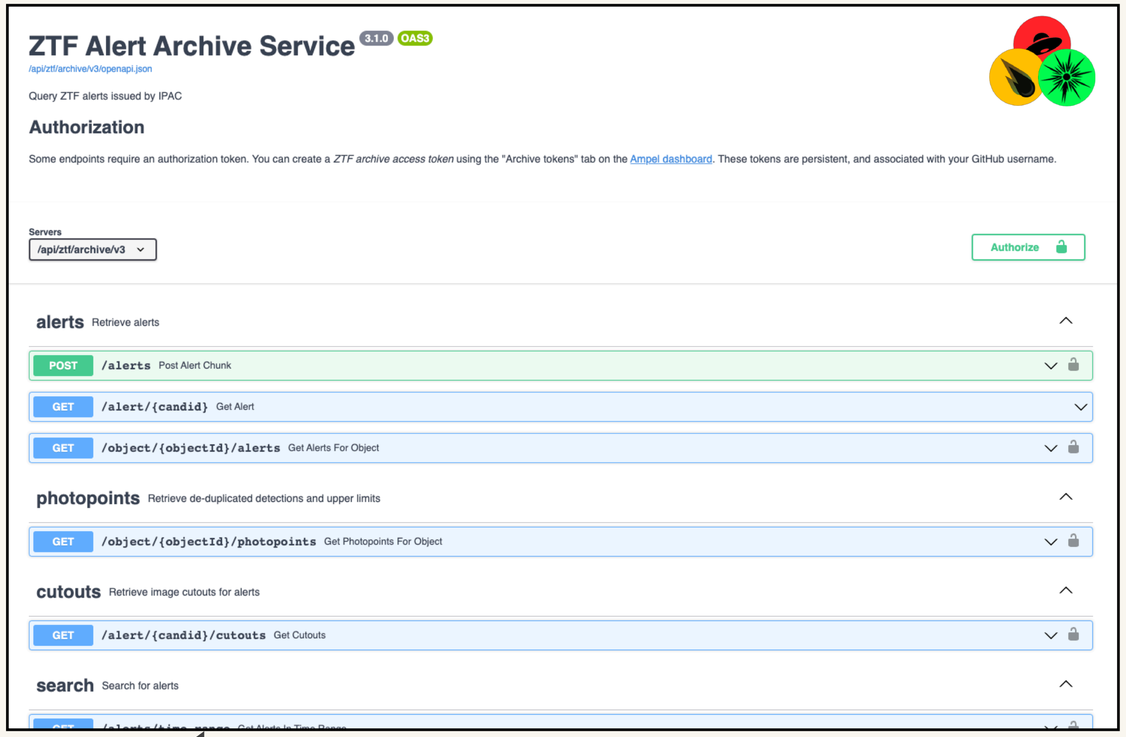
Interact with Alerts | *Brokers*

Public ZTF alerts are available as tarball here | **LSST alert will be public but only through Brokers**

Has a simple frontend



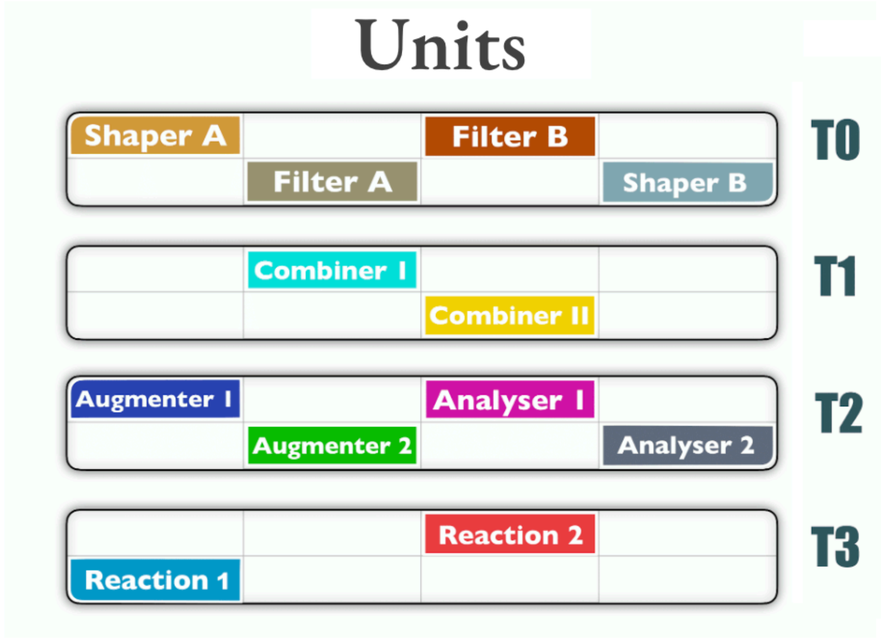
REST API



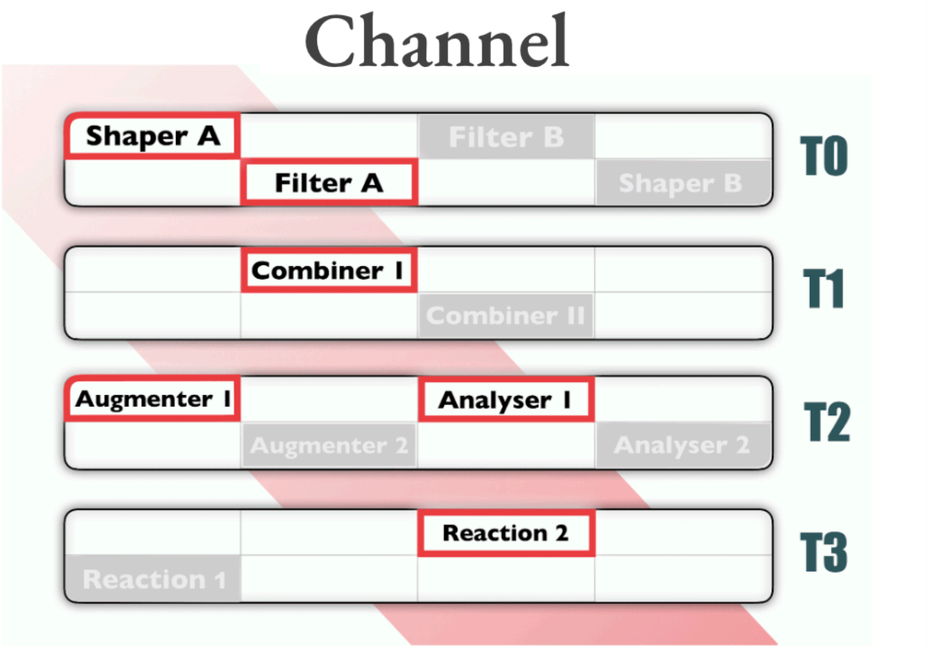
"Best" photo-typer from recent ELassTic LSST challenge

Build your own

What the Broker contains



What you want from it



Concept from J. Nordin for AMPEL

Code → Data

Your laptop will not handle 1 week of LSST alerts

Change the way you analyze data (You will have to)

1. Retrieve data
2. Run analysis software
3. Evaluate result

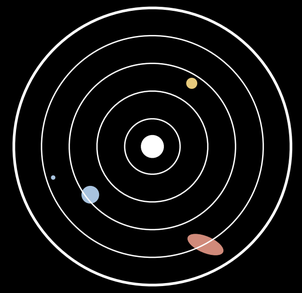
→

3. Define project goals
2. Develop and push software
1. Connect to data streams

ASK NOT WHAT YOUR BROKER CAN DO FOR YOU ASK WHAT YOU CAN DO FOR YOUR BROKER

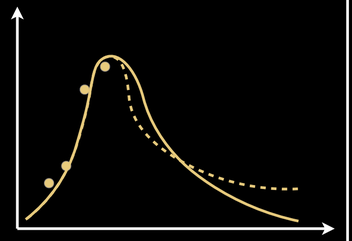
John F. Kennedy

T2 | cross-match



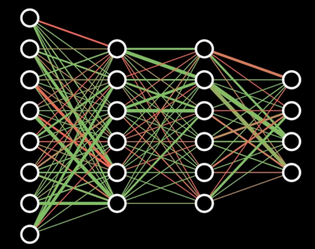
xMatch-NED
xMatch-MPC
xMatch-Catalog
…
YOURS

T2 | light-curves



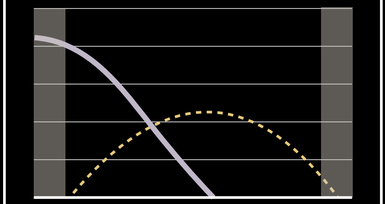
sncosmo-Ia
snoopy-Ia
lens-SN-param
RiseDeclineParam
…
YOURS

T2 | M.L.



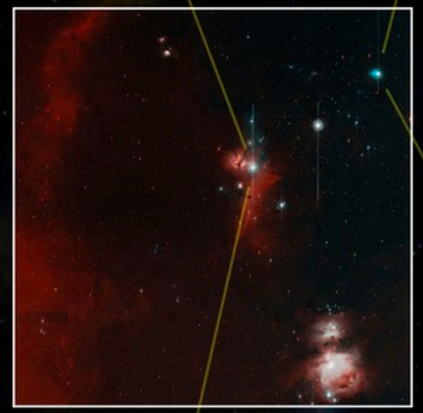
Parsnip-SNtype
"Kilonovaness"
SupersNNova
XgbClassifier
…
YOURS

T2 | Observing

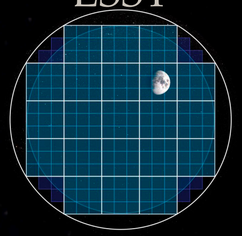


Observability
LCO-exptime
…
YOURS

T2



LSST



ZTF | $O(10^5)$/day

Alerts

LSST | $O(10^6)$/day

obs +10min

BROKERS

Fink (FR), **AMPEL** (DE) +5 others

Filter (*+yours*)

DB management

Science added values (*+yours*)

Reacts (*+yours*)

code

Small queries

user

user

user

Frontend

Skyportal, colibri, …

2020 2025 2030 2035

ZTF

ZTF

LSST

m.rigault@ip2i.in2p3.fr

Mickael Rigault