ALeRCE

Automatic Learning for the Rapid Classification of Events

ALeRCE broker: current status and demo

Danilo Alvares, Javier Arredondo, Nicolás Astorga, Franz Bauer, Guillermo Cabrera-Vives, Rodrigo Carrasco-Davis, **Ernesto Castillo**, Márcio Catelan, Andrew Connolly, Demetra De Cicco, Cristóbal Donoso, Felipe Elorrieta, Pablo Estévez, Susana Eyheramendy, Francisco Förster, Germán García, Matthew Graham, Pablo Huijse, Ashish Mahabal, Giovanni Motta, Rosario Molina, Giuliano Pignata, Pavlos Protopapas, Esteban Reyes, Ignacio Reyes, Diego Rodríguez, Daniela Ruz, Paula Sánchez-Sáez, Camilo Valenzuela, Jorge Vergara

http://alerce.science/

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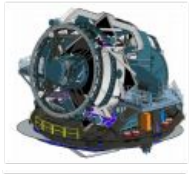
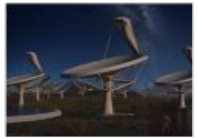
Outline

- Introduction
- Goals
- Team / Methodology
- Infrastructure
- Machine Learning
- Demo
  - Web Interfaces
  - API
  - Jupyter notebooks

Future time domain astronomy ecosystem

Survey telescopes



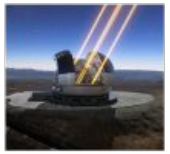
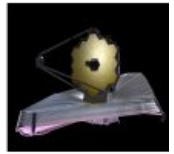


Alert brokers/TOMs

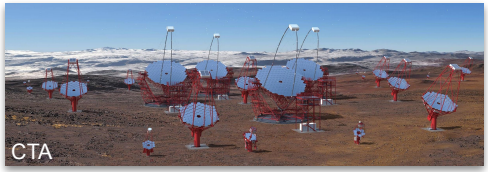
ALeRCE
Automatic Learning for the Rapid Classification of Events

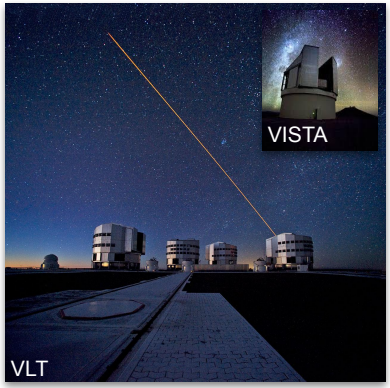
+ *other brokers/TOMs*

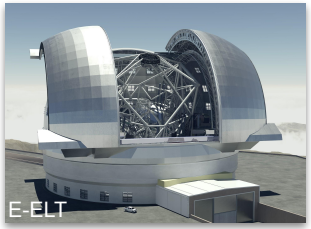
Follow up telescopes

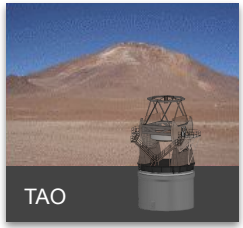



Astronomical infrastructure in Chile









Chilean institutions: access to **~10% observing time**

ALeRCE

Automatic Learning for the
Rapid Classification of Events

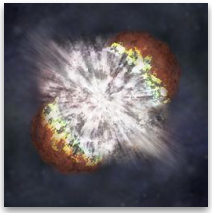
ALeRCE is a Chilean-led initiative to build a community broker for LSST and other large etendue survey telescopes

Goals

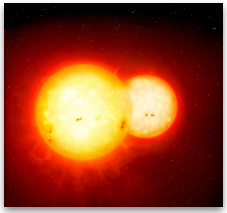
To facilitate the study of non-moving, variable and transients objects:

- **Fast classification** of transients, variable stars and active galactic nuclei
- **Flexibility** to adapt to different **science cases** (taxonomy, data products)
- **Connect** survey and **follow up** resources in Chile and abroad

Scientific Questions



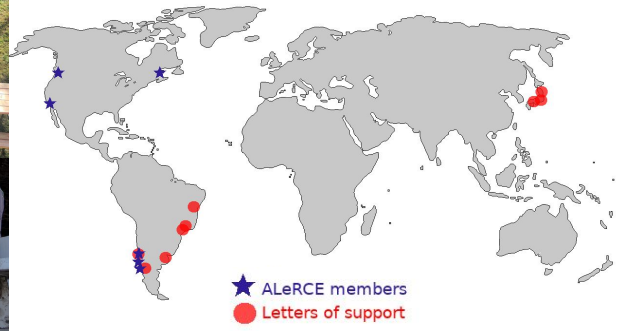
Transients

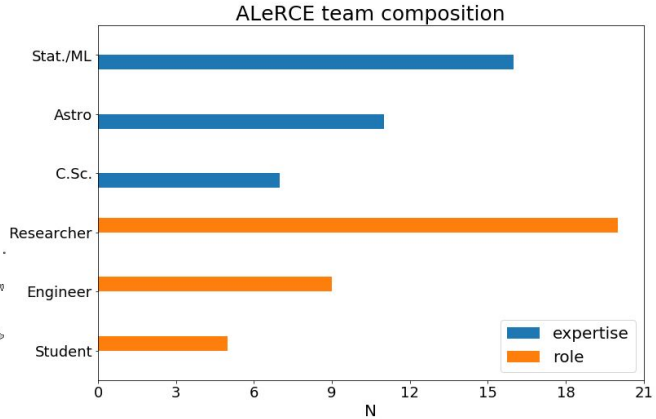


Variable Stars

Active Galactic Nuclei

ALeRCE Team





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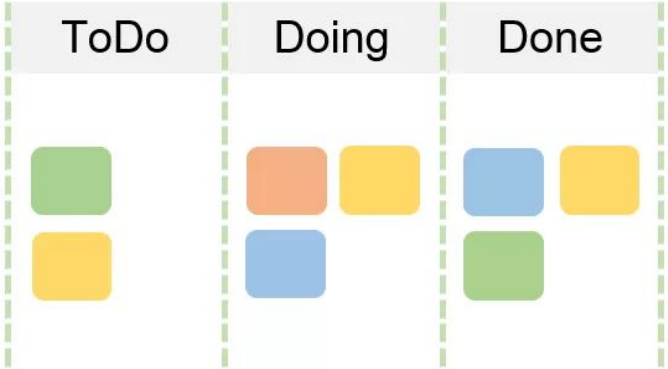
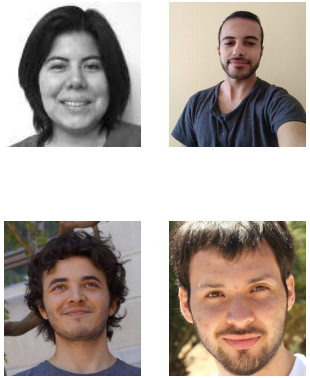
Agile Methodology



- Daily meetings + 2 weeks sprints
- Product owner
- Kanban / Backlog
- Weekly ML/training set meetings



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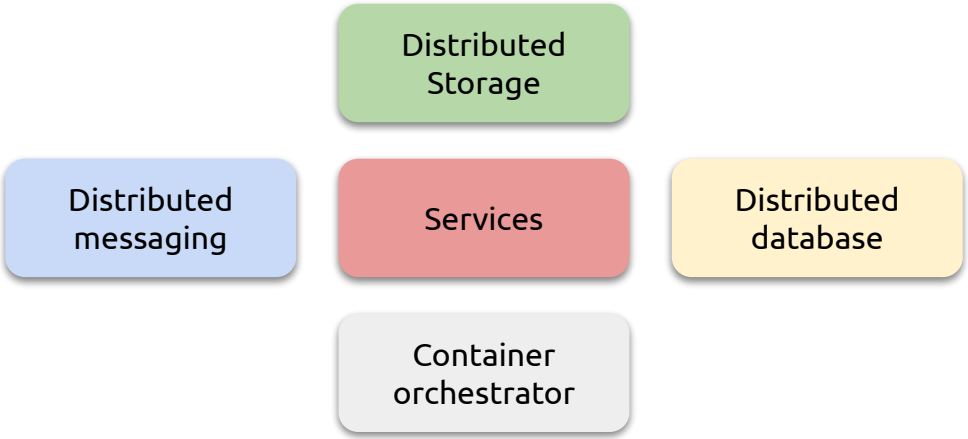
ALeRCE infrastructure



ALeRCE infrastructure

aws

Distributed Storage

Distributed messaging

Services

Distributed database

Container orchestrator

APACHE kafka

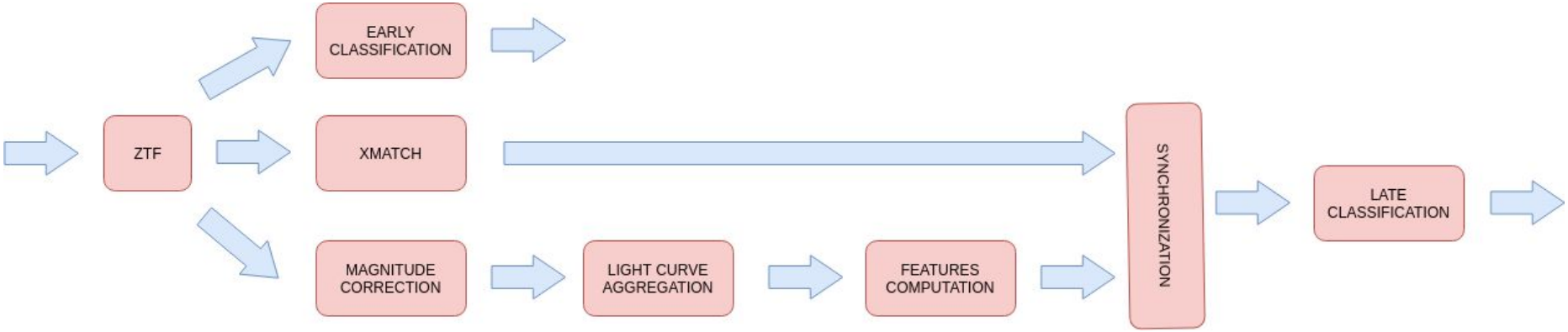
PostgreSQL

cassandra

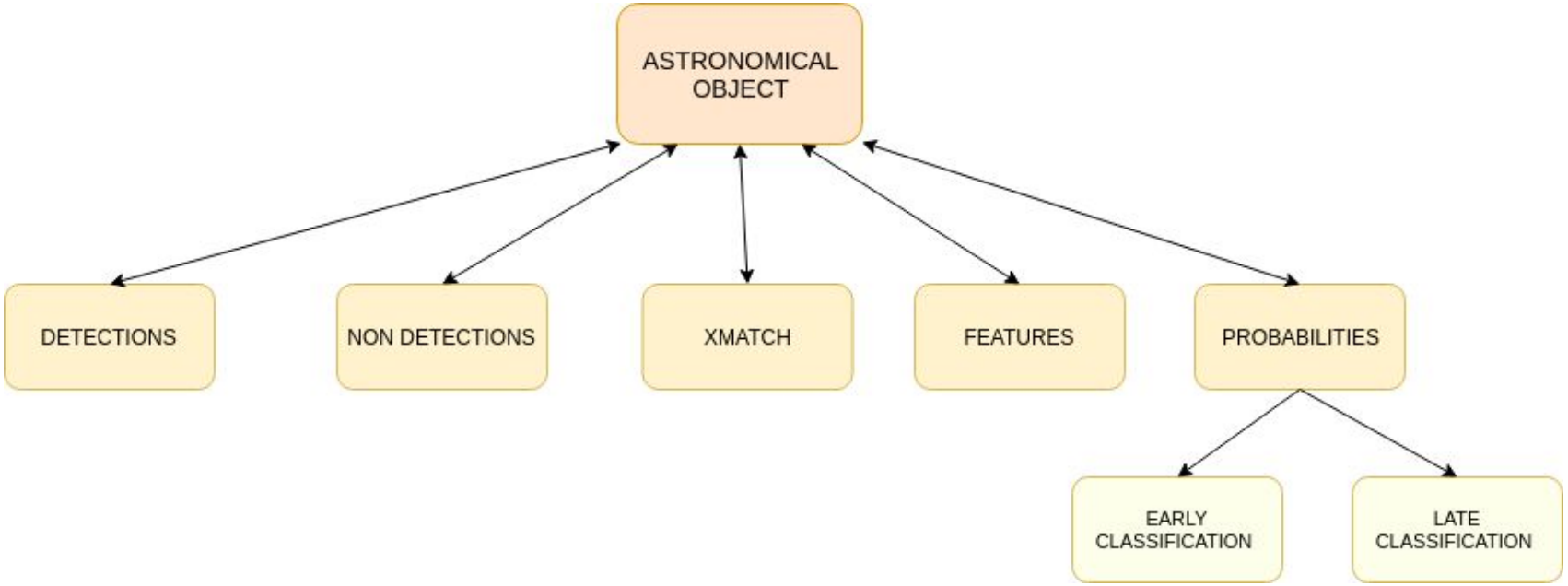
docker

kubernetes

ALeRCE pipeline

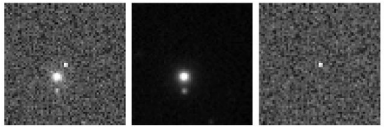


ZTF Data Model

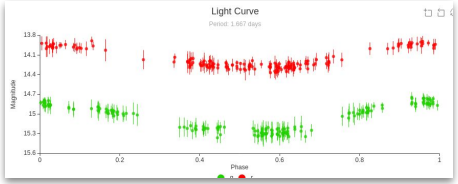


Classification

- Current Classifiers:
  - Convolutional Neural Network (stamps)



  - Random Forest (light curve)

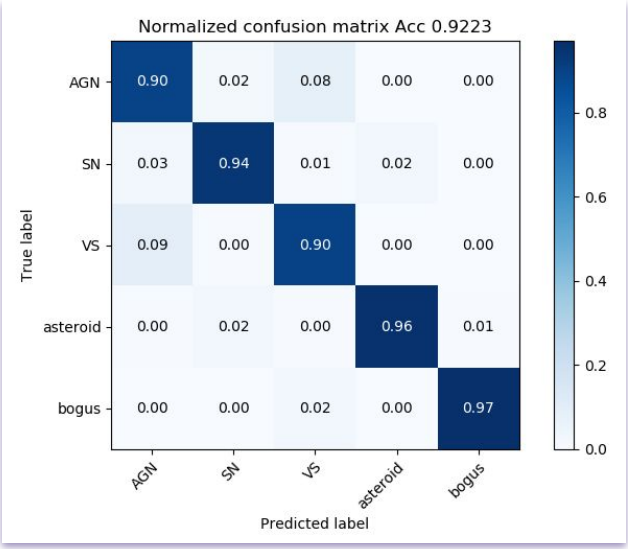


- Future Classifiers:
  - Domain Adaptation
  - Data Augmentation
  - Outlier Detection
  - Forecasting

Early Classifier

Convolutional Neural Network
(using first stamps)

***Classes**: AGN, SN, VS, asteroid, bogus*

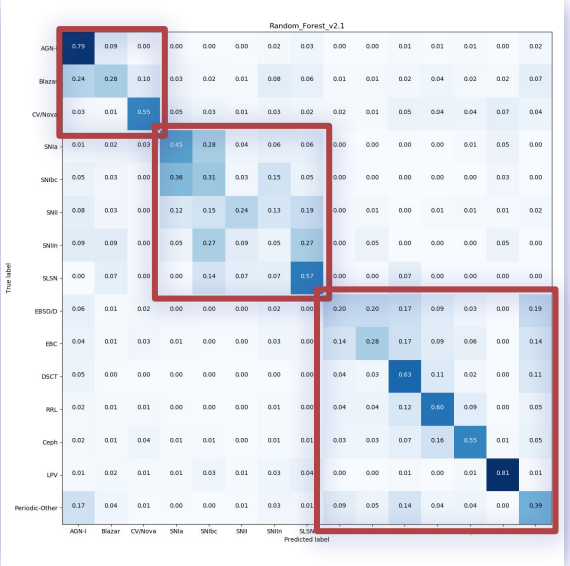


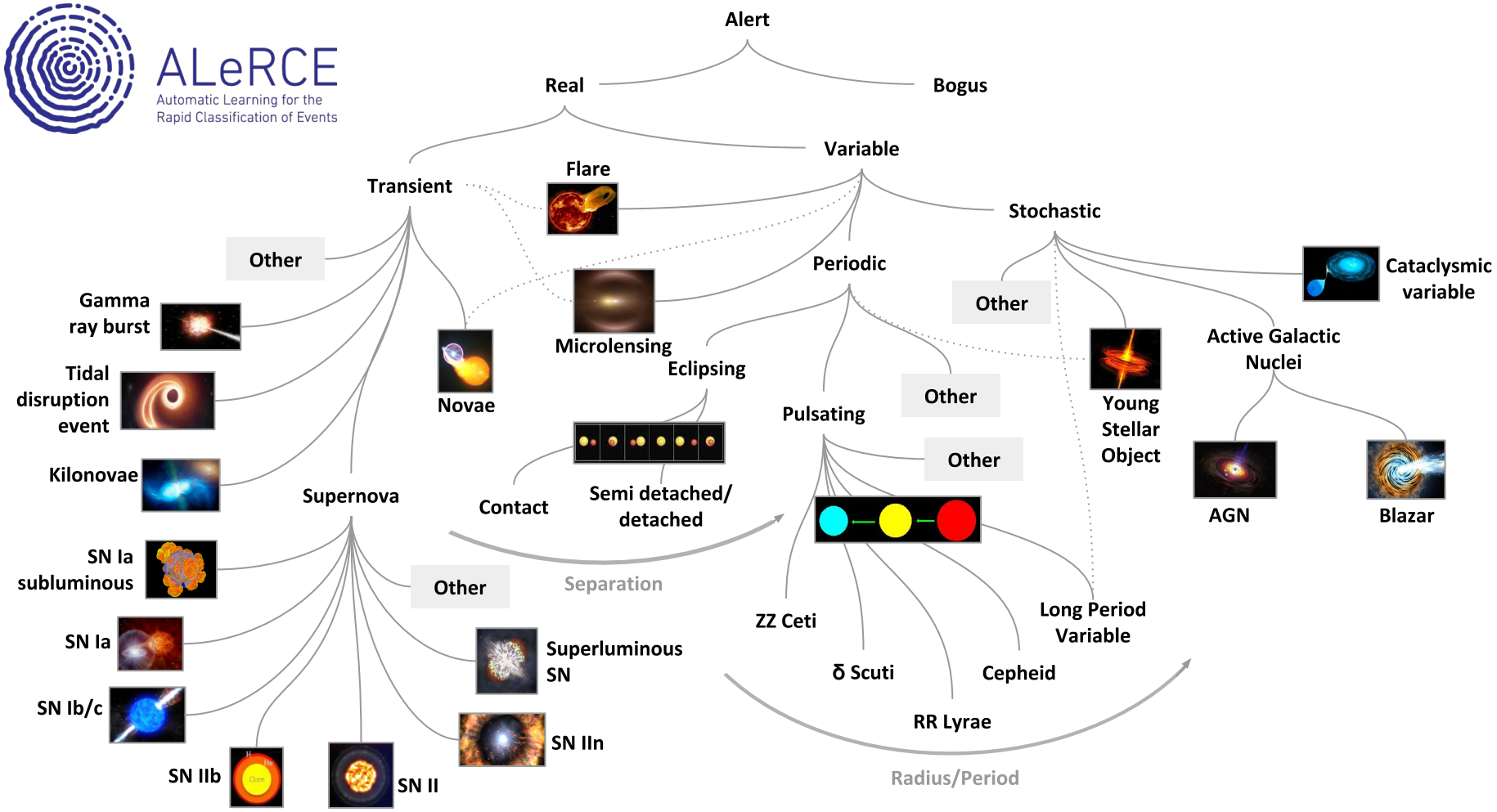
Late Classifier

Random Forest
(using light curve, at least 5 observations)

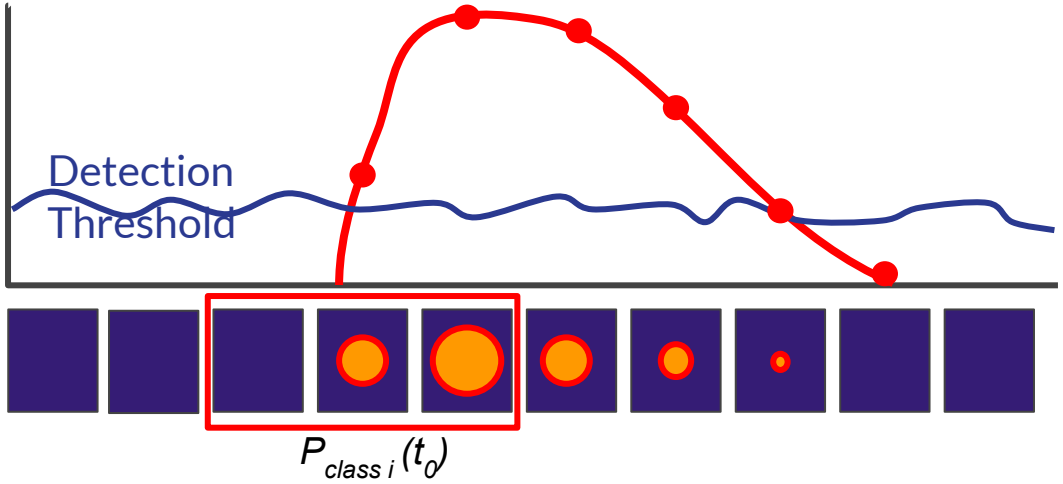
Classes:

- ***Stochastic**: AGN-I, Blazar, CV/Nova*
- ***Transients**: SNe Ia, SNe Ibc,SNe II,SNe IIn, SLSNe*
- ***Periodic stars**: EBSD/D, EBC, DSCT, RRL, Ceph, LPV, Periodic Other*

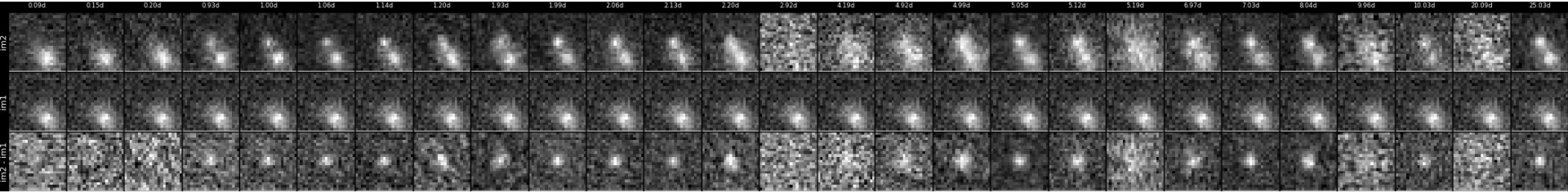



ALeRCE
Automatic Learning for the Rapid Classification of Events
Alert
Real
Bogus
Variable
Transient
Flare
Stochastic
Other
Gamma ray burst
Tidal disruption event
Kilonovae
Novae
Microlensing
Periodic
Eclipsing
Contact
Semi detached/ detached
Separation
Supernova
Other
SN Ia subluminous
SN Ia
SN Ib/c
SN IIb
SN II
SN IIn
Superluminous SN
Pulsating
Other
ZZ Ceti
δ Scuti
RR Lyrae
Cepheid
Long Period Variable
Radius/Period
Other
Young Stellar Object
Active Galactic Nuclei
AGN
Blazar
Cataclysmic variable

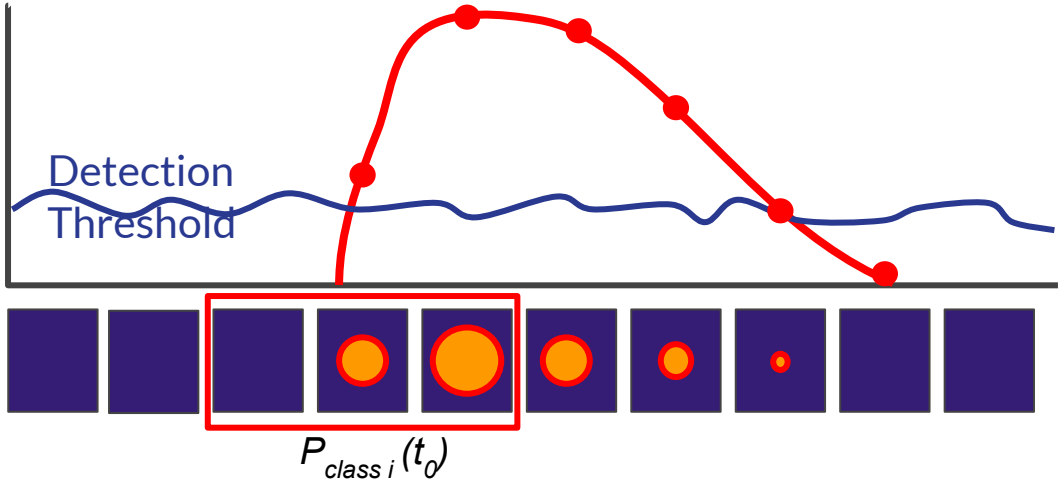
Convolutional recurrent neural network



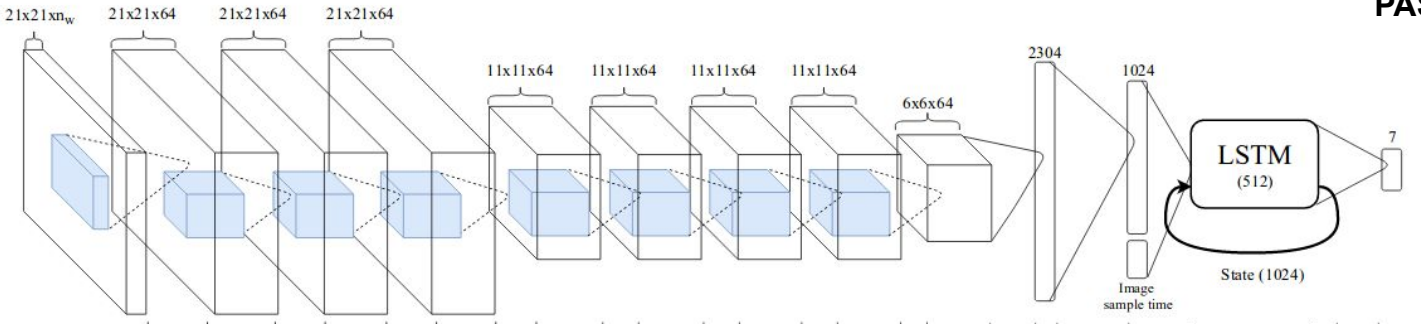
Carrasco-Davis+18
PASP



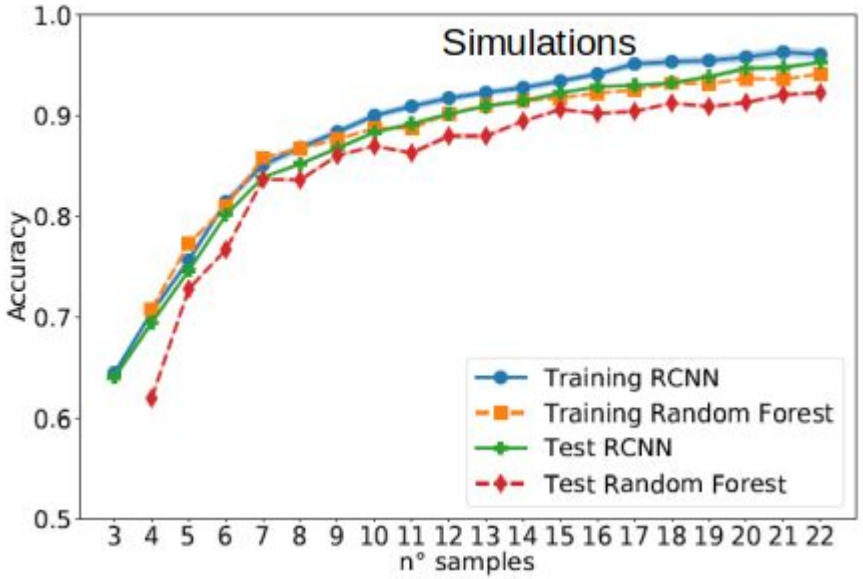
Convolutional recurrent neural network

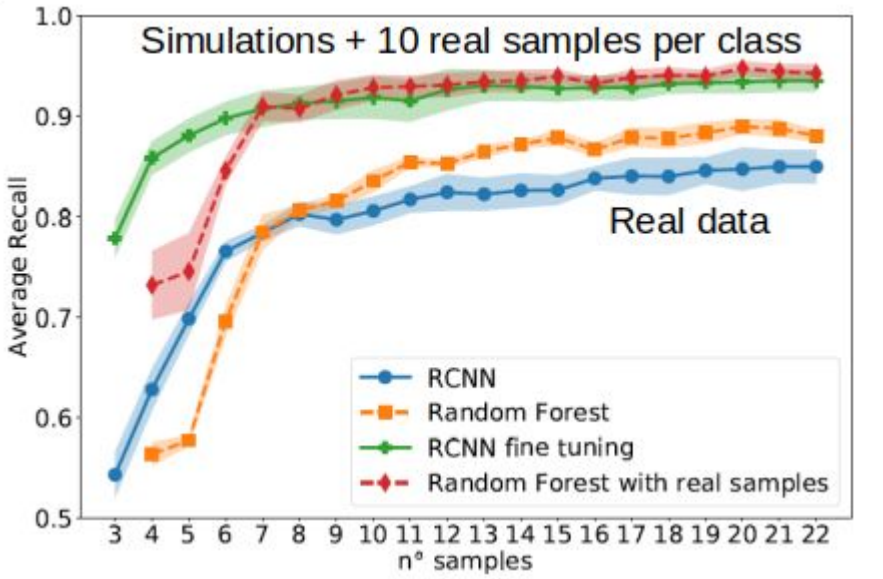


Carrasco-Davis+18
PASP



Training vs domain overfitting





Carrasco-Davis+18
PASP

Summary

- Goals:
  - Fast classification: transients, variable stars and AGN
  - Flexibility to adapt to different science cases
  - Connect survey and follow up

- Interdisciplinary team:
  - Machine Learning
  - Astronomy
  - Computer Science

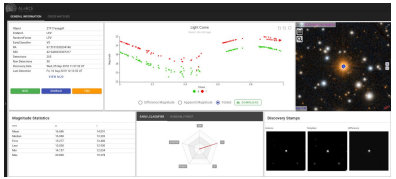
- Infrastructure:
  - Modular / Distributed / Robust

- Machine Learning:
  - Classification: CNN / Random Forest
  - Outlier Detection
  - Domain Adaptation / Data Augmentation
  - Forecasting

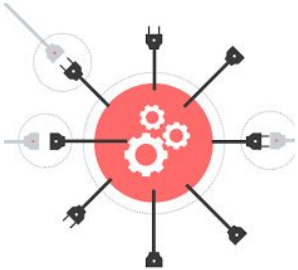
DEMO

http://alerce.science

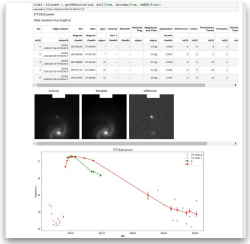
Web Interfaces



API



Jupyter Notebooks



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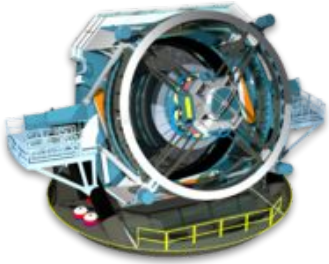
http://alerce.science



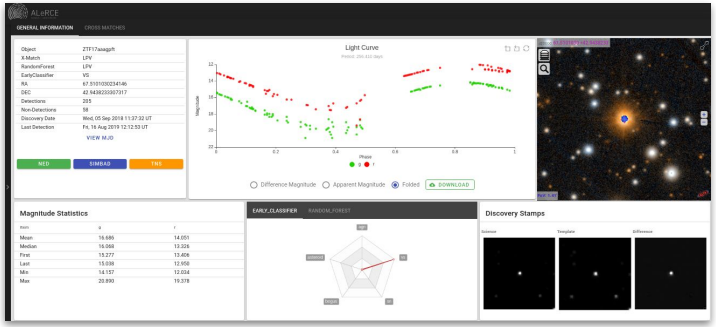
Output stream

(real-time follow-up)

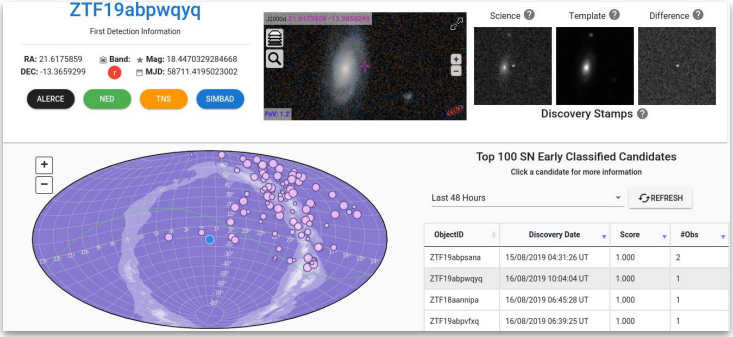
TOMs

Web Interfaces

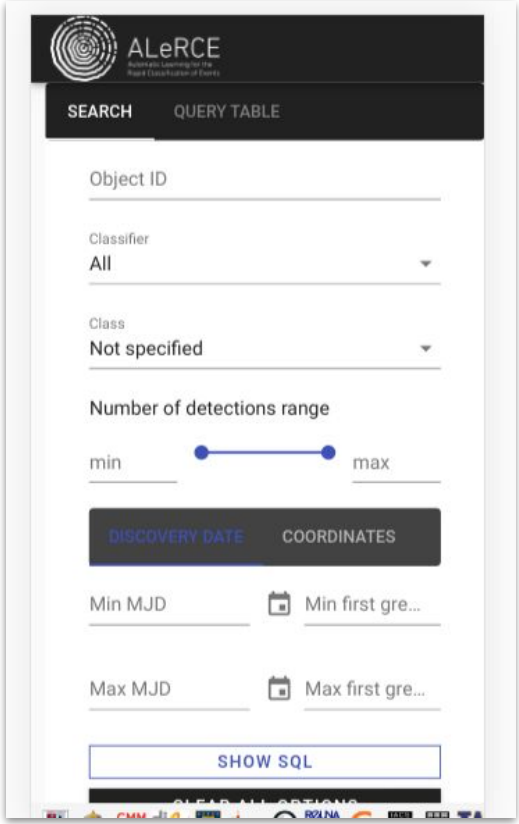
ZTF Explorer
http://alerce.online

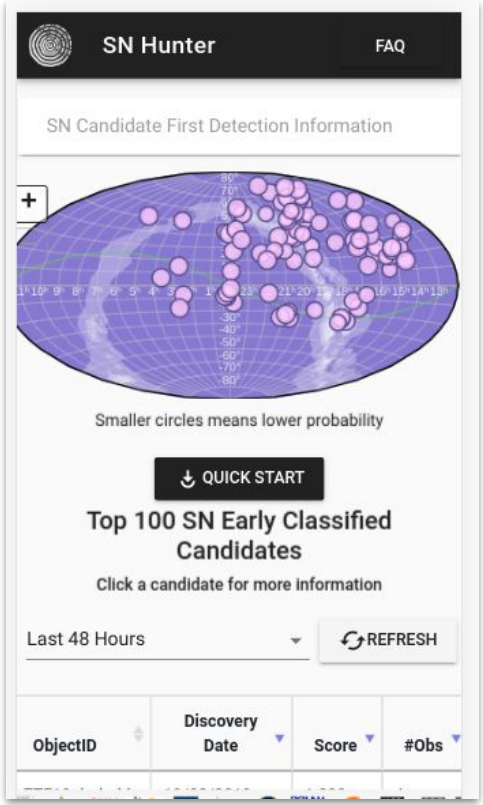


SN Hunter
http://snhunter.alerce.online

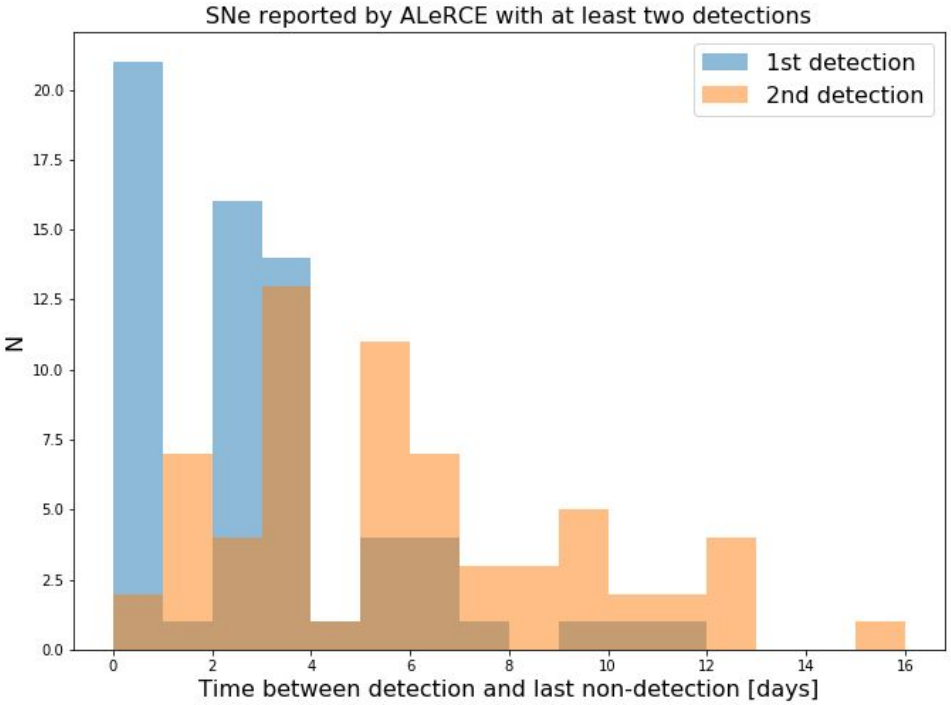


Mobile Phones





SNe reported by ALeRCE



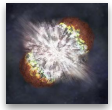
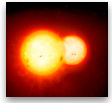
API

- **ZTF Database:** http://ztf.alerce.online
- **Avro/Stamps:** http://avro.alerce.online
- **catsHTM Cone Search & Xmatch:** http://catshtm.alerce.online *

* *Soumagnac & Ofek (2018), (Ofek 2014; ascl.soft 07005)*

Jupyter Notebooks

https://github.com/alercebroker/usecases/tree/master/notebooks

- API
-  Transients
-  Variable Stars
- Active Galactic Nuclei