Alert brokers, discovery and classification in the LSST era

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Lasair is funded by UK STFC grants ST/X001334/1 and ST/X001253/1
Privacy statement

lasair.lsst.ac.uk

Legacy Survey of Space and Time (LSST)

Starting points :

https://www.lsst.org

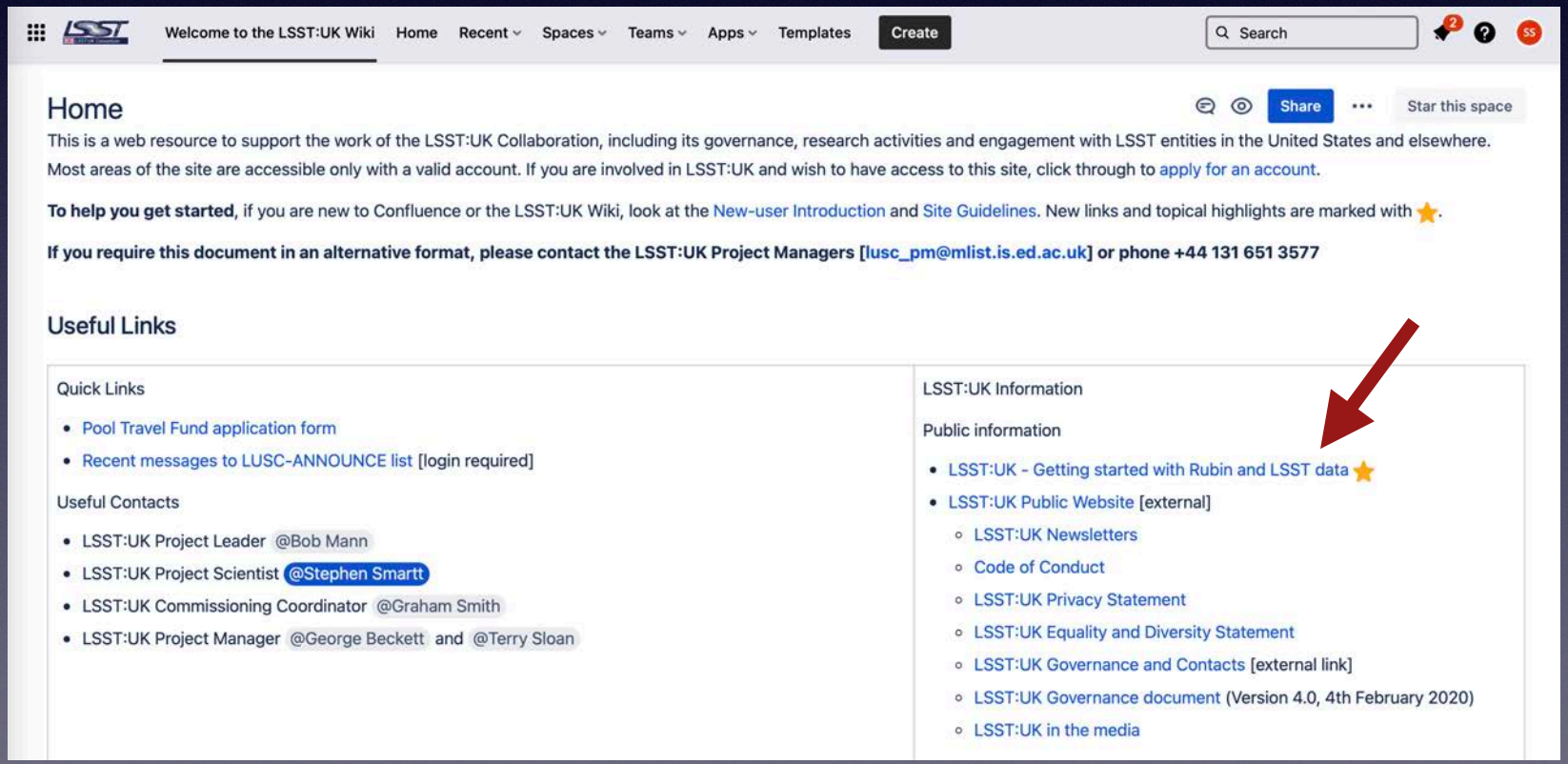
https://www.lsst.ac.uk

https://lsst-uk.atlassian.net

LSST:UK consortium
Stephen Smartt (University of Oxford and Queen's University Belfast)
Project Lead : Bob Mann (University of Edinburgh)

Slides reviewed and last updated : 8 February 2023

https://lsst-uk.atlassian.net

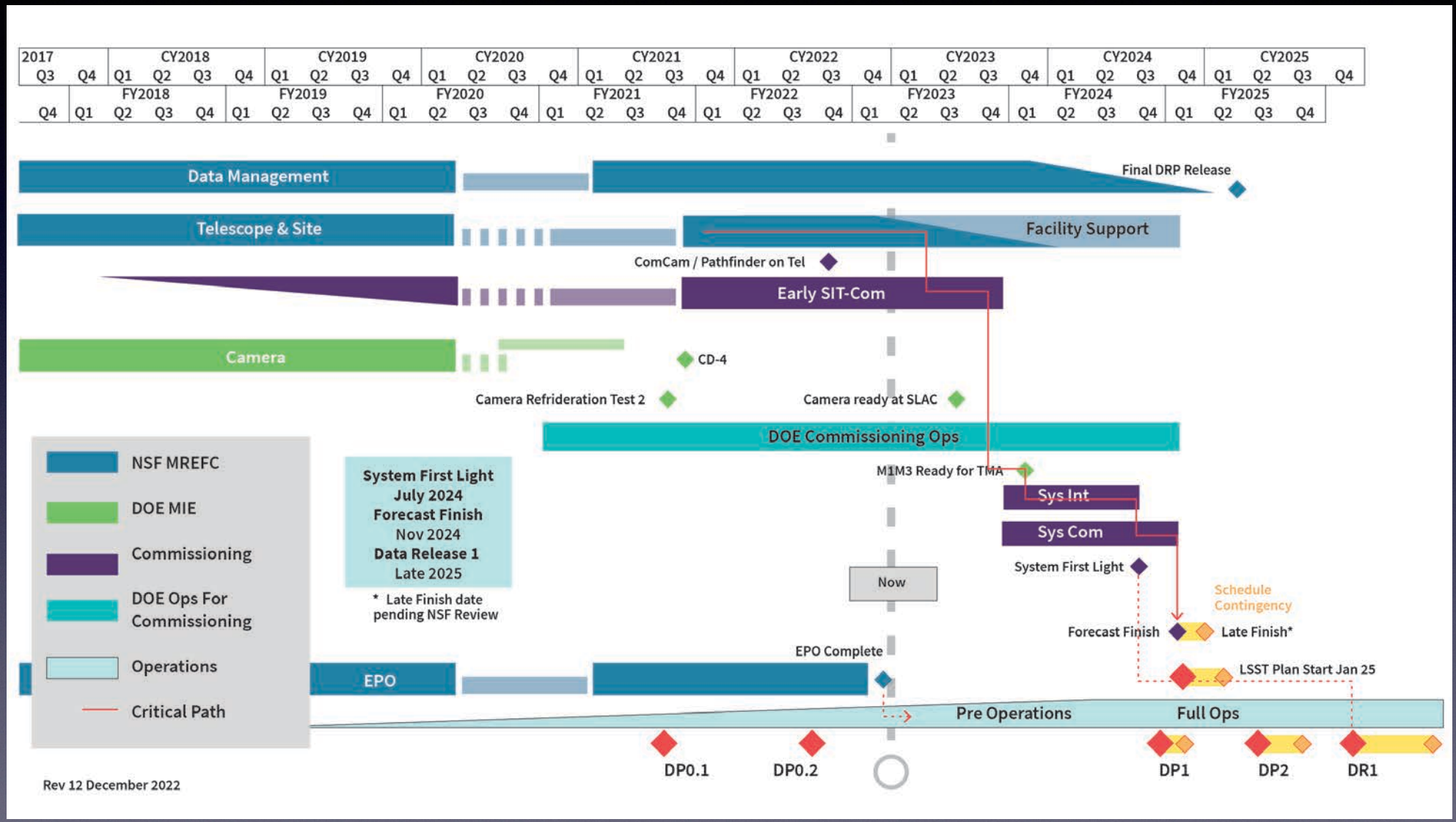


Construction progress : as of Feb 2023

Image Credit: Rubin Obs.

Rubin schedule

Projected science operation start January 2025



Monthly updates (including diagram updates) :
https://www.lsst.org/about/project-status

When will science data arrive ?

Two useful Rubin documents which are continually updated :

Release Scenarios for Rubin - LSST Commissioning and Survey data
Marshall et al. RDO-11
https://docushare.lsstcorp.org/docushare/dsweb/Get/RDO-11

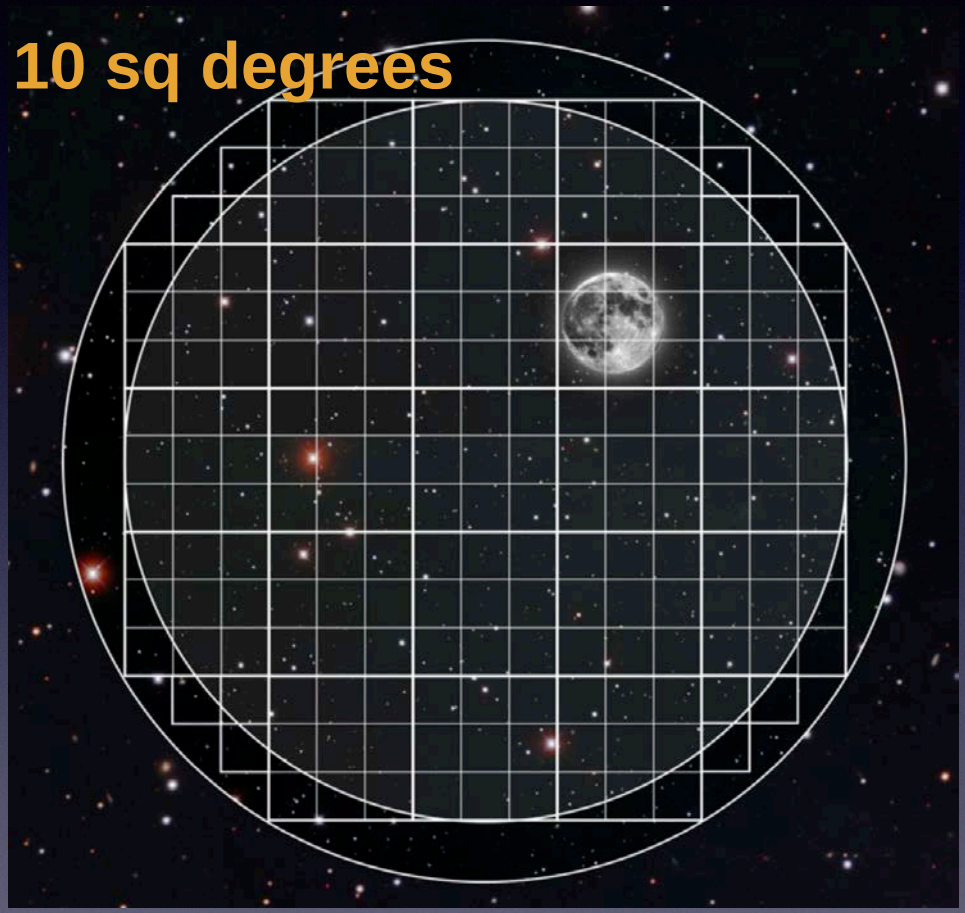
Rubin Observatory Plans for an Early Science Program
Guy et al. RTN-11
https://rtn-011.lsst.io/

Guy et al. Table 1

Rubin Early Data Release Scenario	Jun 2021	Jun 2022	Jun 2023 - Sep 2023	Sep 2024 - Oct 2024	May 2025 - Aug 2025	Nov 2025 - Apr 2026	Nov 2026 - Apr 2027	Nov 2027 - Feb 2028	Nov 2028 - Feb 2029
	DP0.1	DP0.2	DP0.3	DP1	DP2	DR1	DR2	DR3	DR4
Data Product	DC2 Simulated Sky Survey	Reprocessed DC2 Survey	Solar System PPDB Simulation	First Light LSSTCam Data	LSSTCam Science Validation Data	LSST First 6 Months Data	LSST Year 1 Data	LSST Year 2 Data	LSST Year 3 Data
Raw images	☑	☑	☐	☑	☑	☑	☑	☑	☑
DRP Processed Visit Images and Visit Catalogs	☑	☑	☐	☑	☑	☑	☑	☑	☑
DRP Coadded Images	☑	☑	☐	☐	☑	☑	☑	☑	☑
DRP Object and ForcedSource Catalogs	☑	☑	☐	☐	☑	☑	☑	☑	☑
DRP Difference Images and DIASources	☐	☑	☐	☐	☑	☑	☑	☑	☑
DRP ForcedSource Catalogs including DIA outputs	☐	☑	☐	☐	☑	☑	☑	☑	☑
PP Processed Visit Images	☐	☐	☐	☐	☐	☑	☑	☑	☑
PP Difference Images	☐	☐	☐	☐	☐	☑	☑	☑	☑
PP Catalogs (DIASources, DIAObjects, DIAForcedSources)	☐	☐	☐	☐	☑	☑	☑	☑	☑
PP SSP Catalogs	☐	☐	☑	☐	☑	☑	☑	☑	☑
DRP SSP Catalogs	☐	☐	☐	☐	☐	☑	☑	☑	☑

Where to point and when ?

- Rubin Observatory
  - *8m telescope (6.5 m clear aperture) on Cerro Pachon, Chile*
  - *3.5 gigapixel camera, impressive detector quality*
  - *Real time alert stream and multi-colour deep image of the sky*



- ***Science Requirements***
  - *18,000 square degrees observed 825 times over 10 yrs*
  - *Multi-Colour deep image of southern sky*
  - *Parallax and proper motion precision requirements*
  - *Rapid revisit timescale requirements*

Cadence problem in a nutshell:
Can do all southern, visible sky once per night : but we need 2 visits and we have 6 filters
Average return time (in same filter) would be 2 x 6 = 12 days

Multi-colour and deep

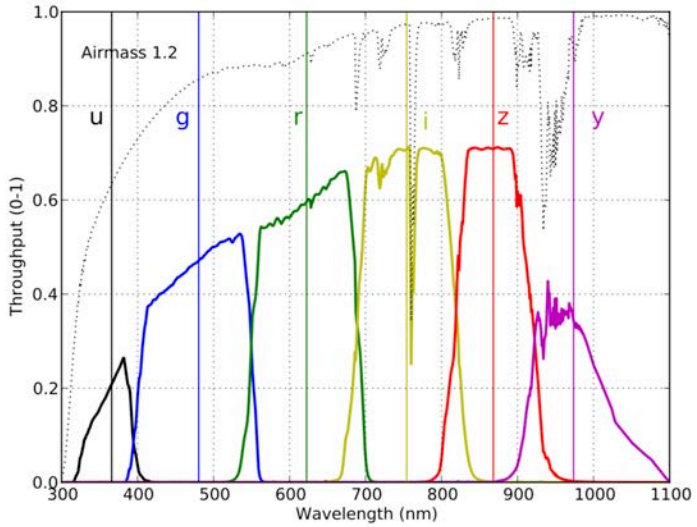
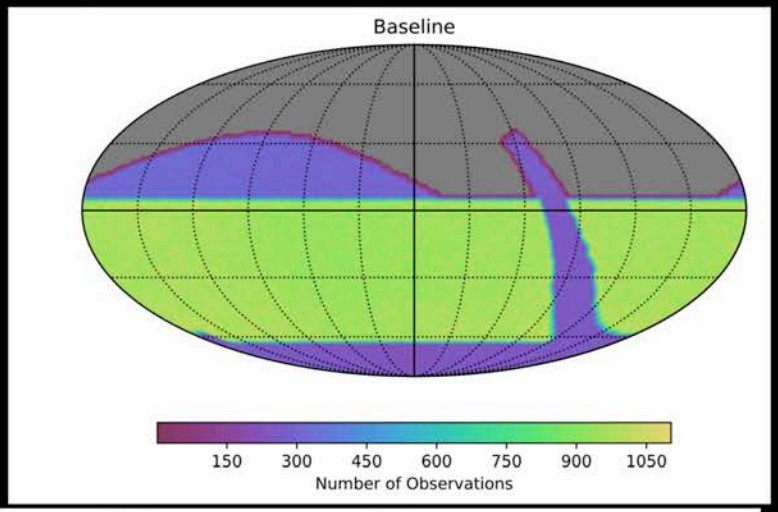
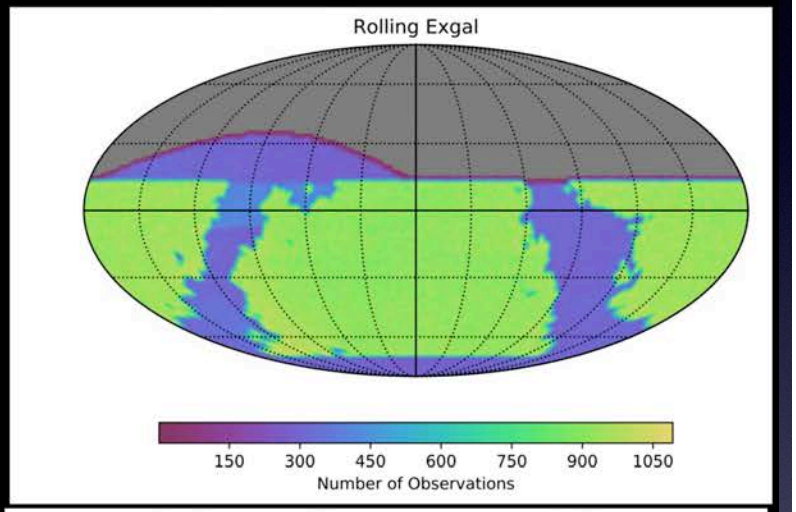
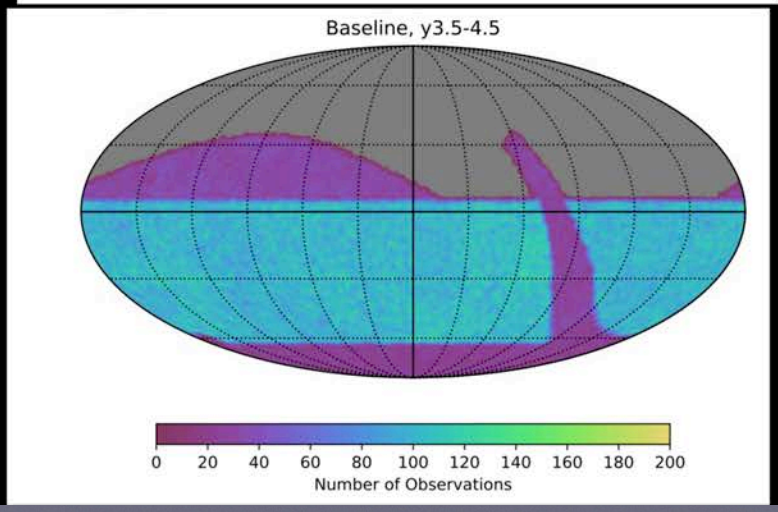
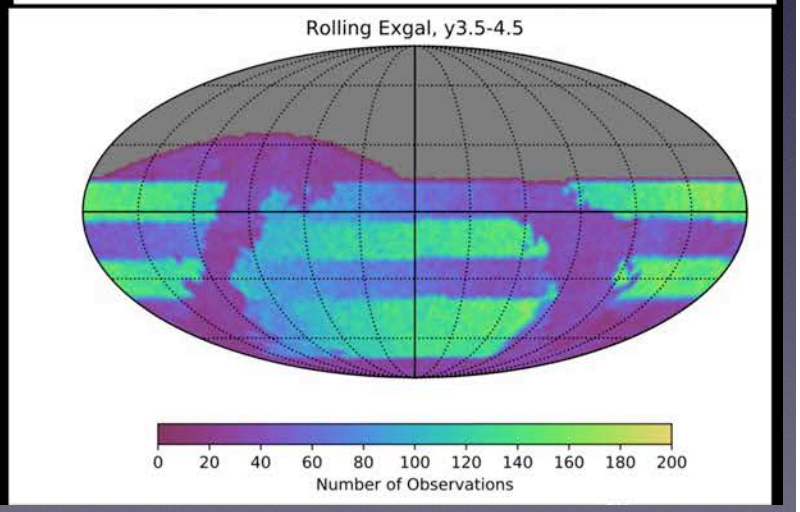


Figure 4. The LSST bandpasses. The vertical axis shows the total throughput. The computation includes the atmospheric transmission (assuming an airmass of 1.2, dotted line), optics, and the detector sensitivity.

	5σ single visit	10 yr depth
u	23.9	26.1
g	25.0	27.4
r	24.7	27.5
i	24.0	26.8
z	23.3	26.1
y	22.1	24.9

Ivezić et al: http://arxiv.org/pdf/0805.2366.pdf

2 example strategies

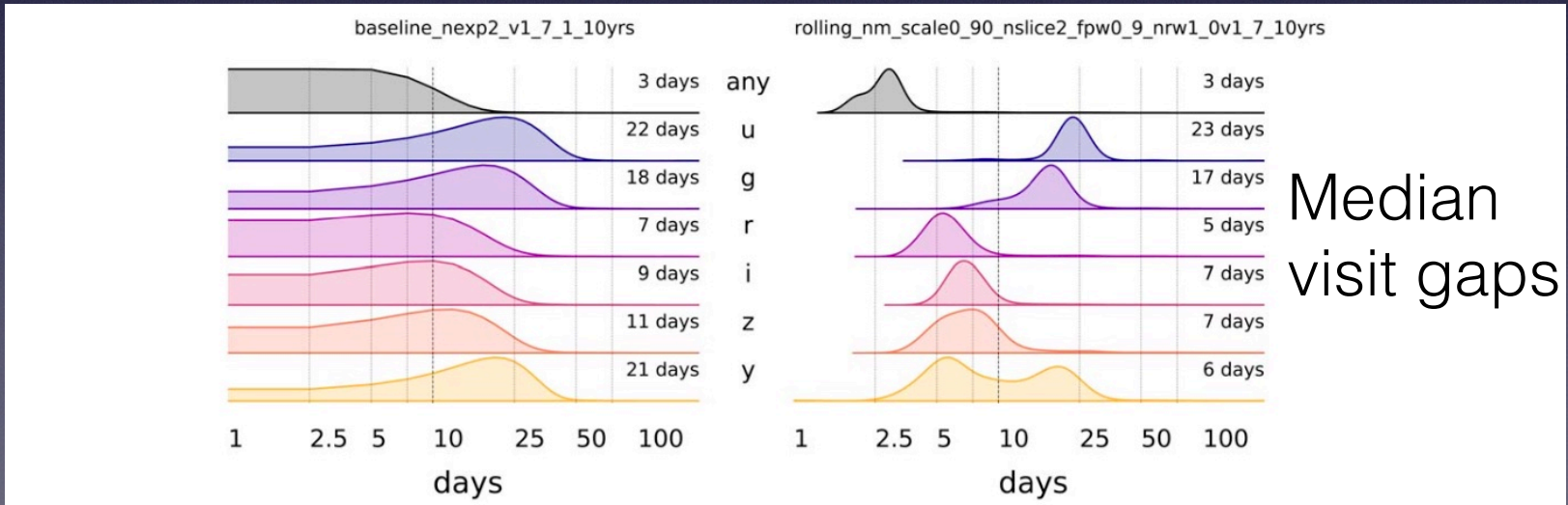
	Baseline	Exgal sky and rolling
Number of observations after 10 years (DDF visits removed)		
Year 3.5-4.5		

From, Peter Yoachim's talk August 2020 at Project & Community Workshop 2020 :
https://project.lsst.org/meetings/rubin2020/agenda/session/community-evaluation-rubin-survey-strategies

LSST Observing sequence and cadence

- Observe a camera footprint with 2x15 second exposures, taken back-to-back (they are called “snaps”. They will be co-added automatically to make a 30 second image, allowing cosmic ray mitigation
- Come back on the same night, about 30mins later, and observe *exactly* the same footprint. Still to be decided if the 2nd visit will be in the same filter as the 1st or a suitable different pair (e.g. ***g+r***, ***i+z*** …. ***u*** and ***y*** would not be paired of course*)*

When does LSST revisit this footprint again ?



Median visit gaps

Figure 2. Distribution of median internight visit gaps (the time elapsed between visits to the same field in different nights) at a given location in the sky for two simulated LSST `OpSim` strategies: `baseline_nexp2_v1.7.1_10yrs` (left) and `rolling_nm_scale0.90_nslice2_fpw0.9_nrw1.0v1.7_10yrs`

Bianco et al. 2022: Optimisation of the Observing Cadence for Rubin

LSST Alerts - Key numbers

Goal is 60 seconds to send an alert. Every 60 seconds the following tables give an idea of number of alerts and their types that will be released.

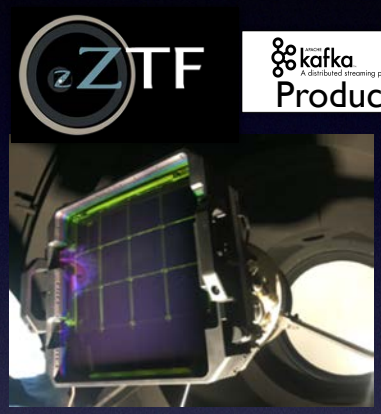
Alert numbers : per visit

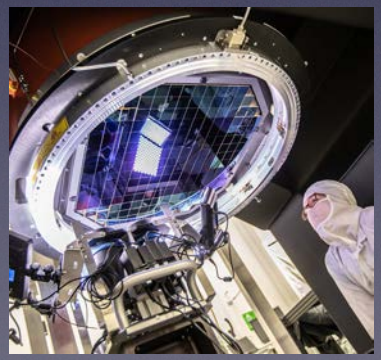
Type	Extragalactic (80% of sky)	Galactic (20% of sky)
Movers	3000	3000
Stars	1800	30000
AGN	70	70
Supernovae and extragalactic transients	200	200

	5σ single visit	10 yr depth
u	23.9	26.1
g	25.0	27.4
r	24.7	27.5
i	24.0	26.8
z	23.3	26.1
y	22.1	24.9

Melissa Graham's "LSST Alerts - Key numbers" https://dmtn-102.lsst.io/DMTN-102.pdf
https://lsst-uk.atlassian.net/wiki/spaces/LUSC/pages/882409581/Summary+of+alert+data

The broker landscape





broker

Lasair — UK

FINK — France

ANTARES — USA

ALeRCE Automatic Learning for the Rapid Classification of Events — Chile

Ampel — Germany

PittGoogle Babamul — USA

Lasair https://lasair.lsst.ac.uk

Lasair

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- Watchlists
- Watchmaps
- Annotators
- Status

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- Schema Browser
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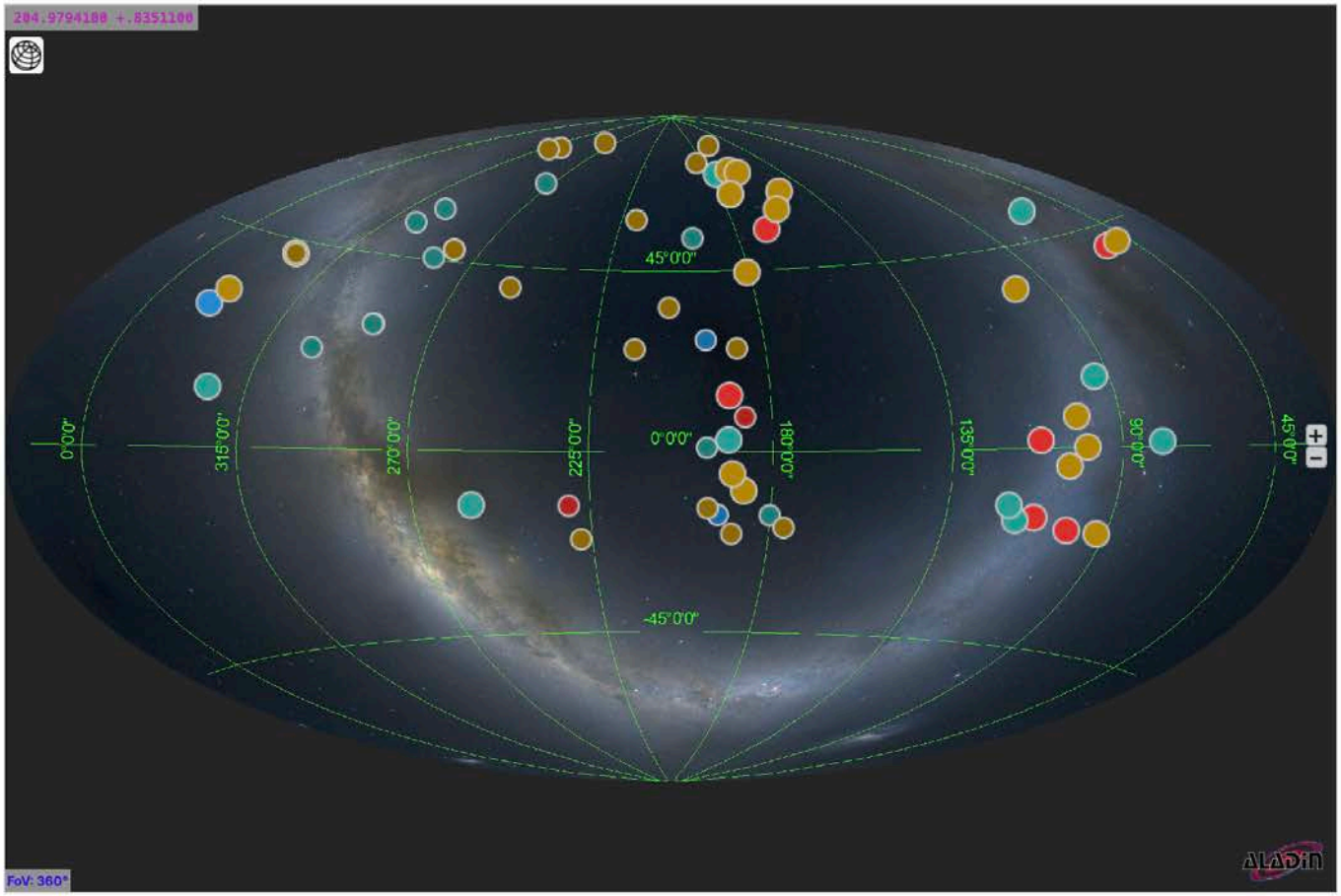
Latest ZTF Transient Alerts Map

This skymap shows the most recent, bright (<17 Mag) ZTF transient detections, coloured by their predicted type. The longer ago the transient was last detected, the smaller and fainter its marker. Click on a markers for information about an object, and then on the 'ZTF' transient ID for full information.



Possible Supernova Nuclear Transient Cataclysmic Variable Active Galaxy

Help

LSST:UK Science Centre THE UNIVERSITY of EDINBURGH QUEEN'S UNIVERSITY BELFAST ZTF VERA C. RUBIN OBSERVATORY

Lasair is funded by UK STFC grants ST/X001334/1 and ST/X001253/1

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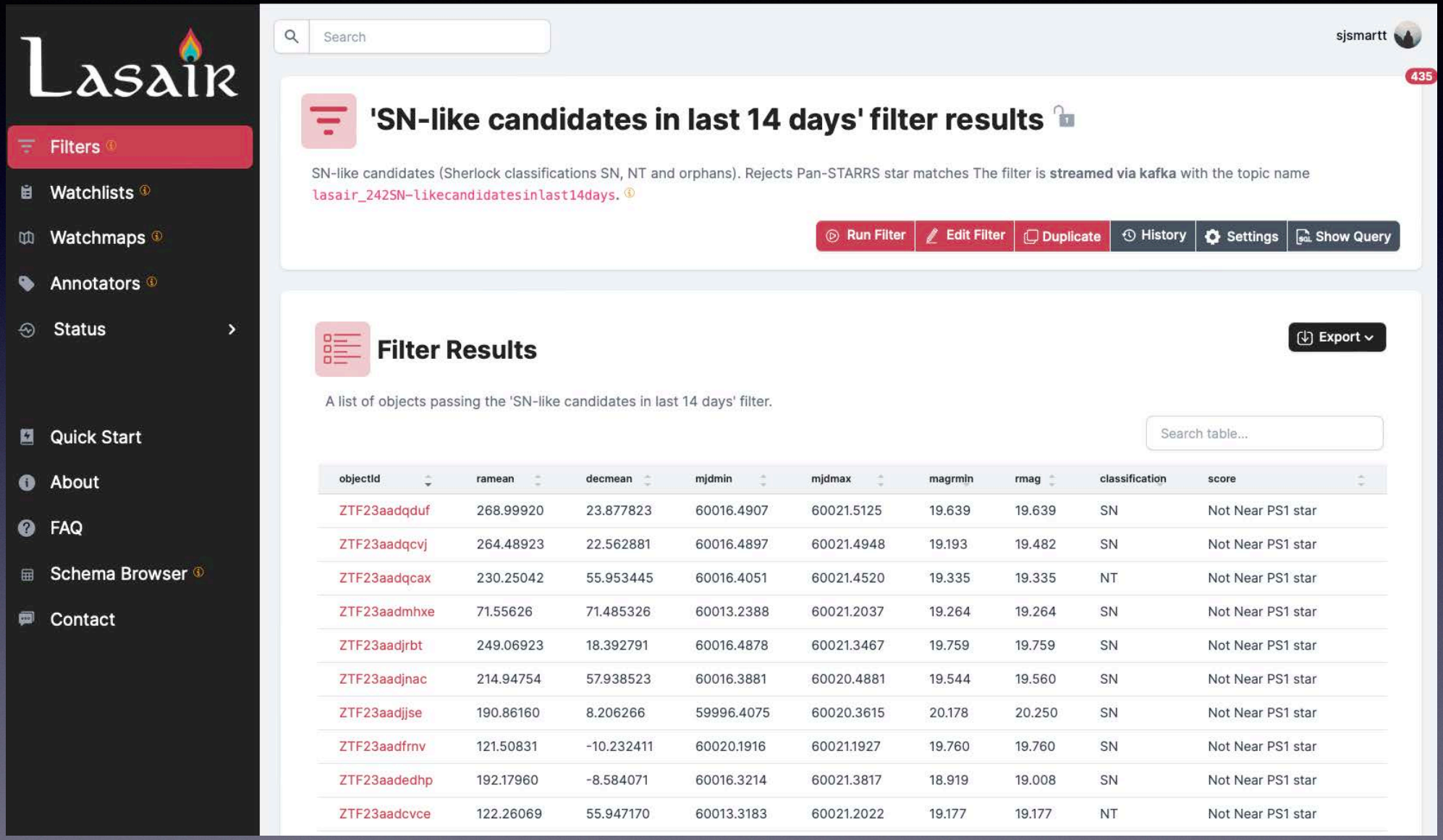
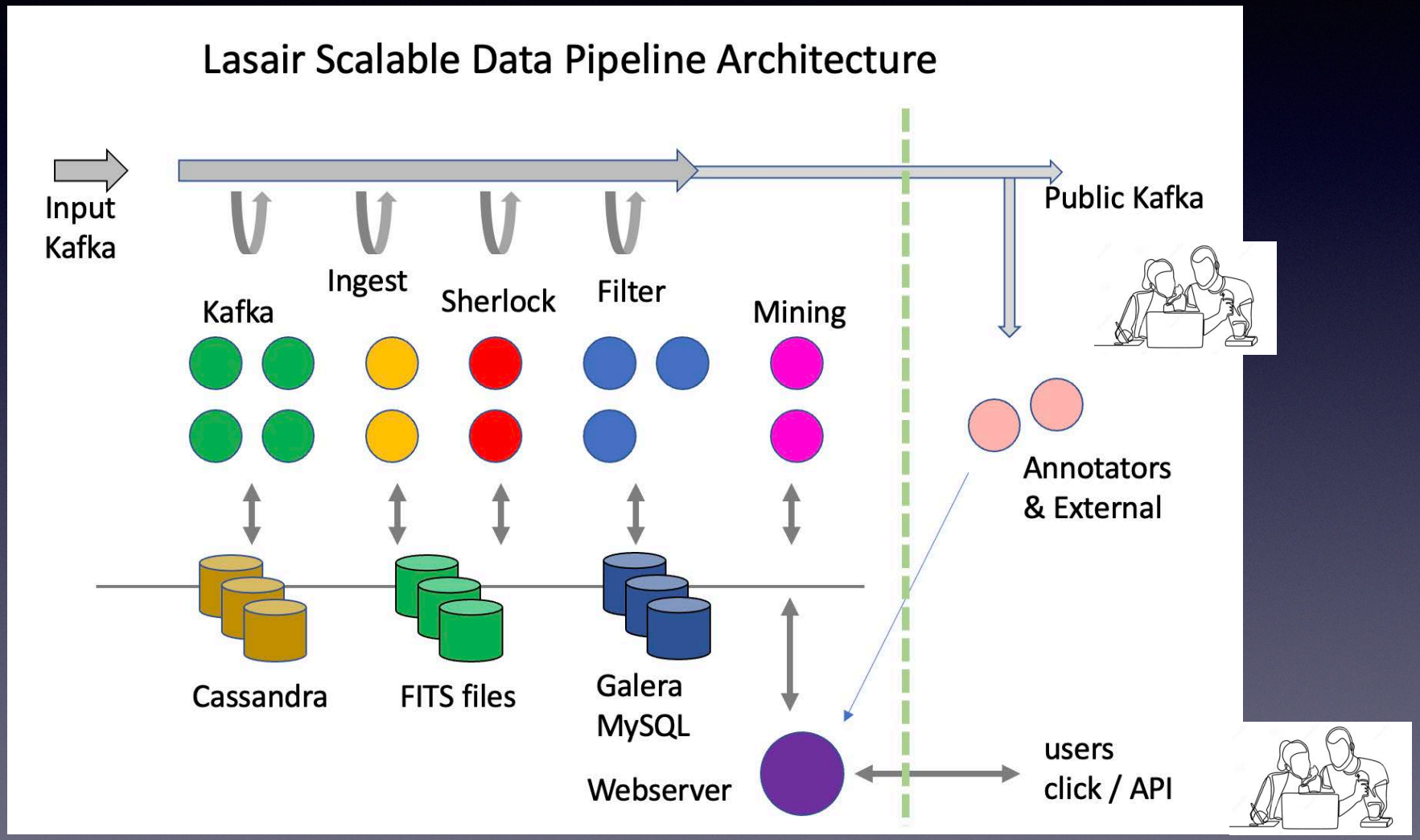
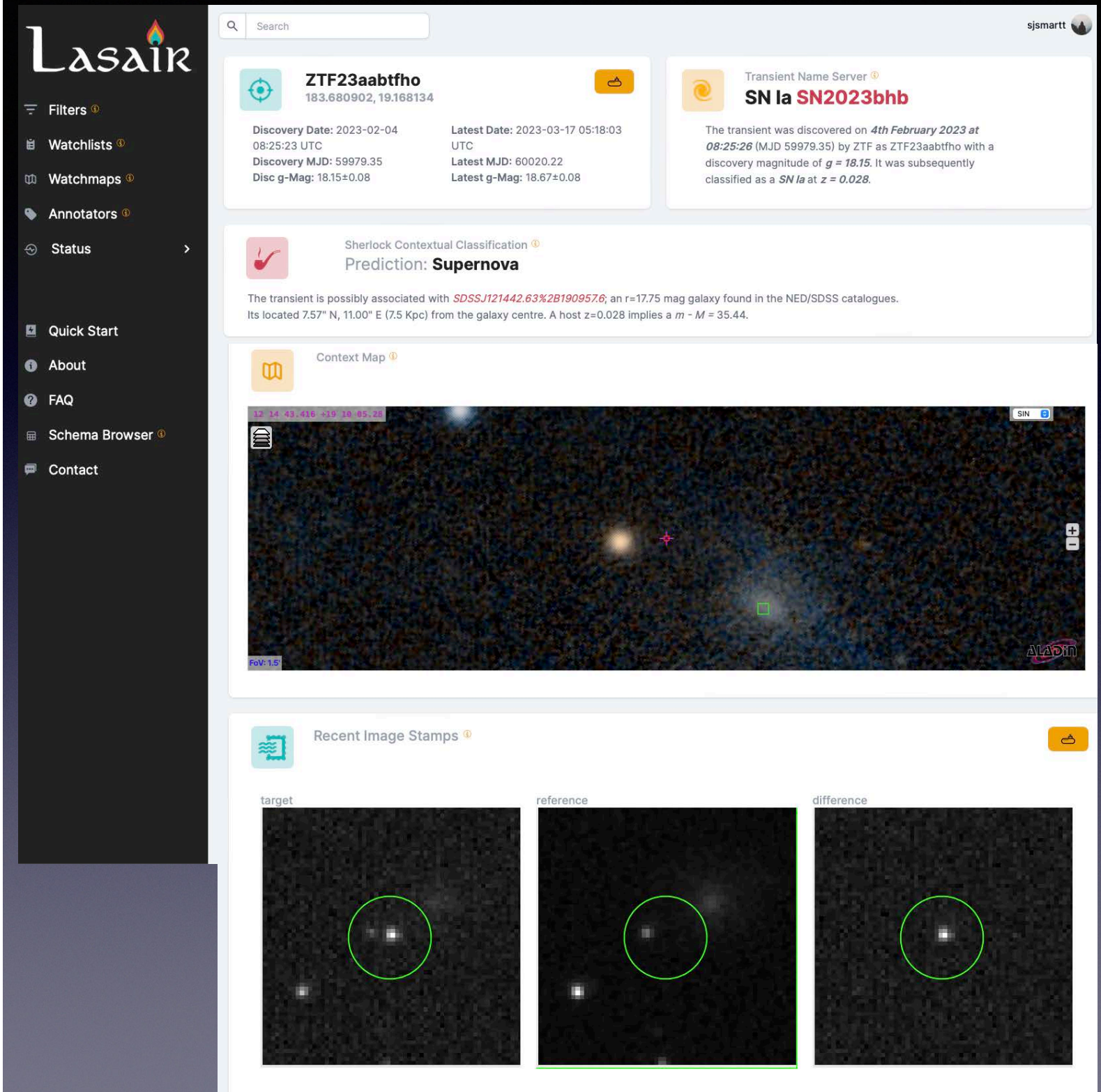
What do brokers do ?



objectId	ramean	decmean	mjdmin	mjdmax	magrmin	rmag	classification	score
ZTF23aadqduf	268.99920	23.877823	60016.4907	60021.5125	19.639	19.639	SN	Not Near PS1 star
ZTF23aadqcvj	264.48923	22.562881	60016.4897	60021.4948	19.193	19.482	SN	Not Near PS1 star
ZTF23aadqcax	230.25042	55.953445	60016.4051	60021.4520	19.335	19.335	NT	Not Near PS1 star
ZTF23aadmhxe	71.55626	71.485326	60013.2388	60021.2037	19.264	19.264	SN	Not Near PS1 star
ZTF23aadjrbt	249.06923	18.392791	60016.4878	60021.3467	19.759	19.759	SN	Not Near PS1 star
ZTF23aadjnac	214.94754	57.938523	60016.3881	60020.4881	19.544	19.560	SN	Not Near PS1 star
ZTF23aadjjse	190.86160	8.206266	59996.4075	60020.3615	20.178	20.250	SN	Not Near PS1 star
ZTF23aadfrnv	121.50831	-10.232411	60020.1916	60021.1927	19.760	19.760	SN	Not Near PS1 star
ZTF23aadedhp	192.17960	-8.584071	60016.3214	60021.3817	18.919	19.008	SN	Not Near PS1 star
ZTF23aadcvce	122.26069	55.947170	60013.3183	60021.2022	19.177	19.177	NT	Not Near PS1 star

Lasair scalable architecture




Lasair
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Schema Browser
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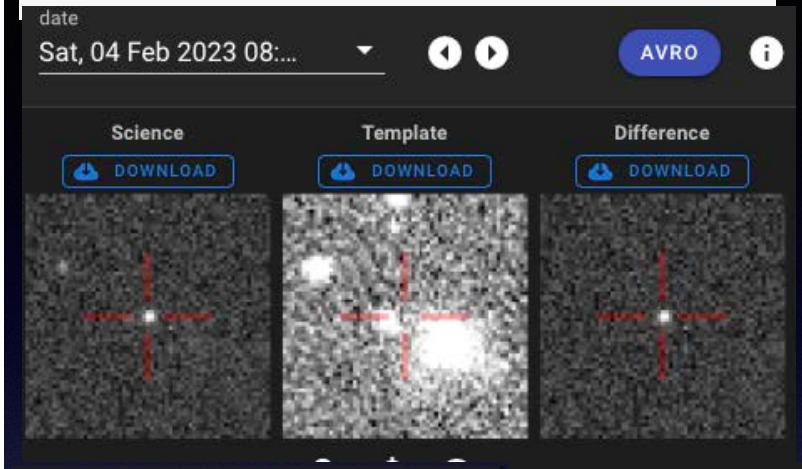
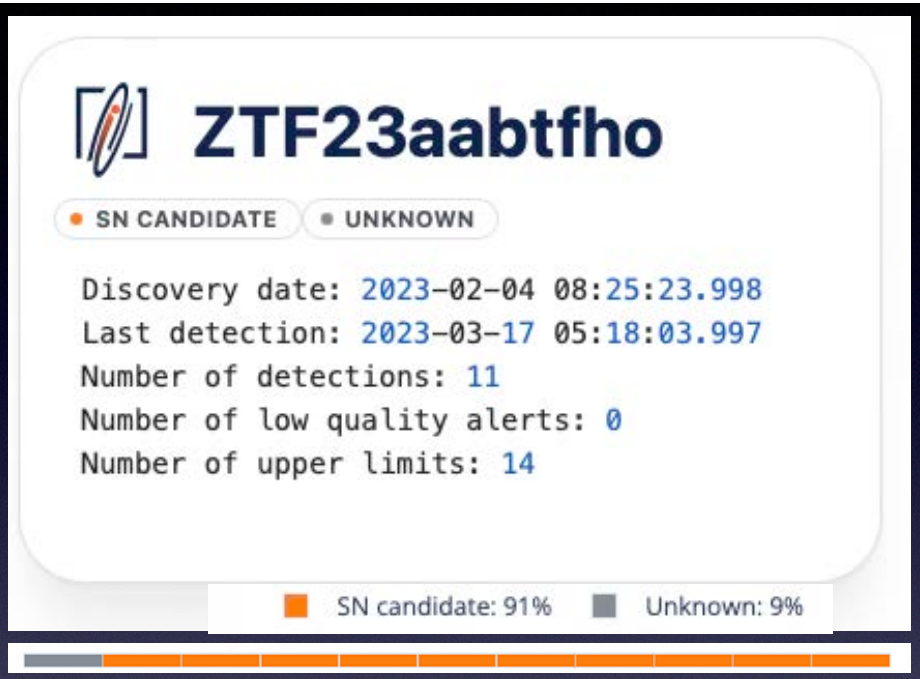
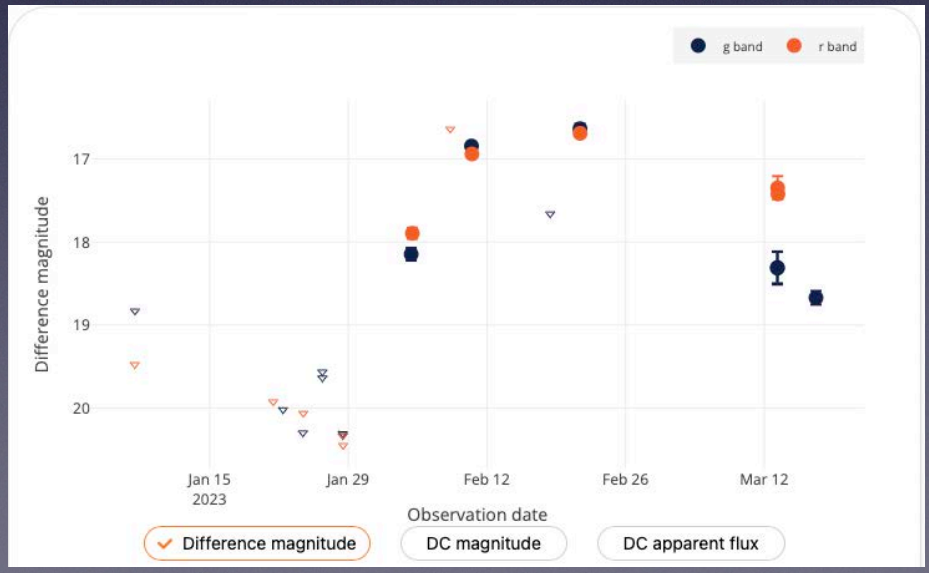
ZTF23aabtfho
183.680902, 19.168134
Discovery Date: 2023-02-04 08:25:23 UTC
Discovery MJD: 59979.35
Disc g-Mag: 18.15±0.08
Latest Date: 2023-03-17 05:18:03 UTC
Latest MJD: 60020.22
Latest g-Mag: 18.67±0.08
Transient Name Server
SN Ia SN2023bhb
The transient was discovered on 4th February 2023 at 08:25:26 (MJD 59979.35) by ZTF as ZTF23aabtfho with a discovery magnitude of g = 18.15. It was subsequently classified as a SN Ia at z = 0.028.
Sherlock Contextual Classification
Prediction: Supernova
The transient is possibly associated with SDSSJ121442.63%2B190957.6; an r=17.75 mag galaxy found in the NED/SDSS catalogues.
Its located 7.57" N, 11.00" E (7.5 Kpc) from the galaxy centre. A host z=0.028 implies a m - M = 35.44.
Context Map
SIN
FoV: 1.5'
ALADIN
Recent Image Stamps
target
reference
difference

ALeRCE
Automatic Learning for the Rapid Classification of Events

FINK







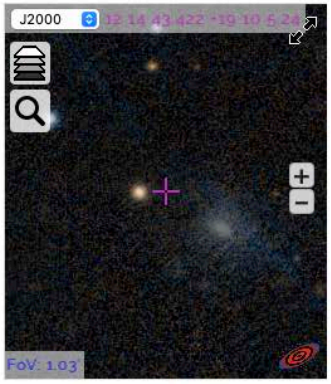
ANTARES

ZTF23aabtfho ICRS: 12:14:43.42 19:10:5.24 183.6809 19.1681 Gal: 254.3613 78.4074

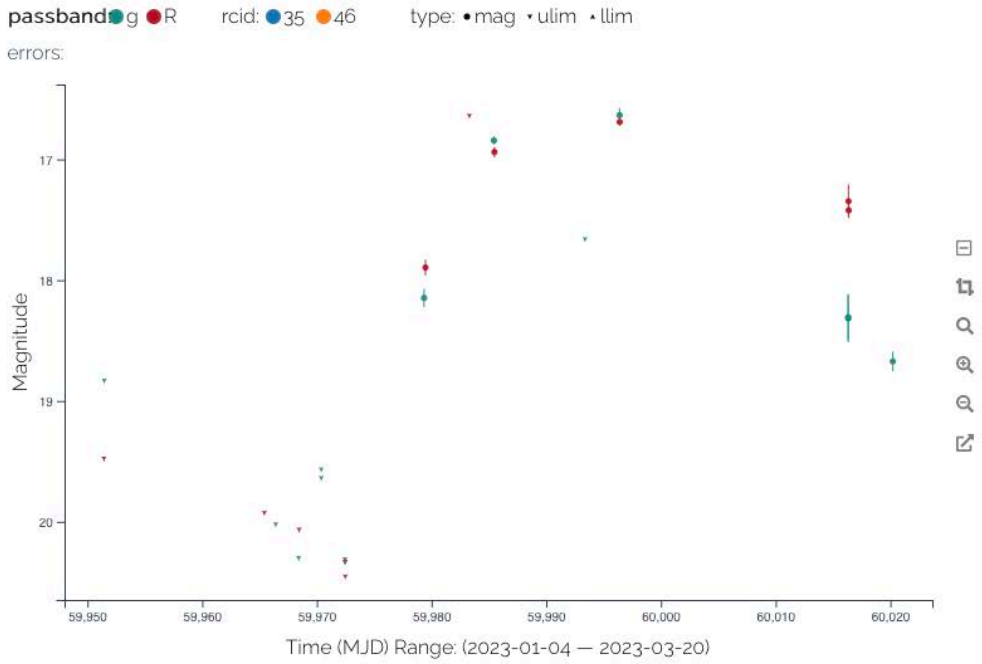
ZTF23aabtfho

Num. Alerts: 25
Num. Mag. Values: 11
Associated Tags:
nova_test
high_amplitude_transient_candi...
refitt_newsources_snrcut
lc_feature_extractor
Alert Brokers: ALeRCE, MARS
External Services : IPAC, NED, SIMBAD, SNAD, TNS, VizieR

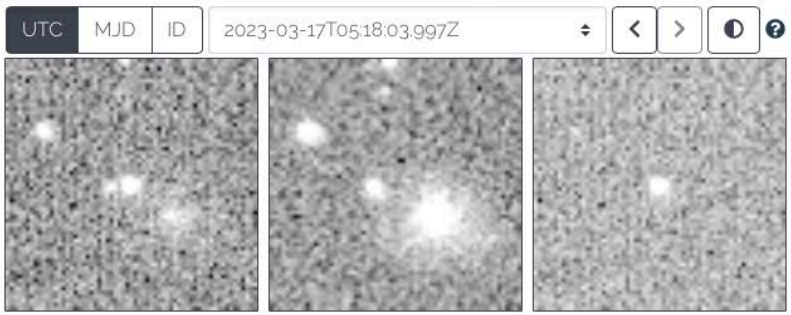
Finder Chart



Lightcurve

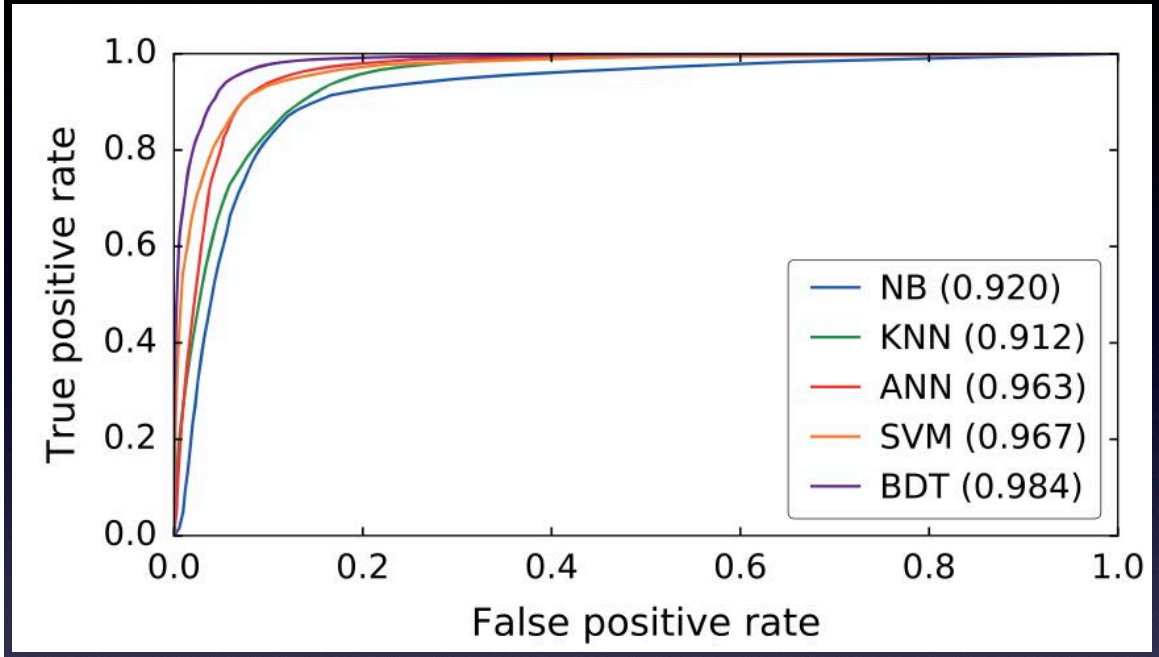


Alert Thumbnails

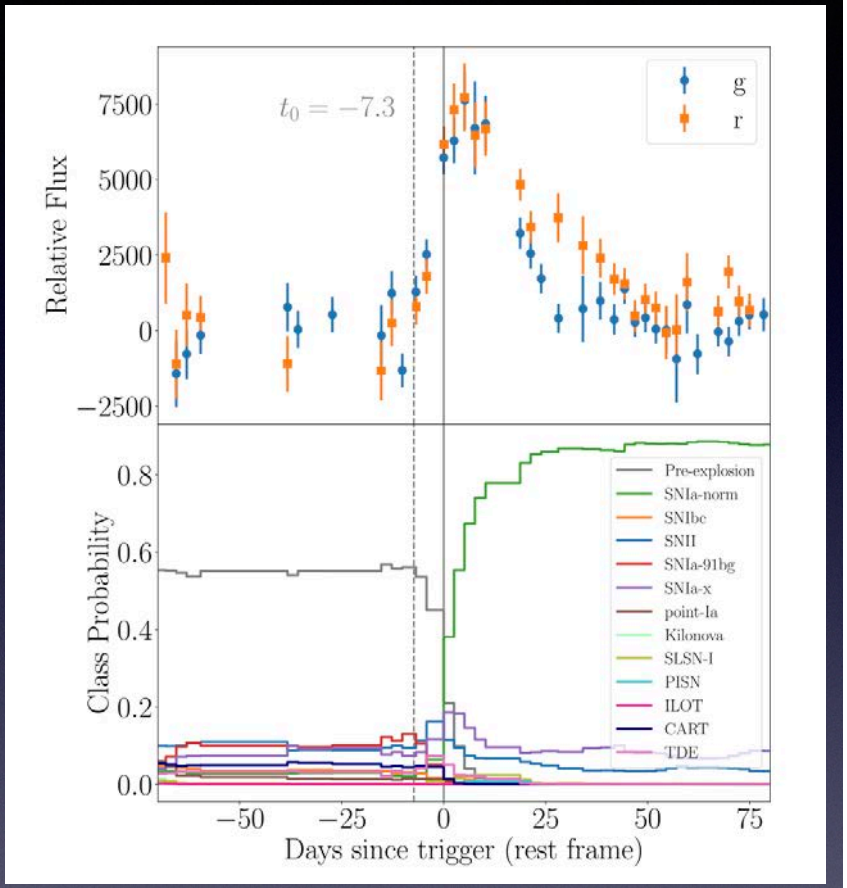


Alerts

ML classification



Lochner et al. 2016

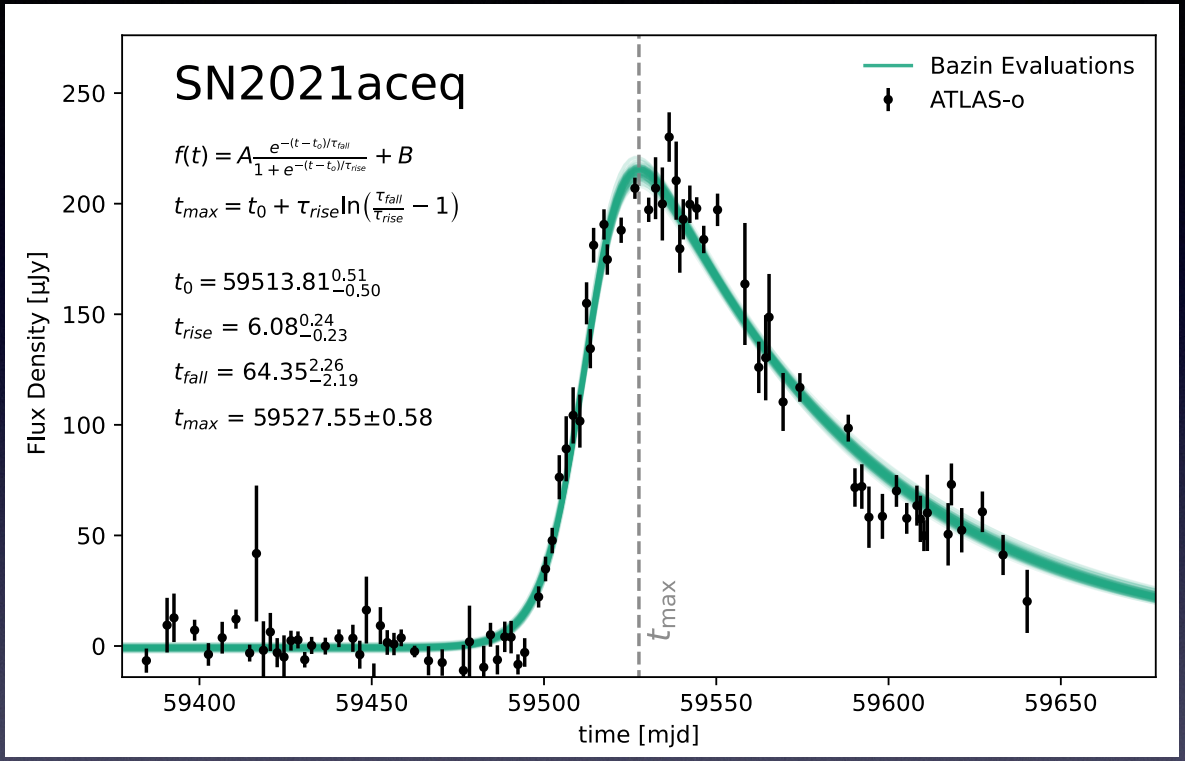


Muthukrishna et al. 2019

Potential for major advances

- Improved ML methods
- Better training, with data and models
- Large and expert community - rapidly changing field

Lasair and lightcurve fitting

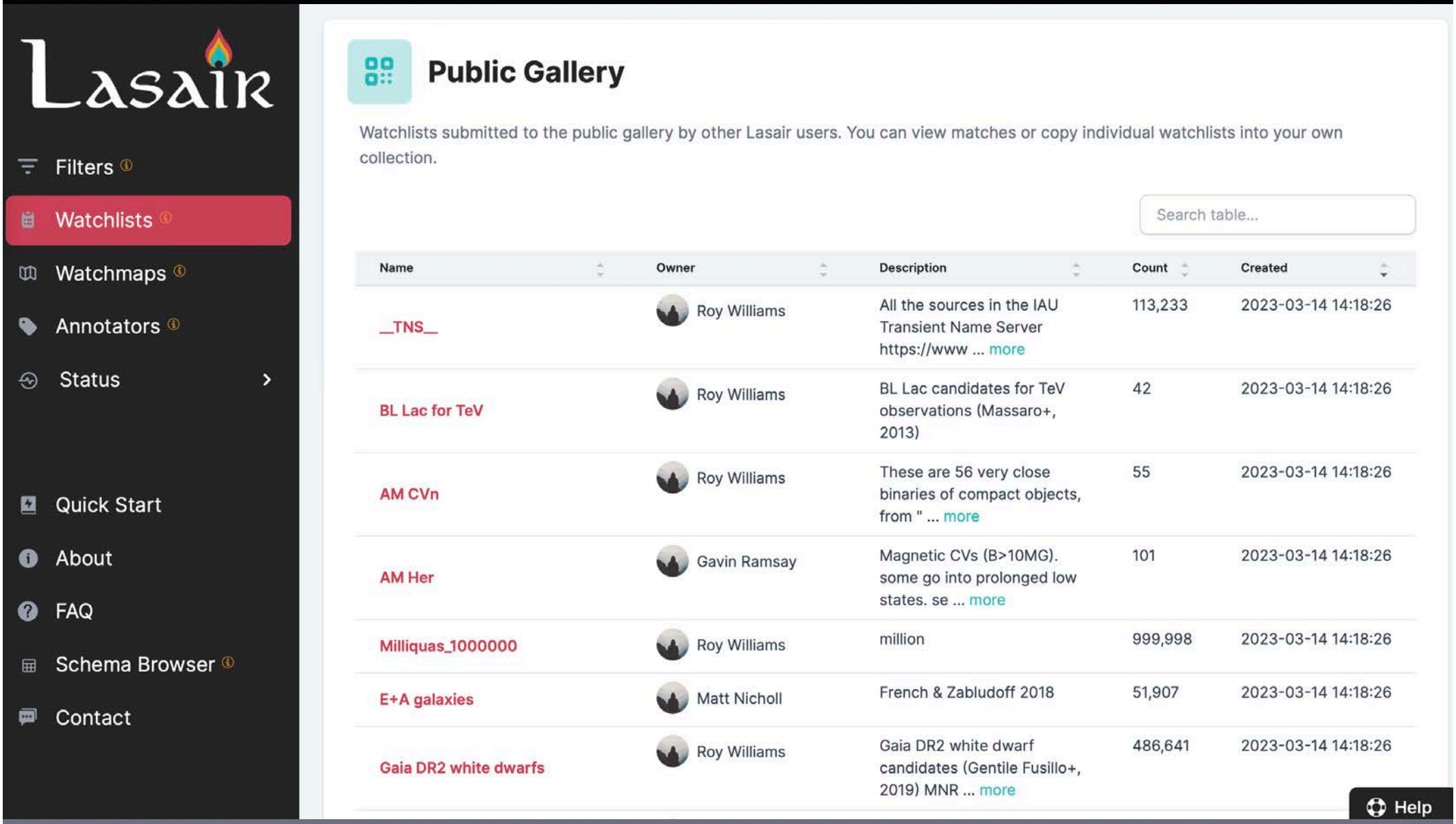


$$f(t) = A\frac{e^{-(t-t_0)/\tau_{fall}}}{1+e^{-(t-t_0)/\tau_{rise}}} + B$$

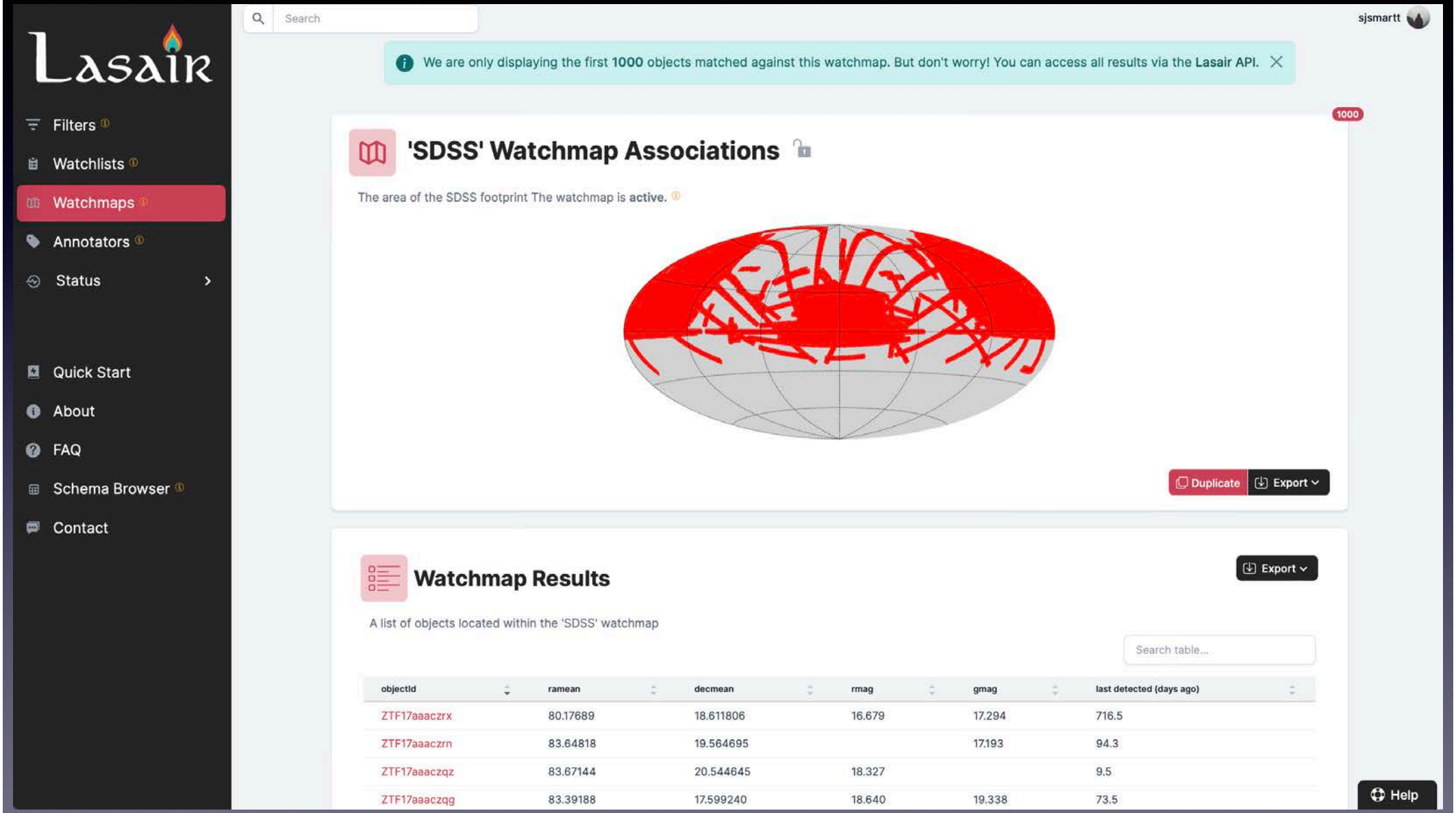
Lasair focus

- Mover/star/galaxy separations (galaxy offset or nuclear transient or AGN)
- Provide trustworthy measurements and values
- Host galaxy match and redshift
- Trust in the data values
- User decides
- Can work with Lasair team on “Annotator”

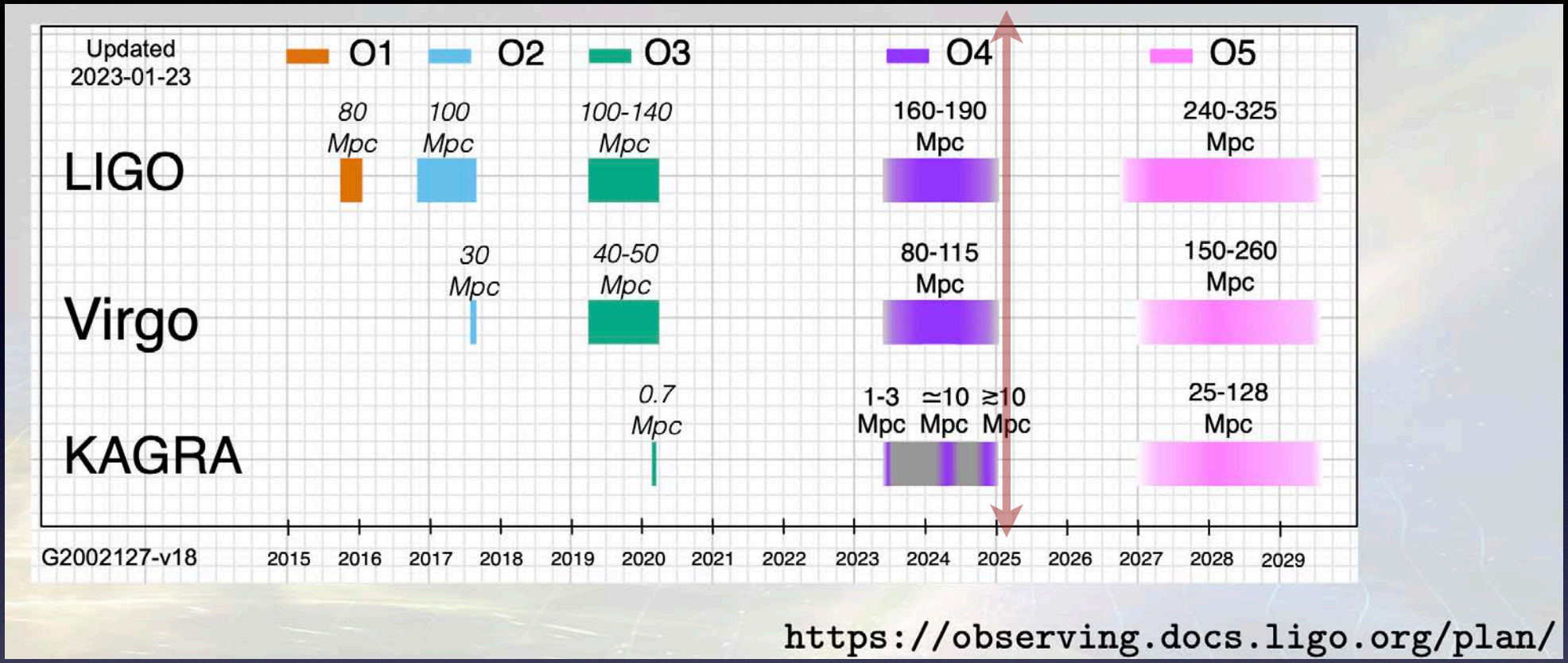
Lasair watchlists



Lasair Watchmaps



Landscape now to 2030



https://observing.docs.ligo.org/plan/

Discussion points

1. Are we taking the right approach with Lasair ?
2. Can we facilitate your science, and what extra can we do ?
3. A UK strategy for time domain real-time data federation, classification and curation

Roy Willams

Ken Smith

Dave Young

Gareth Francis

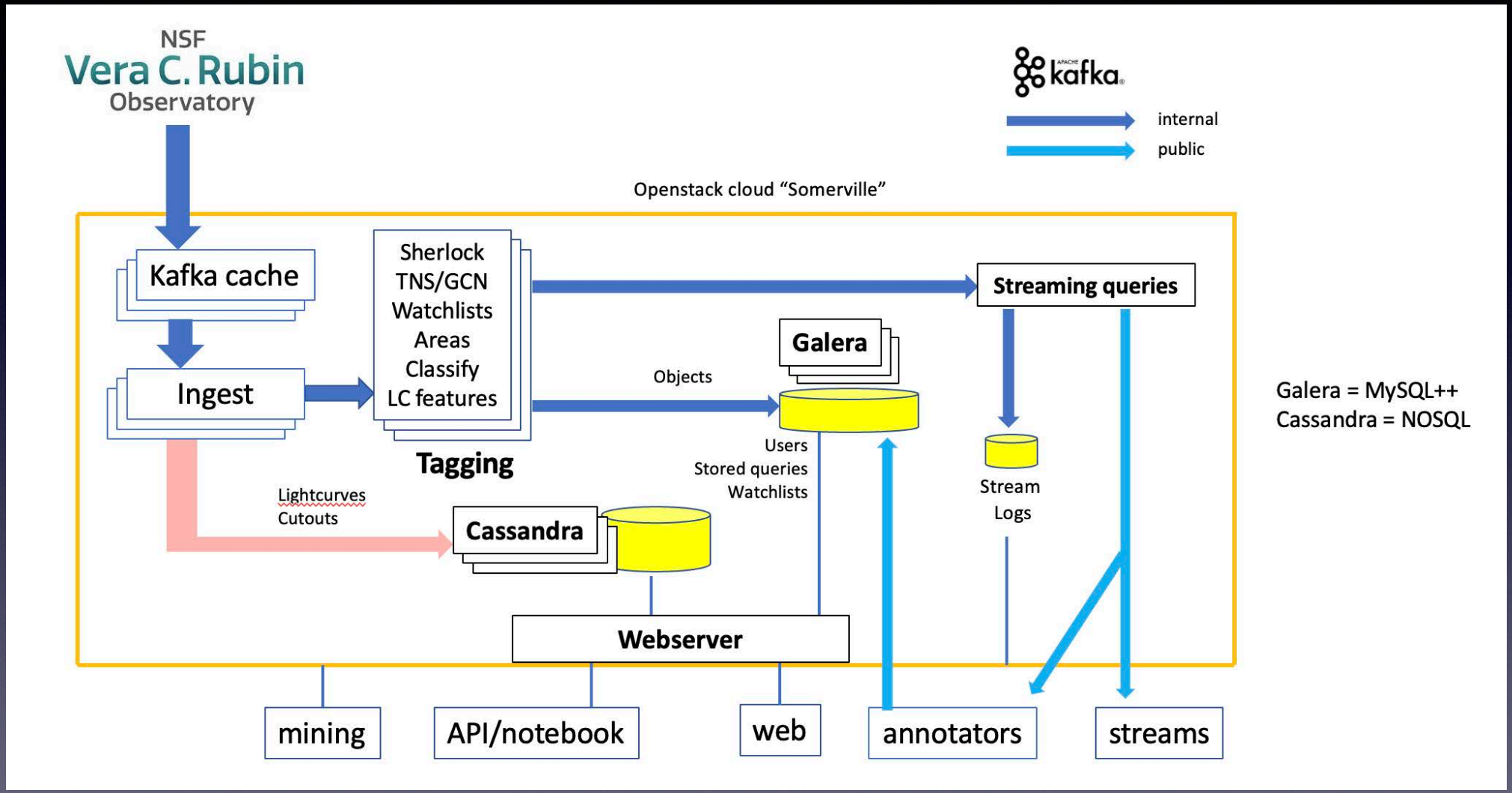
All very helpful!

Finally the last word ….
the latest on alerts from LSST
7th Feb 2023

The LSST Survey start: 4-7 months after System First Light. Some “near-live” alerts are planned around the time of the LSST Survey start, and then alert production is planned to increase smoothly to "live" during the early months of the LSST Survey, covering more regions over time as the static-sky templates are built up.

Monthly updates (including diagram updates) :
https://www.lsst.org/about/project-status
https://lsst-uk.atlassian.net

Fin


NSF
Vera C. Rubin
Observatory
kafka
internal
public
Openstack cloud "Somerville"
Kafka cache
Ingest
Sherlock
TNS/GCN
Watchlists
Areas
Classify
LC features
Tagging
Streaming queries
Galera
Objects
Users
Stored queries
Watchlists
Stream
Logs
Lightcurves
Cutouts
Cassandra
Webserver
mining
API/notebook
web
annotators
streams
Galera = MySQL++
Cassandra = NOSQL