

# Lasair -The UK: LSST Transient Server

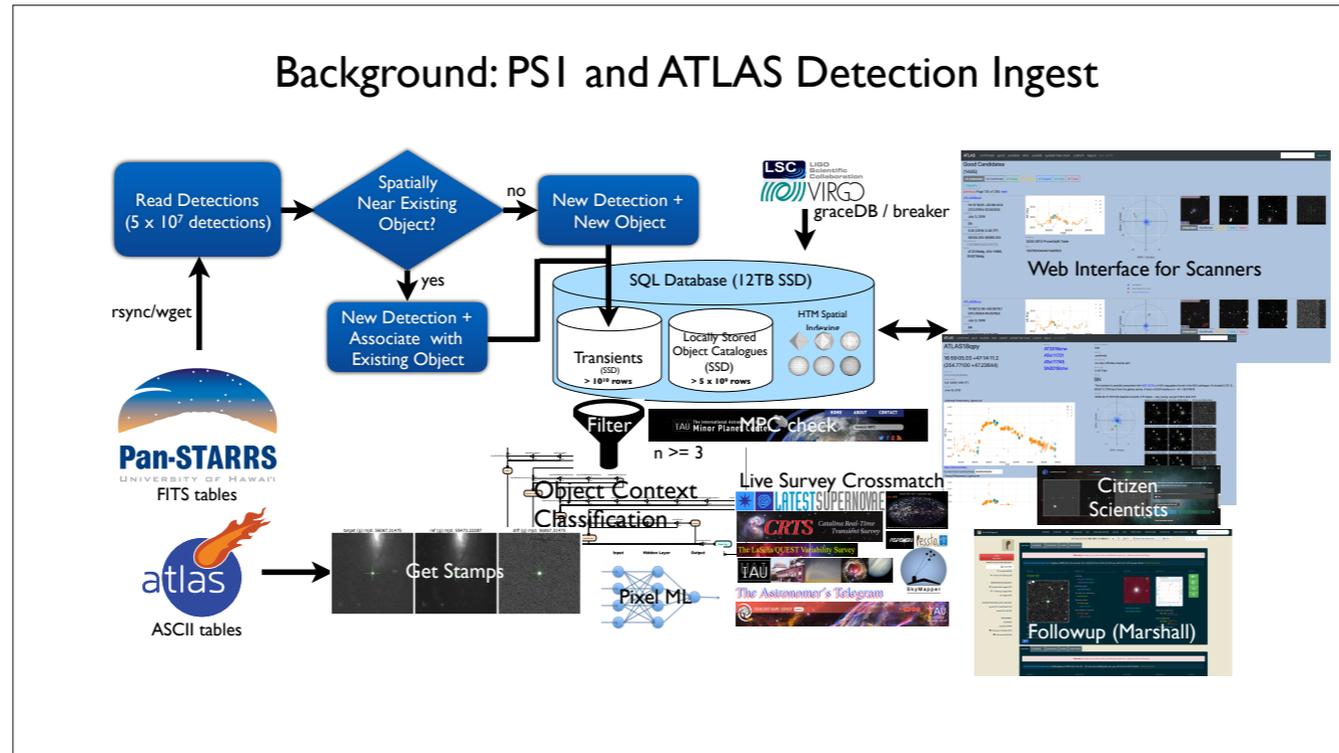
<https://lasair.roe.ac.uk>



Ken W. Smith

Smith, K. W., Williams, R. D., Young, D. R., et al. 2019, Research Notes of the American Astronomical Society, 3, 26  
<http://adsabs.harvard.edu/abs/2019RNAAS...3a..26S>

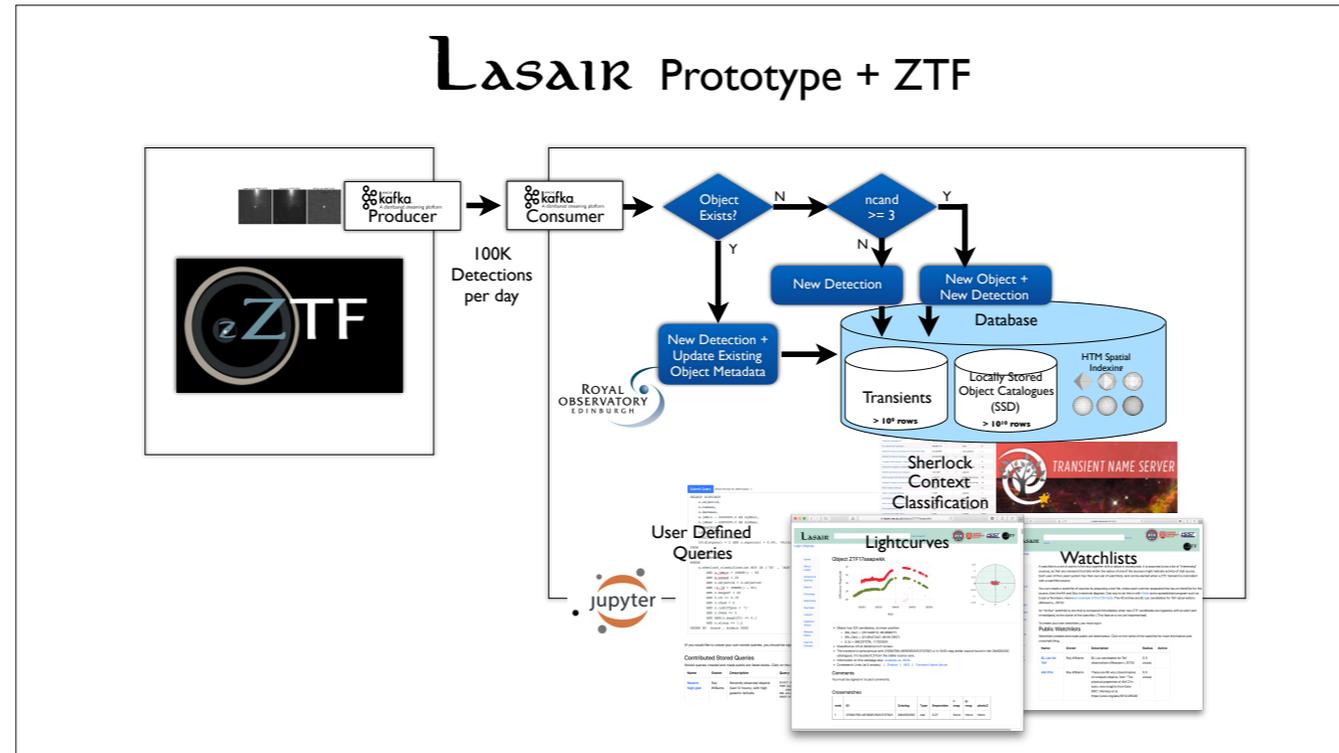
## Background: PSI and ATLAS Detection Ingest



Data comes from Pan-STARRS in the form of FITS binary tables. Data comes from ATLAS in the form of headed ascii text files. First thing we ask – is the object near to anything we have already ingested. (Build lightcurves). If so, create detection and associate with object. Otherwise create new object and new detection.

For ATLAS / PS1 only 1% objects are real (100k)

# Lasair Prototype + ZTF



The elements of the core services are already in place. Diagram shows our main web interface elements. Hardware is on order, so testing is being done on OpenStack VM platform.

# LASAIR Object search

by object name & coordinates

Discovery of 9 ASAS-SN Supernovae

During the ongoing All Sky Automated Survey for SuperNovae (ASAS-SN) using data from the quadruple 14-cm "Brutus" telescope in Haleakala, Hawaii, the quadruple 14-cm "Leavitt" telescope in Fort Davis, Texas, the quadruple 14-cm "P. Sutherland" telescope in Fort Davis, Texas, the quadruple 14-cm "Cassius" and "Tololo" telescopes in Chile, we discovered several new transient sources. Properties associated with these sources are shown in the archival imaging (left) and the right) are included in the table below:

Object	RA (J2000)	Dec (J2000)	mag	filter	Dist.
ASAS-SN18bnp	22:57:57.535	-22:03:14.700	16.0	g	2018
ASAS-SN18bna	00:48:03.105	+16:00:58.080	16.0	g	2018
ASAS-SN18bnl	02:22:45.7	-21:54:56.0	16.0	g	2018
ASAS-SN18bnm	24:33:39.280	-48:57:53.22	16.0	g	2018
ASAS-SN18bno	23:42:03.807	-42:38:18.74	16.0	g	2018
ASAS-SN18bnp	02:02:17.467	-13:56:34.77	16.0	g	2018
ASAS-SN18bnq	03:24:02.117	-17:33:44.95	16.0	g	2018
ASAS-SN18bnr	01:56:50.465	-67:43:27.59	16.0	g	2018

Cone Search

Enter RA and Dec and optionally radius in arcseconds, to search for objects in ZTF in that cone. They can be separated by spaces, commas, semicolons, or vertical bars. They can be in decimal degrees (floating point number), or sexagesimal in the form hh:mm:ss and dd:mm:ss or hh mm ss and dd mm ss. You can also enter an objectId, beginning with 'ZTF'.

RA Dec radius: 00:48:03.105 +16:00:58.08

Run Cone Search

RA,Dec,radius=12.01294,16.01613,5.0

1 objects found in cone

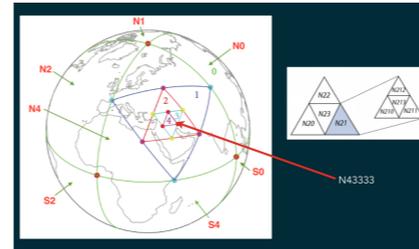
ZTF object	RA	Dec	Arcsec
ZTF18acdyppo	12.012851	16.016185	0.4

Objects can be searched for by ZTF name and also by coordinates (sexagesimal or decimal)

# Lasair Context Classification

“Sherlock” Catalogues (10<sup>10</sup> objects)

Description	Number Rows	Visible	NED	Objects	Weight (1-10)
Guide Star Catalogue 2.3	945,569,477	✓		stars	3
PS1 Universal Star Catalogue	706,861,417			stars	6
SDSS DR12 Stars and Galaxies from PhotoObjAll Table	474,036,669			stars, galaxies	7
2MASS Point Source Catalogue	470,862,970	✓	✓	stars	5
A stream of NED sources – built as transients matched again	13,703,332		✓	multiple	8
SDSS DR12 Galaxies and QSOs from specObjAll table	3,050,811			galaxies, QSOs	10
2MASS Extended Source Catalogue	1,647,599	✓	✓	galaxies	5
Million Quasars (MLLQAS) Catalog	1,153,111			QSOs, AGN, BL Lac	10
Catalog of Quasars and Active Galactic Nuclei by Veron-Cett	169,944	✓		QSOs, AGN, BL Lac	10
NED-D Galaxy Catalogue	94,959			galaxies	8
Kepler 2 Campaign Galaxies	11,905			galaxies	7
Coordinates parsed from ATLAS	6,316			multiple	None
SNe in the Bright Supernova List	6,289			SNe	None
SN candidates from PSBT	5,855			SN Candidates	None
Transients from CRTS - MLS	5,437			multiple	None
Transients from CRTS - CSS	5,083			multiple	None
SN candidates from LSQ	3,031			SN Candidates	None
Catalog and Atlas of Cataclysmic Variables	1,830	✓		CVs	10
Cataclysmic Binaries Catalog	1,721	✓		CVs, LMXB	10
Galaxies from the IFS survey	1,088			galaxies	10
The all-transients stream from ASASSN	1,002			multiple	None
Candidate from TOCP pages	836			multiple	None
SN candidates from the OGLE survey	728			SN Candidates	None
Transients from CRTS - SSS	694			multiple	None
SN candidates from PESSTO users	487			SN Candidates	None
The uncertain SN stream from ASASSN	308			SN Candidates	None



HTM Indexing Scheme

MySQL Catalogue Database

- at the heart of the classifier is an ever growing database of catalogues and streams that can be crossmatched against
- each table is indexed with the HTM indexing scheme (levels 10, 13 and 16)
- we can exploit the local DAC infrastructure to include catalogues in Edinburgh

# LASAIR Context Classification

## “Sherlock”: Programmable Algorithms for Event Annotation

```
search algorithm:  
  GSC star 1:  
    database table: tcs_view_star_guide_star_catalogue_v2_3  
    mag column: V  
    bright:  
      mag limit: 16.  
      angular radius arcsec: 100.0  
      synonym: VS  
      association: BS  
    faint:  
      mag limit: 19.5  
      angular radius arcsec: 2.0  
      annotation: SN  
    general:  
      angular radius arcsec: 0.5  
      synonym: VS  
  GSC star 2:  
    database table: tcs_view_star_guide_star_catalogue_v2_3  
    mag column: B  
    bright:  
      mag limit: 16.  
      angular radius arcsec: 100.0  
      synonym: VS  
      association: BS  
    faint:  
      mag limit: 19.5  
      angular radius arcsec: 2.0  
      annotation: SN  
    general:  
      angular radius arcsec: 0.5  
      synonym: VS  
  GSC unknown:  
    database table: tcs_view_unknown_guide_star_catalogue_v2_3  
    general:  
      angular radius arcsec: 2.0  
      annotation: UNCLEAR  
  2mass star:
```

### Search Module Parameters

- angular separation crossmatch radius
- physical separation crossmatch radius
- source magnitude filtering
- magnitude dependent search radii for bright stars and galaxies

### Classifications & Reliabilities

- transient given a predicted classification based on the parameters of the catalogued source it matches against
- transients can be given multiple classifications which are later ranked
- a transient can either be **synonymous** with (within 0.5"), **associated** with (>0.5" away) or **annotated** by a catalogued source

Search Algorithms are written in  
YAML - plain text

- although the code for Sherlock is written in python, the search algorithm is abstracted into a plain text YAML file
- advantages are that various search algorithms can be switched out without changing code, and algorithms are easy to write and adapt by anyone
- The algorithm is made of multiple ‘search modules’ - if a transient yields to all the criteria of the search module and matches against a source in the catalogue it is given the suggested classification and reliability (synonymous, association or annotation)

# Lasair Context Classification

How to search

Login | Signup

- Home
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- Search
- Coverage
- Watchlists
- Skymaps
- Jupyter
- Ingestion Status
- Release Notes
- Team & Contact

## Object ZTF19aabyuzq

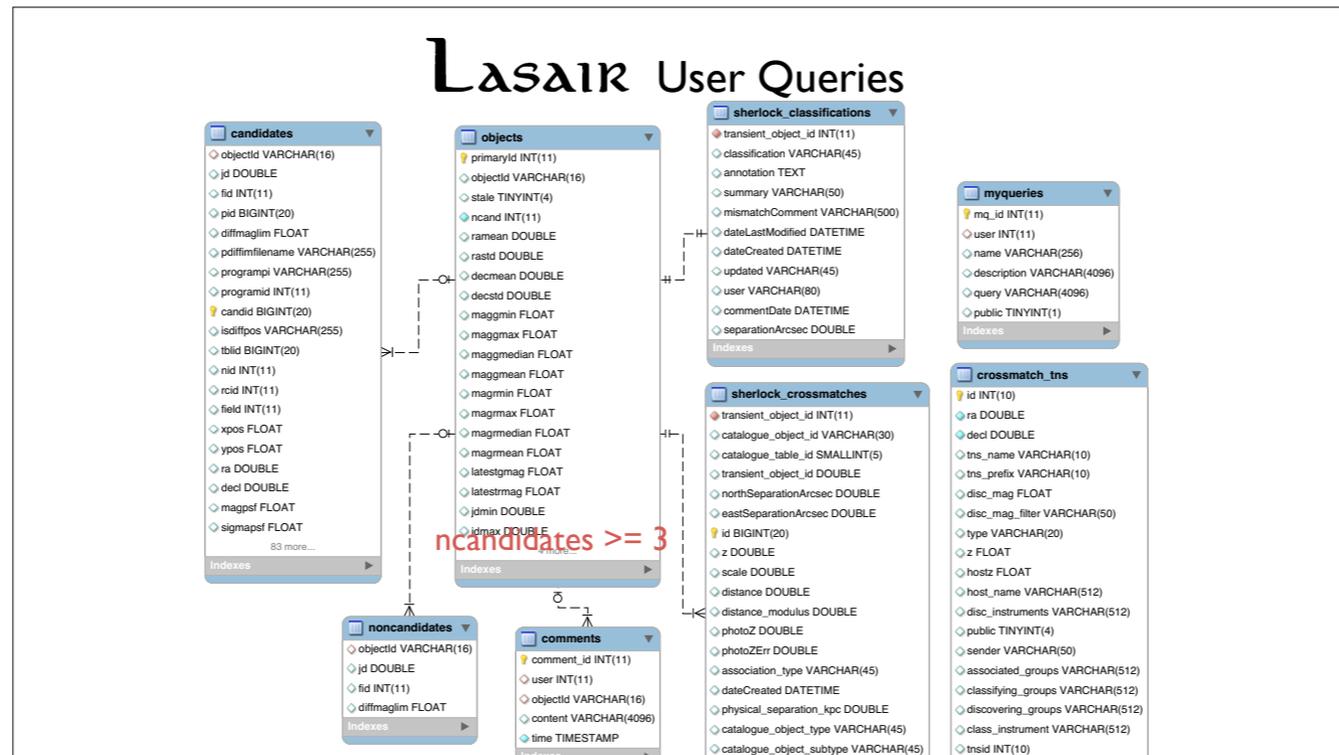
- Object has 22 candidates, at mean position:
  - (RA, Dec) = (190.407813, 48.268959)
  - (RA, Dec) = (12:41:37.875, 48:16:8.254)
  - (l, b) = (127.442522, 68.773313)
- Classified as SN at distance 2.05 arcsec.
- The transient is possibly associated with [SDSS J12413768+481608.0](#); an  $r=18.88$  mag galaxy found in the SDSS DR12 PhotoObjAll Table catalogue. It's located 0.31 N, 2.03 E (3.9 Kpc) from the galaxy centre. A host photoZ=0.104 ( $\pm 0.040$ ) implies a transient  $M = -18.59$ .
- Information on this webpage also available as [JSCR](#).
- Conesearch Links (at 5 arcsec): | [Simbad](#) | [NED](#) | [Transient Name Server](#)

### Comments

Lasair	Jan. 26, 2019,	In TNS as <a href="#">AT2019ql</a> at 0.1 arcsec, discovered 2019-01-08 12:55:11
Bot	1:36 p.m.	(MJD 58491.00) by ZTF

Sherlock will make a high level statement about the type of object, the suspected host, and the estimated absolute magnitude at discovery.

# Lasair User Queries



Quick overview of the main database tables (in particular candidates, objects, sherlock\_crossmatches)

# LASAIR User Queries

User can make their own queries and choose private or public

Community provided public queries

Default “stream” queries supplied

The screenshot shows a web browser window with the URL `lasair.roe.ac.uk/objlist/`. The main content area is a query editor with a blue border. It contains a SQL query that selects distinct columns from `objects` and `candidates` tables, filtered by various conditions including `o.sherlock_classification`, `o.jdmin`, `o.jdmax`, `o.magrmis`, `l1strmag`, and `IF(distpsnr1 < 2 AND c.sgscore1 > 0.49, 'Within Zaresec of PS1 star', 'Not Near PS1 star') score`. The query is ordered by `score` and `jdmin` in descending order.

Below the query editor, there is a note: "(If you would like to create your own stored queries, you should be signed in. See links at top left.)".

The section titled "Contributed Stored Queries" contains a table with the following data:

Name	Owner	Description	Query
Recent high galat	Roy Williams	Recently observed objects (last 12 hours), with high galactic latitude.	<code>SELECT objectId, hcmd FROM objects WHERE (jmax &gt; jnow) - 8.5 AND abs(latitude) &gt; 38.8 ORDER BY hcmd DESC</code>
Recent solar system	Roy Williams	Recently observed solar system candidates (last 12 hours)	<code>SELECT objectId, sname AS magnitude, sname AS MPC_name FROM candidates WHERE (jmax &gt; jnow) - 8.5 AND (jd &gt; jnow) - 8.5 ORDER BY jd DESC</code>
Active CVs	Roy Williams	Cataclysmic variables with wide swarms in magnitude.	<code>SELECT objectId, hcmd, magmean, magmean FROM objects WHERE</code>

Users can generate their own queries.

Template queries are supplied and these can be cut & pasted and modified as necessary

Three default “stream” queries are supplied.

# Lasair Watchlists

Lasair  [help to search](#)

Logged in as ken ([Logout](#))

- Home
- About Lasair
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- Search
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- Skymaps
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A watchlist is a set of points in the sky, together with a radius in arcseconds. It is assumed to be a list of "interesting" sources, so that any transient that falls within the radius of one of the sources might indicate activity of that source. Each user of the Lasair system has their own set of watchlists, and can be alerted when a ZTF transient is coincident with a watchlist source.

You can create a watchlist of sources by preparing a text file, where each comma-separated line has an identifier for the source, then the RA and Dec in decimal degrees. One way to do this is with [Vizier](#) and a spreadsheet program such as Excel or Numbers. Here is [an example of the CSV data](#). The 42 entries are *BL Lac candidates for TeV observations (Massaro+, 2013)*

An "Active" watchlist is one that is compared immediately when new ZTF candidates are ingested, with an alert sent immediately to the owner of the watchlist. (This feature is not yet implemented).

[Create new watchlist](#)

**Up to several thousand objects per list (at the moment)**

### My Watchlists

Your private watchlists are listed below. Click "Create new watchlist" above to make a new one. Click on the name of the watchlist for more information and crossmatching.

Name	Description	Radius	Active	Public
				<input type="checkbox"/>

**Can be public or private**

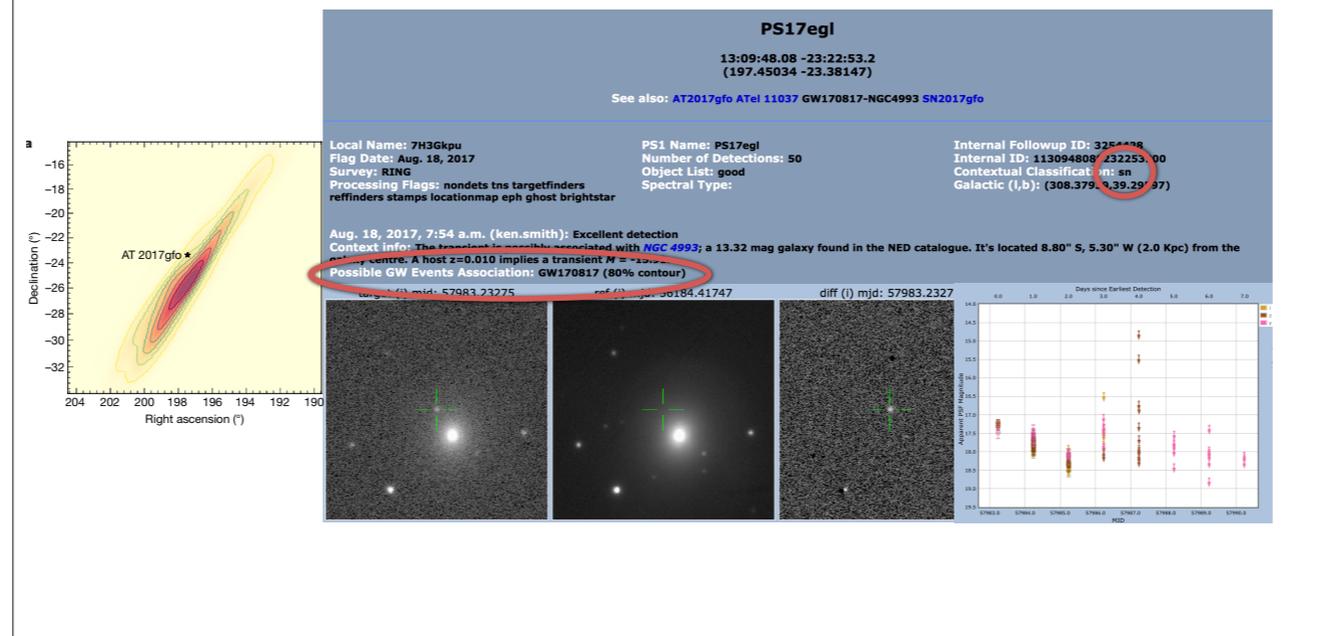
### Public Watchlists

Watchlists created and made public are listed below. Click on the name of the watchlist for more information and crossmatching.

Name	Owner	Description	Radius	Active
<a href="#">BL Lac for TeV</a>	Roy Williams	BL Lac candidates for TeV observations (Massaro+, 2013)	0.5 arcsec	
<a href="#">AM CVn</a>	Roy Williams	These are 56 very close binaries of compact objects, from "The physical properties of AM CVn stars: new insights from Gaia DR2", Ramsey et al, <a href="https://arxiv.org/abs/1810.06548">https://arxiv.org/abs/1810.06548</a>	5.0 arcsec	

Users can add watchlists of up to a few thousand of their favourite galaxies, AGNs, CVs, etc. These will automatically be crossmatched during data ingest.

# Coming Soon: LASAIR GW Event Tagging



We already tag objects with the GW contour

# Lasair UK Workshop

October 2018: Resulting Requirements

## **Near term requirements**

LIGO - Virgo object tagging for O3 (starting soon!)  
APIs (e.g. TAP service for querying Lasair)  
User defined alert mechanism (e.g. SMS)  
Mobile version of web interface.

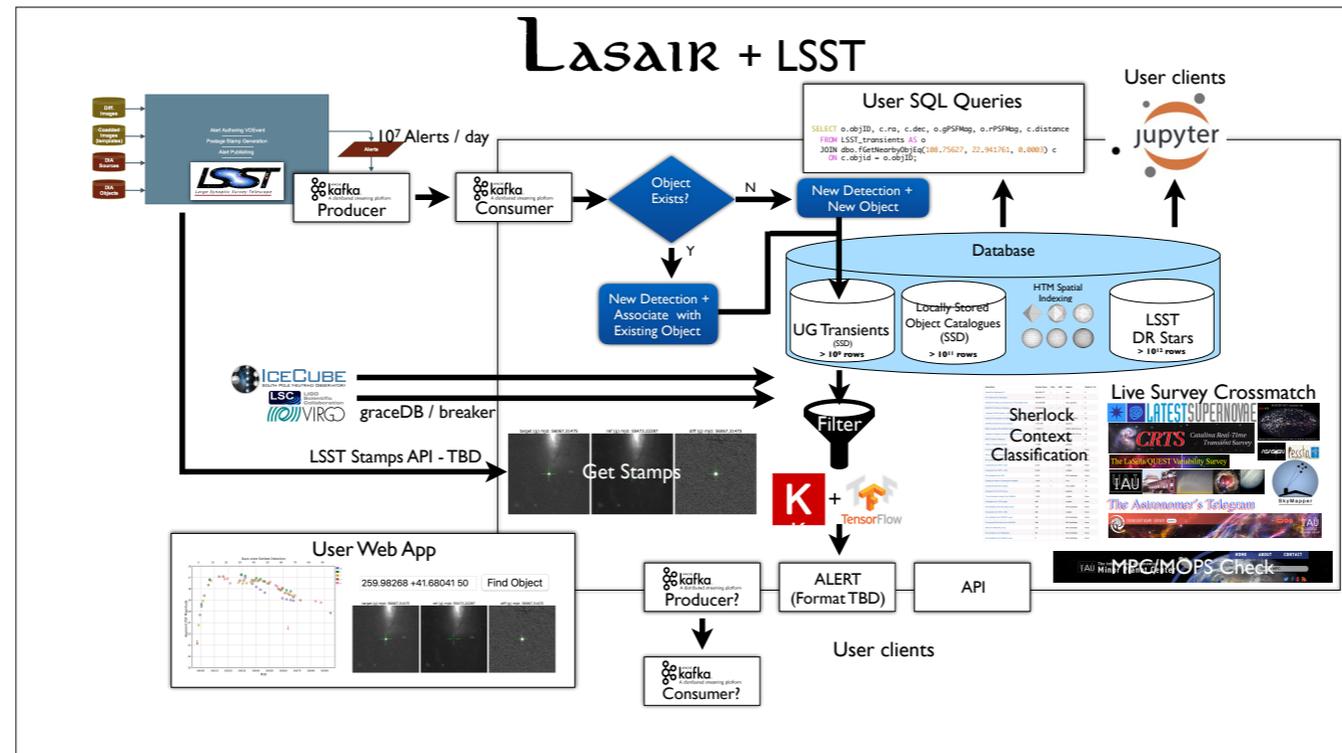
## **Jupyter:**

Make Jupyter available to all users - with "Overviews", "How-tos", "Getting started" pages  
Provide standard queries for Jupyter notebooks  
Allow private areas/folders and the ability to define groups within the Jupyter hub  
Have ability for Jupyter notebooks to run automatically.

## **Longer term requirements**

Provide a mechanism for allowing lightcurve analysis code to be uploaded  
Vizier integration to allow spectra of objects in watch list to be pulled  
Model and empirical lightcurve fitting  
Lightcurve mashing from user-provided and other surveys  
VISTA and or UKIDSS stamps  
EUCLID: optical and NIR images, high-resolution stamps of transient location  
HST and Spitzer overlap. Provide postage stamp of the pre-discovery position  
Store transmission characteristics of filters for mapping lightcurves

Who attended? What were the outcomes? Jupyter Notebooks, queries. About 20 attendees from around the UK



What is our vision of the Transient Server. Perhaps something like this. UG = User Generated = L1. DR = Data Release = L2. MARS have built their web interface atop the same API which they expose to users.

# Lasair Next Steps

Deploy DAC hardware and scale up from ZTF to LSST, including database replication

Lightcurves – assimilate all diaSource alerts in diaObjects: providing interactive webpages (linked to database), plots, ability to select ranges, submit user added points. Previous history from Pan-STARRS, DES, Skymapper, ATLAS, CRTS, PTF/ZTF

Postage stamps (if available) – all LSST detections and most recent non-detections. Plus multi-colour images from LSST, near infra-red (VISTA/UKIDSS), H-alpha (VPHAS) and EUCLID, or HST/JWST if space based imaging is available.

Massive catalogue cross-match - with star, galaxy, AGN, x-ray, radio catalogues and provide enhanced classification (e.g. integrating machine learning) via "Sherlock"

In real-time, cross-match to all other wavelength time-domain surveys : gamma-ray, x-ray and radio (e.g. MEERKat/Thunderkat through 4pisky.org, Swift, SVOM, eRosita)

Cross match to all previously known transients: supernovae, transients, gamma ray-bursts, x-ray and radio burst sources (e.g. searching for currently unknown physical links over the time dimension)

Provide absolute mags when likely host spectroscopic (or photoZ) information is available

Probabilistically classify all transients as: supernova – kilonova – GRB – Tidal Disruption Event – AGN – XRB – CV – eruption star – microlens – orphan (e.g. use of first 24-48hrs lightcurve - rapid rise/decline?)

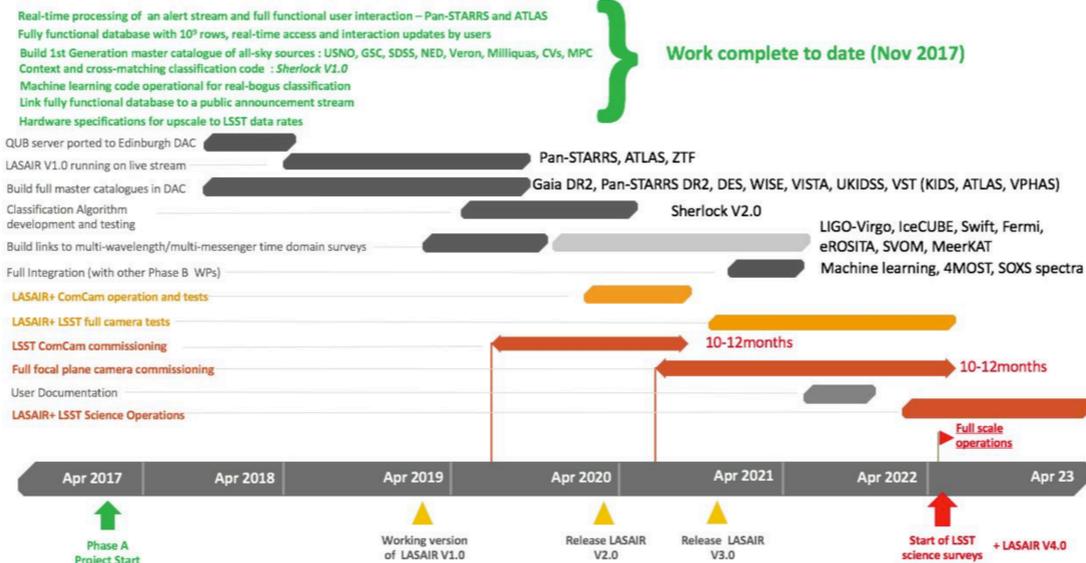
Multi-messenger cross-matching: 4D coincidence tag for LIGO/Virgo + IceCube

TOM outgest - especially 4MOST and SOXS

Machine learning algorithms for real-bogus classification

Lightcurve fitting

# LASAIR Current Plan



# Lasair is being used!

(26 ATels as of Feb 18 2019)

## SOAR telescope spectroscopic classification of optical transients

## FDST spectroscopic classification of SN 2019awc

ATel #12508; *R. Cartier (CTIO), G. Terreran, R. Margu (CTIO)*  
on 16 Feb 2019; 20:07 UT  
Distributed as an Instant Email Notice  
Credential Certification: Regis Cartier (rgc)

ATel #12503; *C. P. Gutierrez (University of Southampton), C. Frohmaier (University of Portsmouth - ICG), T. Muller-Bravo (University of Southampton), C. Inserra (Cardiff University), J. Anderson (ESO), C. Angus (University of Southampton), R. Cartier (CTIO), T.-W. Chen (MPE), T. de Jaeger (UC Berkeley), L. Galbany (University of Pittsburg), S. Gonzalez-Gaitan (CENTRA), M. Grayling (University of Southampton), H. Kuncarayakti (University of Turku), J. Lyman (University of Warwick), A. Pastorello (INAF - Padova Astronomical Observatory) M. Pursiainen (University of Southampton), R. Roy (IUCAA), T. Schweyer (MPE), M. Smith (University of Southampton), M. Sullivan (University of Southampton), P. Wiseman (University of Southampton).*

on 14 Feb 2019; 18:40 UT

Credential Certification: *Claudia Gutierrez (c.p.gutierrez-avendano@soton.ac.uk)*

Subjects: Optical, Supernovae



Tweet

We report the following supernova classifications. The targets were observed through the Lasair broker (<http://lasair.roe.ac.uk/>), the ESA C and DPAC (<http://gsaweb.ast.cam.ac.uk/alerts>), and by the A PASP, 123, 58) and Tonry et al. (ATel #8680). The observation was performed on February 13 at the 4.1-m SOAR Telescope equipped with a Spectrograph using the 400 lines/mm grating, and a slit width of 1.5 arcseconds. Spectral coverage from 380 nm to 775 nm with a resolution of 10000. The observation was performed with SNID (Blondin & Tonry, 2007, ApJ, 666, 1024) and Gelato (Blondin & Tonry, 2007, ApJ, 666, 1024).

Subjects: Optical, Supernovae, Transient



Tweet

Survey Name	IAU Name	RA (J2000)	Dec (J2000)	Disc. Date
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The observations were performed on 2019-02-13 using SPRAT (Piascik et al 2014) on the Liverpool

Questions