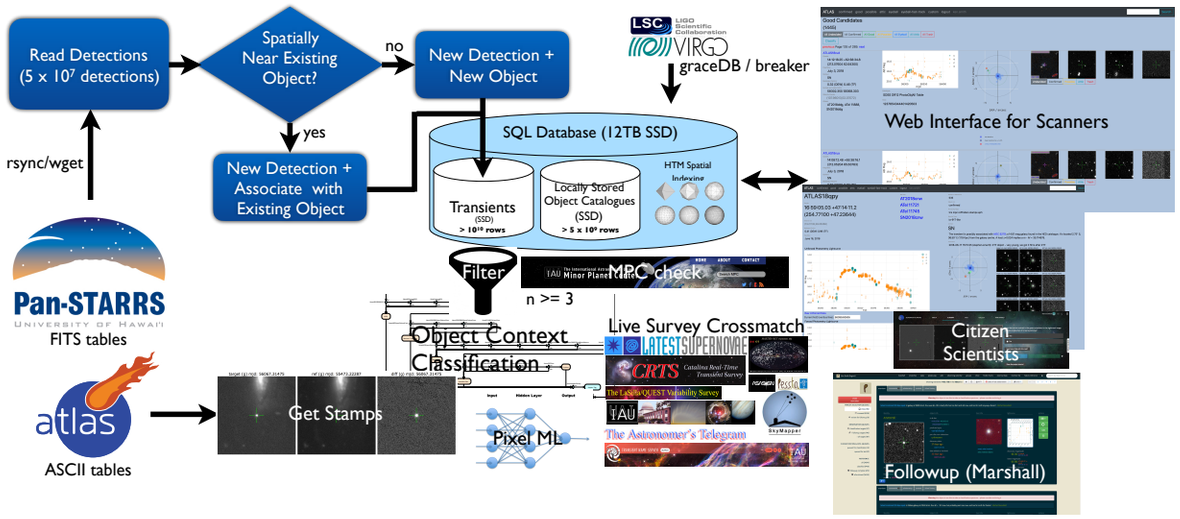
Lasair -The UK: LSST Transient Server

https://lasair.roe.ac.uk

Ken W. Smith

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

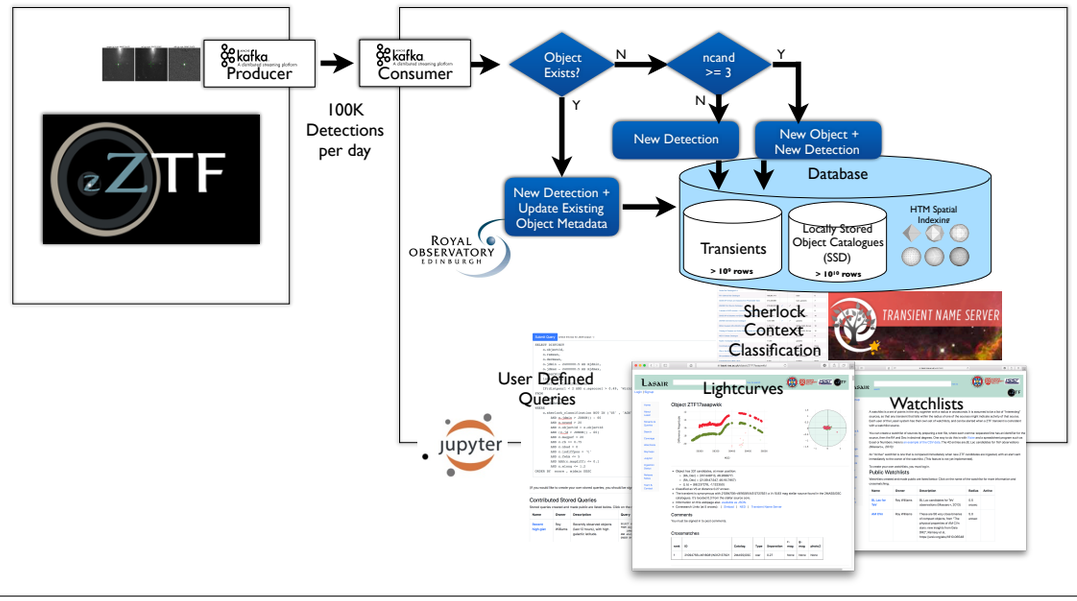
Background: PS1 and ATLAS Detection Ingest



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)

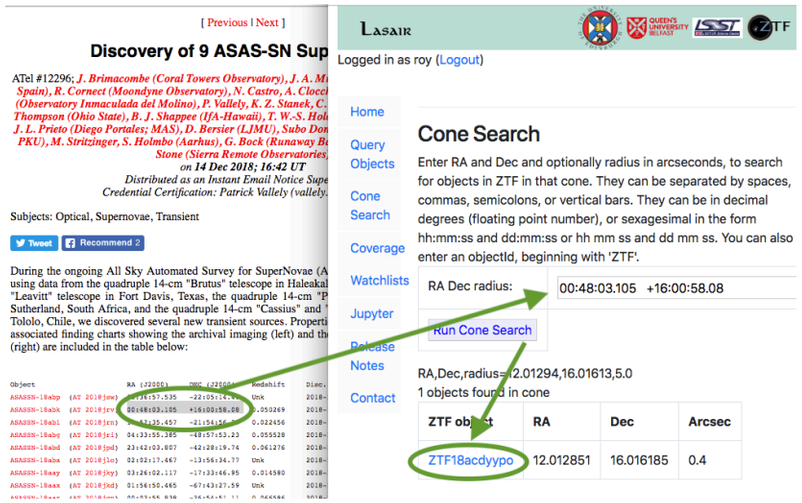
Lasair Prototype + ZTF



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

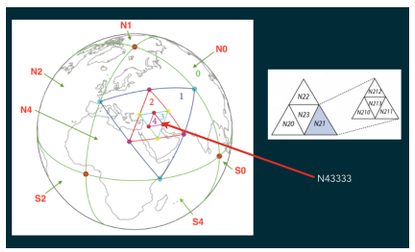


Objects can be searched for by ZTF name and also by coordinates (sexagesimal or decimal)

Lasair Context Classification

"Sherlock" Catalogues (10^{10} objects)

Description	Number Rows	Vizier	NED	Objects	Weight (1-10)
Guide Star Catalogue 2.3	945,569,477	✓		stars	3
PS1 Ubercal Star Catalogue	706,861,417			stars	6
SDSS DR12 Stars and Galaxies from PhotoObjAll Table	474,039,669			stars, galaxies	7
2MASS Point Source Catalogue	470,992,970	✓	✓	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 (MILLIQUAS) Catalog	1,153,111			QSOs, AGN, BL Lac	10
Catalog of Quasars and Active Galactic Nuclei by Veron-Cett	168,944	✓		QSOs, AGN, BL Lac	10
NED-D Galaxy Catalogue	94,959			galaxies	8
Kepler 2 Campaign Galaxies	11,905			galaxies	7
Coordinates parsed from ATels	6,316			multiple	None
SNe in the Bright Supernova List	6,289			SNe	None
SN candidates from PSST	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 potential PN stream from ASASSN	308			SN Candidates	None



HTM Indexing Scheme

MySQL Catalogue Database

- at the heart of 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

```yaml
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*

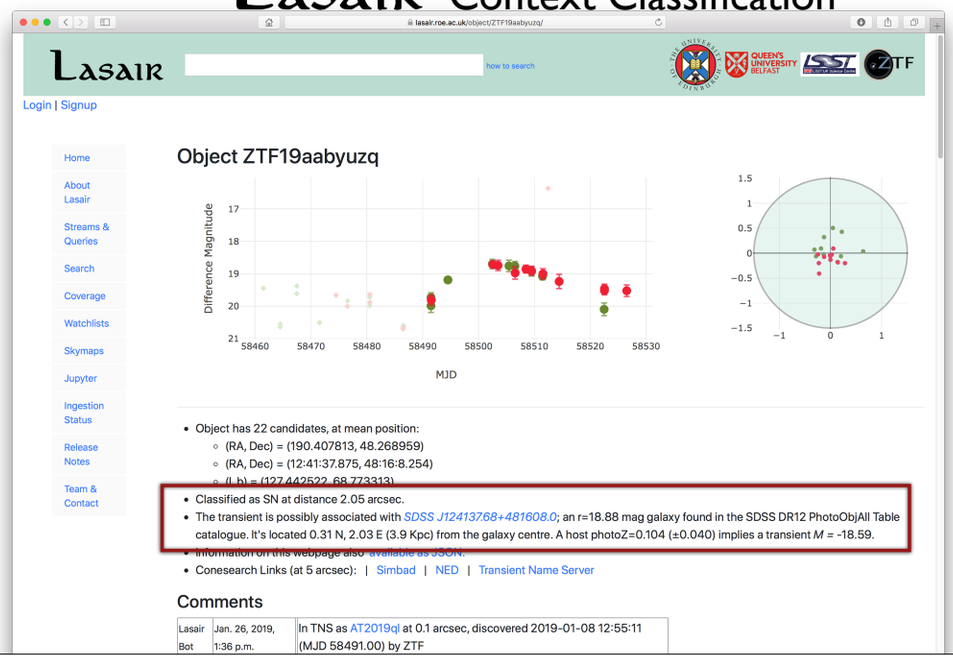
Classifications & Reliabilities

- *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

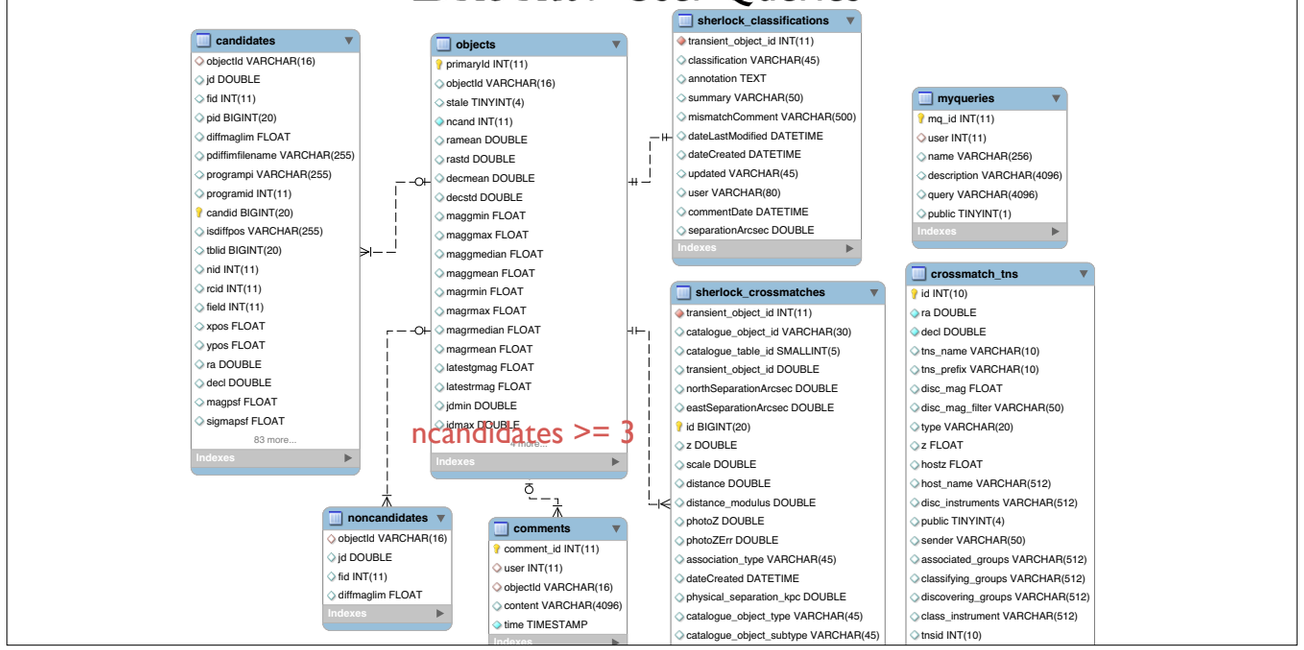
- although the code for Sherlock is written in python, the search algorithm is abstracted into a plain text YAML file
- advantages are that various search algorithms can be switched out without changing code, and algorithms are easy to write and adapt by anyone
- The algorithm is made of multiple ‘search 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



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

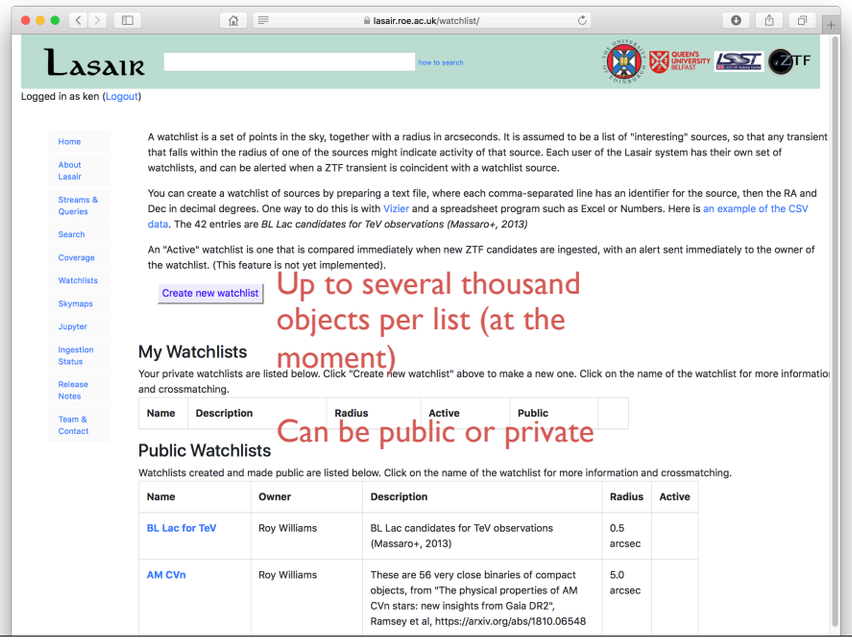
User can make their own queries and choose private or public

Community provided public queries

Default “stream” queries supplied

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



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

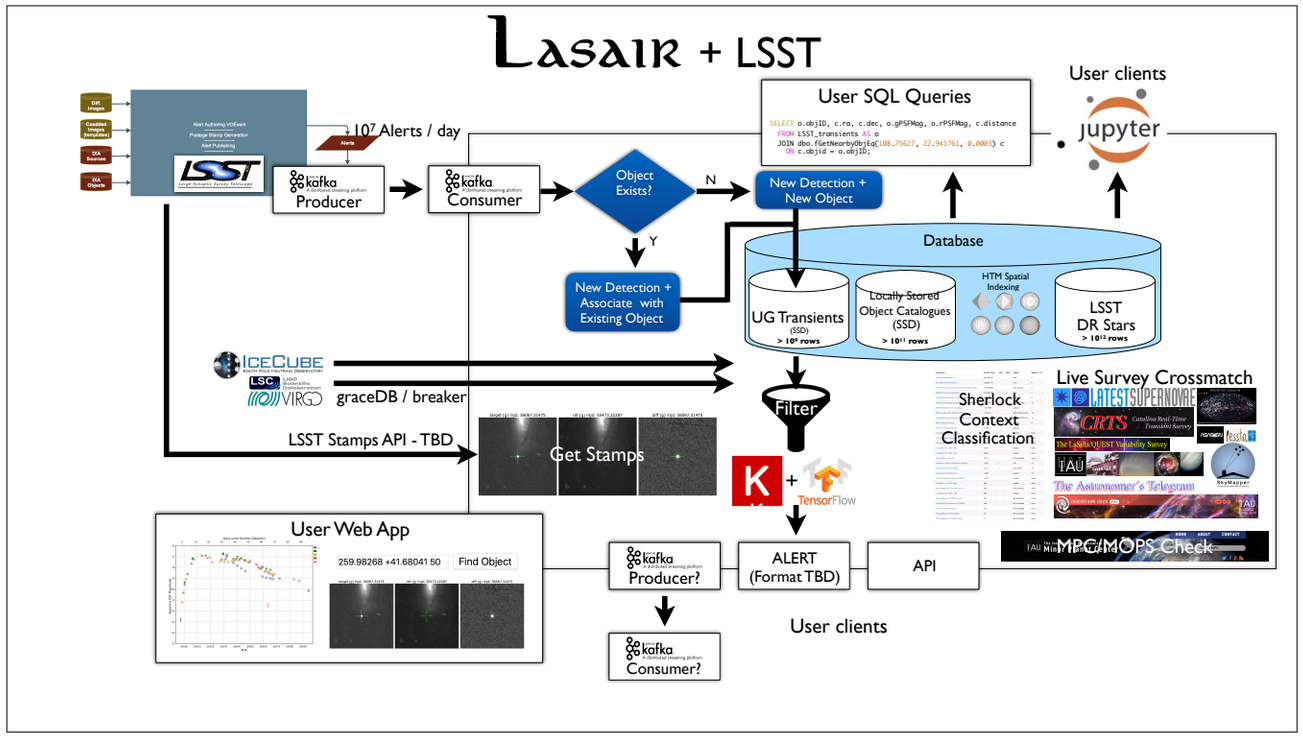
LIGO - Virgo object tagging for O3 (starting soon!)
APIs (e.g. TAP service for querying Lasair)
User defined alert mechanism (e.g. SMS)
Mobile version of web interface.

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?)

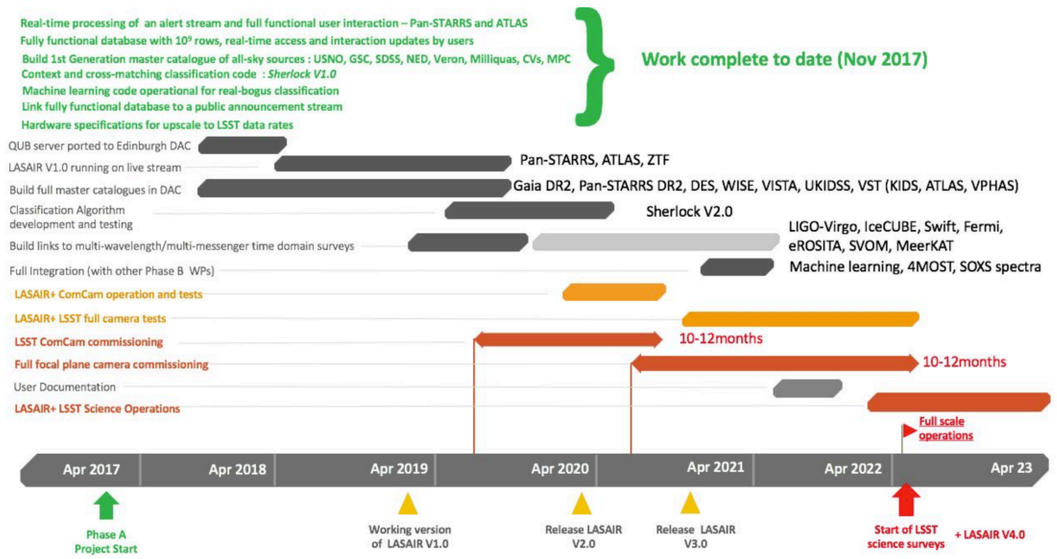
Multi-messenger cross-matching: 4D coincidence tag for LIGO/Virgo + IceCube

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

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

Subjects: Optical, Supernovae

Tweet

We report the following supernova classifications. The targets w
Facility (https://www.ztf.caltech.edu/; Kulkarni et al. 2018,
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
February 13 at the 4.1-m SOAR Telescope equipped w
Spectrograph using the 400 lines/mm grating, and a slit wi
spectral coverage from 380 nm to 775 nm with a resolution of
SNID (Blondin & Tonry, 2007, ApJ, 666, 1024) and Gelato (
383).

Survey Name	IAU Name	RA (J2000)	Dec (J2000)	Disc. Date

FDST spectroscopic classification of SN 2019awc

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, Transient

Tweet

The Fast and Dark Side of Transients experiment (FDST; ATel #12362) reports the spectroscopi
observation of SN 2019awc. Targets were supplied by the Zwicky Transient Facilit
(https://www.ztf.caltech.edu/; Kulkarni et al. 2018, ATel 11266) and processed through the Lasai
broker (http://lasair.roe.ac.uk/). Classifications were done with SNID (Blondin & Tonry, 2007, ApJ
666, 1024).

The observations were performed on 2019-02-13 using SPRAT (Piascik et al 2014) on the Liverpoo

Questions