The ALeRCE community broker

Alejandra M. Muñoz Arancibia
on behalf of the ALeRCE Team

Rubin Project & Community Workshop
Aug 9, 2023

ALeRCE

Automatic Learning for the
Rapid Classification of Events

The ALeRCE community broker

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https://alerce.science/

CMM Center for Mathematical Modeling

INSTITUTO MILENIO DE ASTROFÍSICA

DATA OBSERVATORY

UNIVERSIDAD ADOLFO IBÁÑEZ

UTEM

REUNA Ciencia y Educación en Red

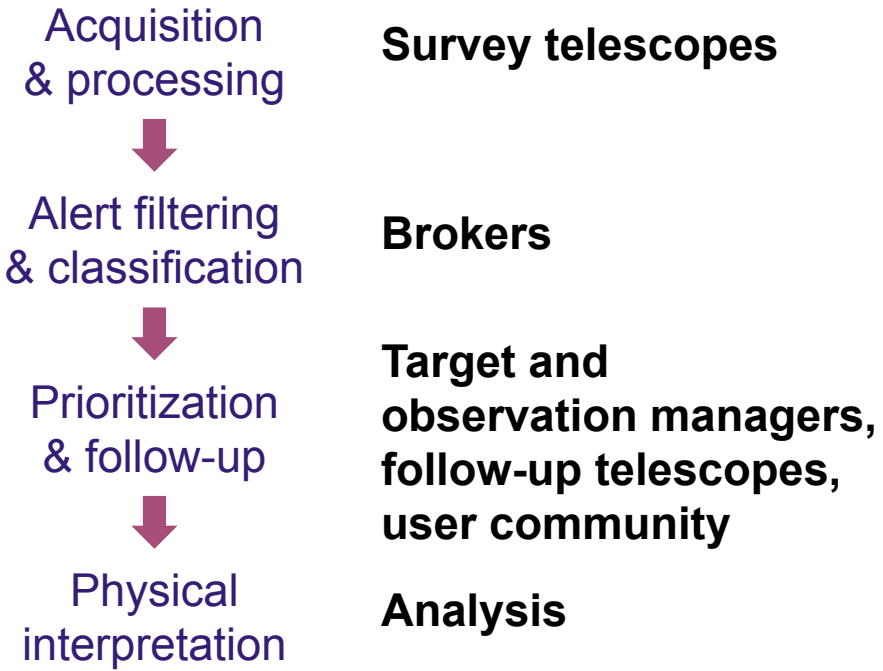
aws

NLHPC National Laboratory for High Performance Computing Chile

IACS

DiRAC

Tools for time domain astronomy



Tools for time domain astronomy

Acquisition & processing

↓

Alert filtering & classification

↓

Prioritization & follow-up

↓

Physical interpretation

Survey telescopes

Brokers e.g., ALeRCE Automatic Learning for the Rapid Classification of Events

Target and observation managers, follow-up telescopes, user community

Analysis

A Chilean-led initiative to build a community broker for Rubin LSST and other large etendue survey telescopes

One of selected Rubin alert brokers

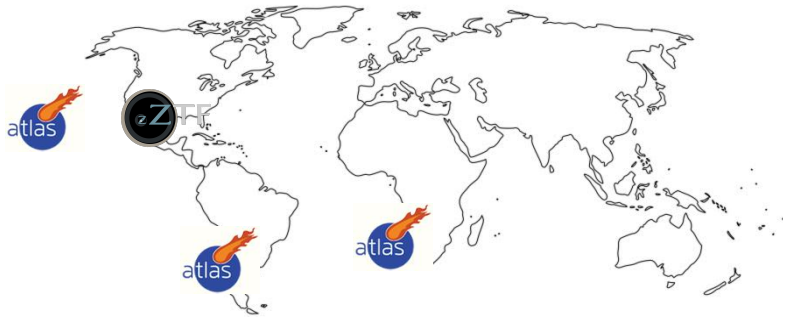
Goals

- Fast classification of transients, variable stars and active galactic nuclei
- Flexibility to adapt to different science cases
- Enable the exploration and systematic study of the database
- Connect survey and follow-up resources in Chile and abroad

ALeRCE is preparing for Rubin operations

- Ingesting and processing the Zwicky Transient Facility (ZTF) public alert stream
- Ingesting Asteroid Terrestrial-impact Last Alert System (ATLAS) data as an alert stream
    - Processing is under development

Towards becoming a multistream broker



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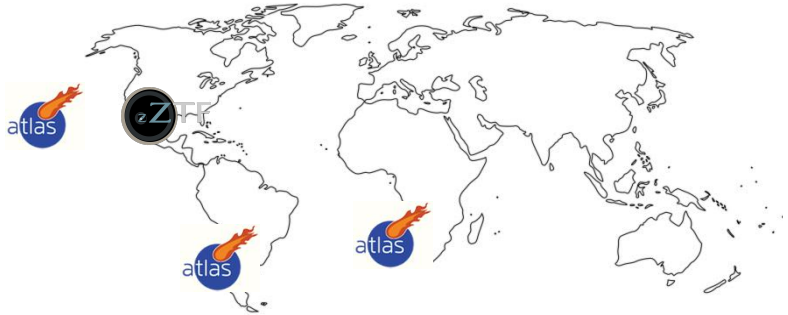


Towards becoming a multistream broker

- Participating on the Extended LSST Astronomical Time-series Classification Challenge (ELAsTiCC)

The DESC ELAsTiCC Challenge

The purpose of ELAsTiCC ("Extended LSST Astronomical Time-series Classification Challenge") is to spur the creation and testing of an end-to-end real-time pipeline for time-domain science. The challenge starts with a simulation of ~5 million detected events that includes ~50 million alerts. These alerts will be streamed from LSST to brokers, who will classify the events and send new alerts with classifications back to DESC. A talk about ELAsTiCC given at the LSSTC Enabling Science Broker Workshop in 2021 can be found on YouTube.

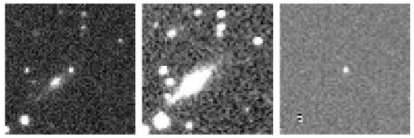
For discussion or questions about the challenge, use the `#elasticc-comms` channel on the DESC Slack.

LSST DESC Dark Energy Science Collaboration

https://portal.nersc.gov/cfs/lsst/DESC_TD_PUBLIC/ELASTICC/

ALeRCE public real-time products from ZTF data

Presentation paper (Förster+2021)



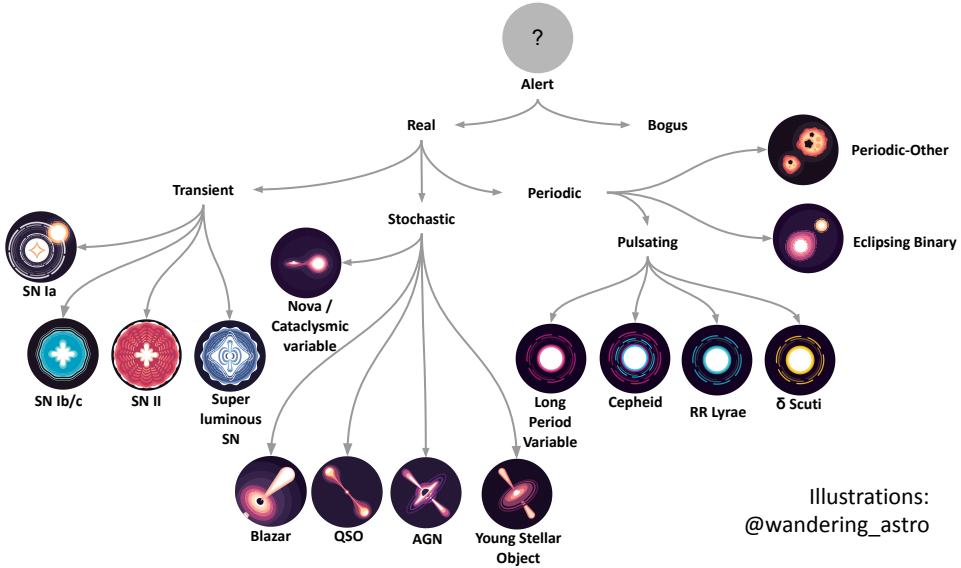
>357 M detections processed
>3 B non-detections
>89 M unique objects
>85 M stamp-based classifications
>1.9 M light curve-based classifications

Stamp classifier (Carrasco-Davis+2021)

- Convolutional neural network
- 5 classes: SN, AGN, VS, Asteroid, Bogus
- Uses first triplet of stamps per object
- Enables fast discovery of transient candidates

Light curve classifier (Sánchez-Sáez+2021)

- Balanced hierarchical random forest
- 15 classes
- Starts from 6 detections in any band per object
- Updates after every new detection
- Involves computing up to 174 features per object



Illustrations:
@wandering_astro

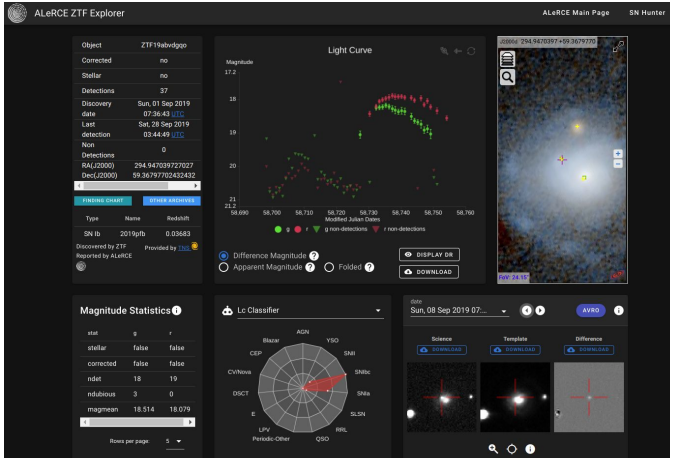
ALeRCE public real-time products from ZTF data

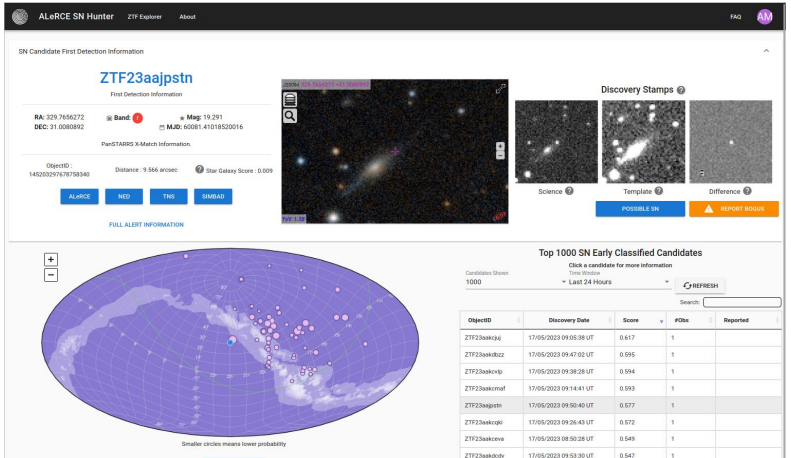
Access via

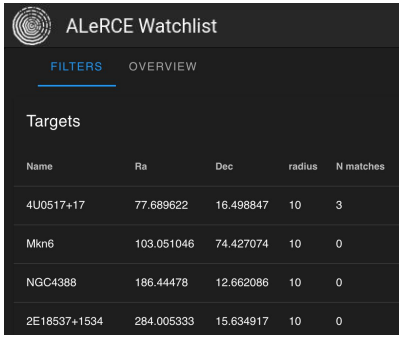
- Web interfaces
  - Explorer: https://alerce.online/
  - SN Hunter: https://snhunter.alerce.online/
  - Watchlist: https://watchlist.alerce.online/
- Python client, API, direct DB connection
- Stream (upon request)

Learn to use these tools!

- Use case notebooks: https://github.com/alercebroker/usecases
- Workshops (videos, slides & notebooks): https://workshops.alerce.online/



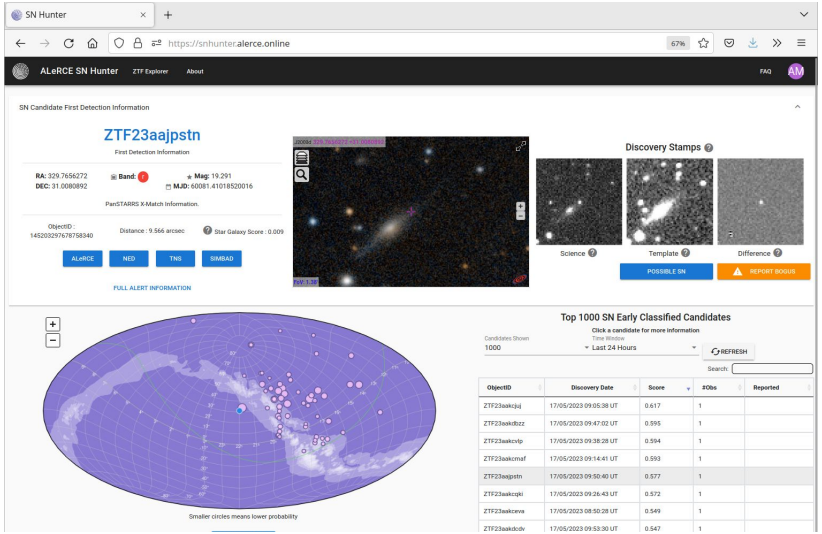




ALeRCE public real-time products from ZTF data

An additional service: *reporting transient candidates to the Transient Name Server (TNS)*

- Daily use of SN Hunter to inspect objects classified as SN from their first stamp



ALeRCE public real-time products from ZTF data

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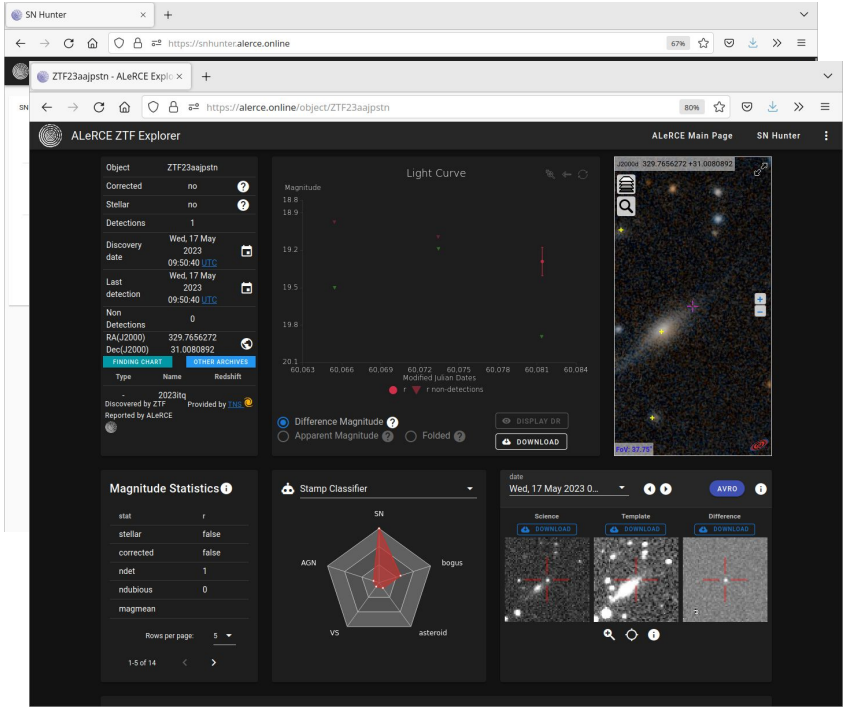
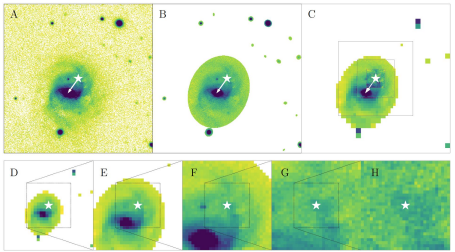
    - Complement with Explorer (previous epochs in ZTF alerts and ZTF Data Release, access to other archives)

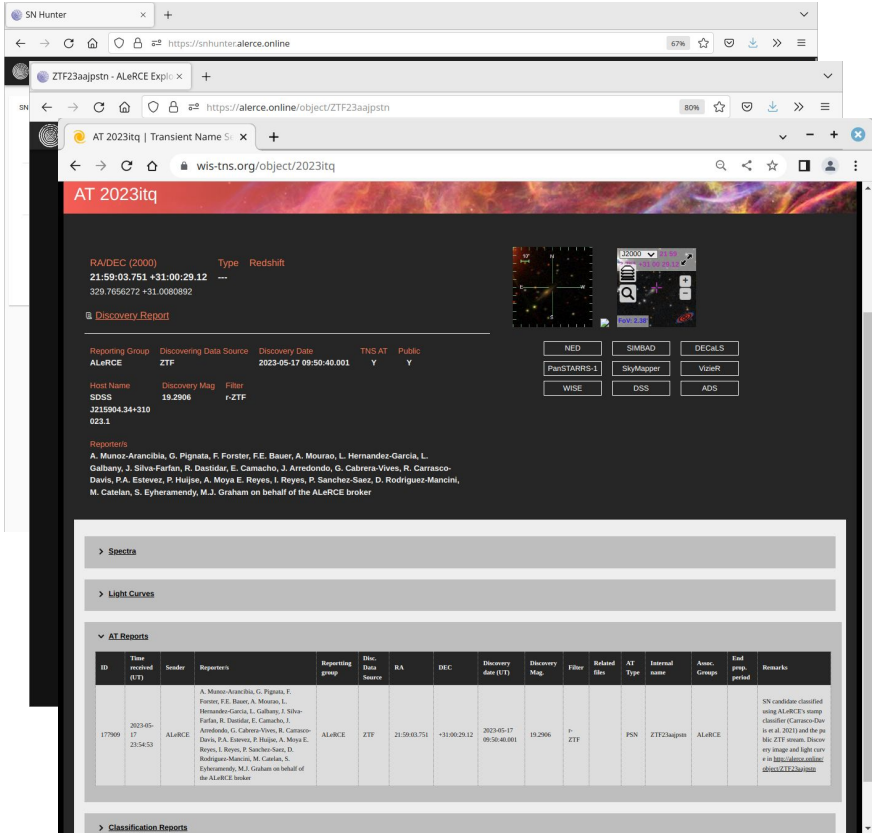


ALeRCE public real-time products from ZTF data

An additional service: *reporting transient candidates to the Transient Name Server (TNS)*

- Daily use of SN Hunter to inspect objects classified as SN from their first stamp
  - Complement with Explorer (previous epochs in ZTF alerts and ZTF Data Release, access to other archives)
- Team examines, vetoes and reports
  - Includes finding tentative host galaxy using Deep Learning Identification of Galaxy Hosts in Transients (DELIGHT, Förster+2022) with PanSTARRS archival images

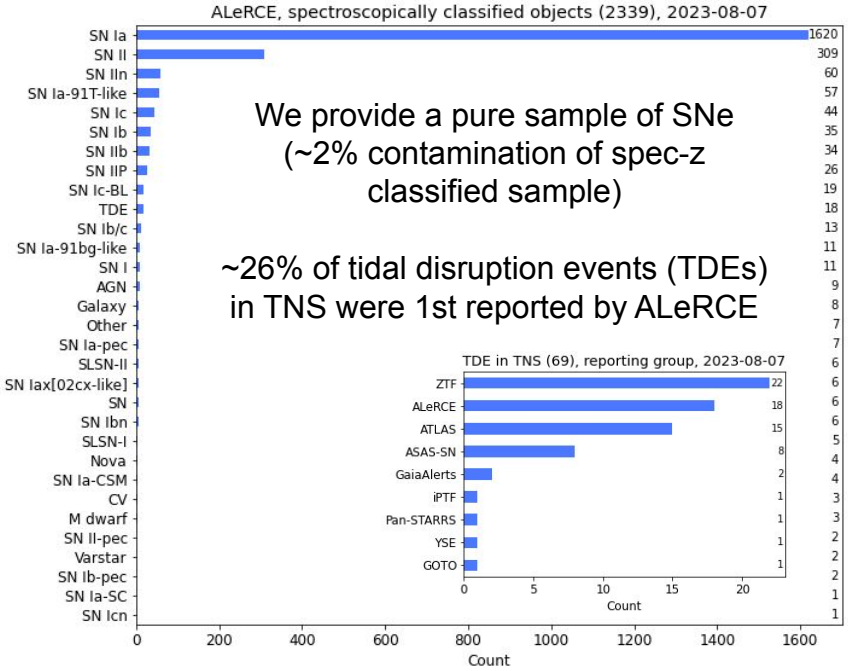




ALeRCE public real-time produ

An additional service: *reporting transient candidates to the Transient Name Server (TNS)*

- TNS reports by Aug 7, 2023



https://www.wis-tns.org/stats-maps

TNS Transients Statistics and Skymaps

TNS Transients Statistics | Reports Timeline | Skymaps

ALL transients reported since Jan 1, 2016	123533	
PUBLIC transients reported since Jan 1, 2016	120908	
PUBLIC transients for the top 5 reporting groups	Pan-STARRS	35769
	ZTF	19132
	ALeRCE	18990
	GaiaAlerts	17166
	ATLAS	15780
PUBLIC transients for the top 5 data source groups	ZTF	41331
	Pan-STARRS	38152
	GaiaAlerts	17166
	ATLAS	15780
	iPTF	1642
PUBLIC classified SNe reported since Jan 1, 2016	12660	
PUBLIC classified SNe for the top 5 reporting groups	ZTF	3577
	ATLAS	3413
	ALeRCE	2285
	ASAS-SN	803
	Pan-STARRS	710
PUBLIC classified SNe for the top 5 data source groups	ZTF	6184
	ATLAS	3413
	Pan-STARRS	886
	ASAS-SN	802
	GaiaAlerts	577
ALL spectra reported to the TNS	15307	
PUBLIC spectra reported to the TNS	15099	

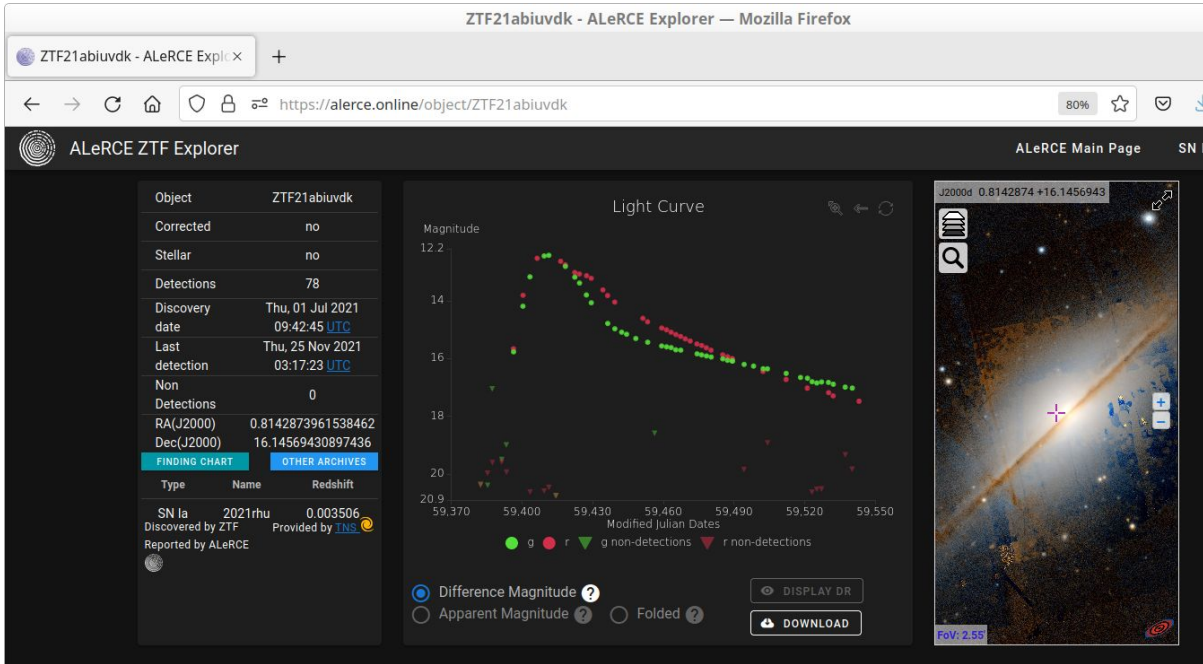
ALeRCE public real-time products from ZTF data

An additional service: *reporting transient candidates to the Transient Name Server (TNS)*

- Most ALeRCE TNS reports shortly after first ZTF detection
  - Enables prompt follow-up

SN 2021rhu / ZTF21abiuvdk

z = 0.0035
Discovery date Jul 1, 2021
+4 h ALeRCE TNS report
+13 h first spectrum (SN Ia)
+4 d third ZTF detection



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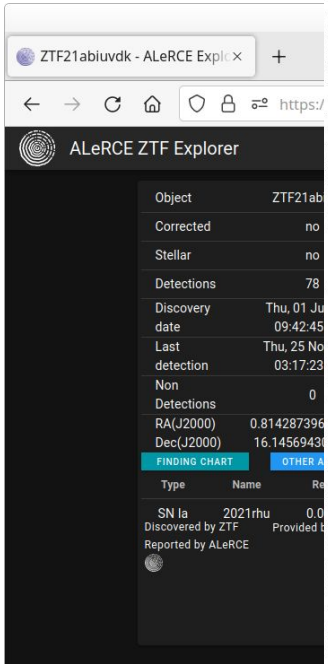
Followed up by e.g. Dhawan+2022, Yang+2022, Harvey+2023



Monthly Notices of the ROYAL ASTRONOMICAL SOCIETY
MNRAS 522, 4444–4467 (2023) https://doi.org/10.1093/mnras/stad1226
Advance Access publication 2023 May 3

Early-time spectroscopic modelling of the transitional Type Ia Supernova 2021rhu with TARDIS

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Accepted 2023 April 18. Received 2023 February 24; in original form 2022 November 1

ABSTRACT

An open question in SN Ia research is where the boundary lies between 'normal' Type Ia supernovae (SNe Ia) that are used in cosmological measurements and those that sit off the Phillips relation. We present the spectroscopic modelling of one such '86G-like' transitional SN Ia, SN 2021rhu, that has recently been employed as a local Hubble Constant calibrator using a tip of the red-giant branch measurement. We detail its modelling from −12 d until maximum brightness using the radiative-transfer spectral-synthesis code TARDIS. Please check and correct this paper accordingly. We base our modelling on literature delayed-detonation and deflagration models of Chandrasekhar mass white dwarfs, as well as the double-detonation models of sub-Chandrasekhar mass white dwarfs. We present a new method for 'projecting' abundance profiles to different density profiles for ease of computation. Due to the small velocity extent and low outer densities of the W7 profile, we find it inadequate to reproduce the evolution of SN 2021rhu as it fails to match the high-velocity calcium components. The host extinction of SN 2021rhu is uncertain but we use modelling with and without an extinction correction to set lower and upper limits on the abundances of individual species. Comparing these limits to literature models we conclude that the spectral evolution of SN 2021rhu is also incompatible with double-detonation scenarios, lying more in line with those resulting from the delayed-detonation mechanism (although there are some discrepancies, in particular a larger titanium abundance in SN 2021rhu compared to the literature). This suggests that SN 2021rhu is likely a lower luminosity, and hence lower temperature, version of a normal SN Ia.

Summary

- ALeRCE as an interdisciplinary, Chilean-led initiative
- Selected as a community broker for Rubin LSST
- Currently ingesting and processing the ZTF public alert stream
- Also ingesting an ATLAS stream, towards becoming a multi-stream broker
- Participating in DESC ELAsTiCC
- Providing classification and visualization, enabling exploration
  - All data products public in real time
  - Access via web interfaces, Python client / API, and direct database connection
- Helping to find early transients
  - Stamp classifier + human evaluation, aiming for purity in our TNS reports
  - Working towards more automatic steps
- ALeRCE products and TNS reports being cited by the community

2. METHODS

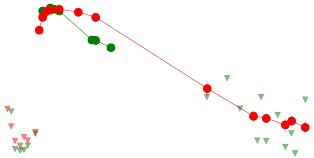
We query the ZTF public alert stream between 2018 May 04 and 2021 December 18 using the criteria detailed below. Several public astronomical alert brokers filter, store, and deliver ZTF alerts together with contextual information for each alert. Among them are the Automatic Learning for the Rapid Classification of Events (ALeRCE; Förster et al. 2021) broker[1], the Arizona-NOAO Temporal Analysis and Response to Events System (ANTARES; Narayan et al. 2018)[2], Lasair (Smith et al. 2019)[3], FINK (Möller et al. 2021)[4], and Make Alerts Really Simple (MARS; which has been discontinued)[5]. After experimenting with several brokers, we chose ALeRCE for this work (though it could be undertaken with most other brokers as well) owing to its rapid and complete databases, informative website, connections to external archives, and user-friendly PYTHON API access.

From Li+2023

Much more info:

ALeRCE homepage: https://alerce.science
Explorer: https://alerce.online/
SN Hunter: https://snhunter.alerce.online/
Watchlist: https://watchlist.alerce.online/
Use case notebooks: https://github.com/alercebroker/usecases
Workshops (videos, slides & notebooks): https://workshops.alerce.online/

The ALeRCE pipeline



ZTF stream

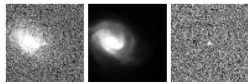
ATLAS stream

Sorting hat

Alert Archiving

Light curve update

Stamp classification (1 detection)



Crossmatch

Feature computation (6+ detections)

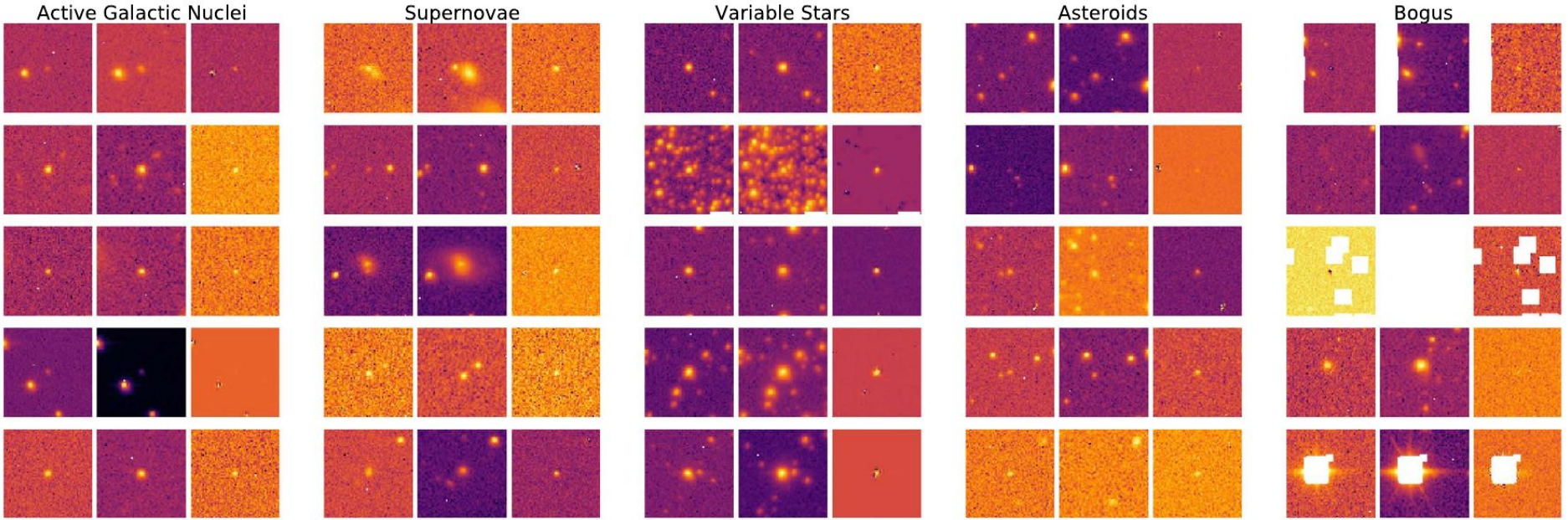
Light curve classification (6+detections)

ZTF alerts (production)

ATLAS alerts (production)

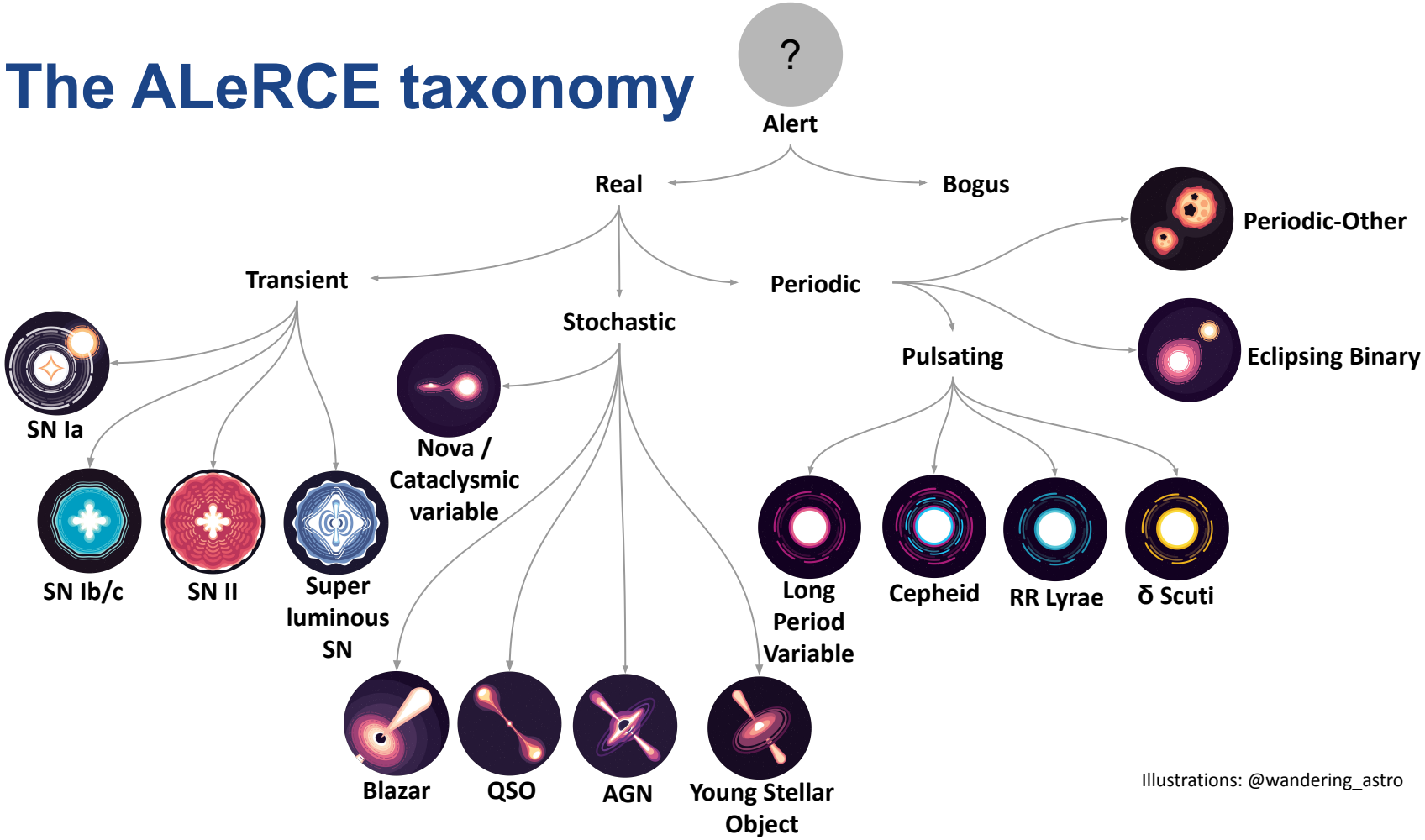
ATLAS alerts (development)

Image stamps



Carrasco-Davis+2021

The ALeRCE taxonomy



Illustrations: @wandering_astro